[DESCRIPTION]

[Title of Invention] INFORMATION COMMUNICATION METHOD

[Technical Field]

[0001]

The present invention relates to a method of communication between a mobile terminal such as a smartphone, a tablet terminal, or a mobile phone and a home electric appliance such as an air conditioner, a lighting device, or a rice cooker.

[Background Art]

[0002]

In recent years, a home-electric-appliance cooperation function has been introduced for a home network, with which various home electric appliances are connected to a network by a home energy management system (HEMS) having a function of managing power usage for addressing an environmental issue, turning power on/off from outside a house, and the like, in addition to cooperation of AV home electric appliances by internet protocol (IP) connection using Ethernet® or wireless local area network (LAN). However, there are home electric appliances whose computational performance is insufficient to have a communication function, and home electric appliances which do not have a communication function due to a matter of cost.

[0003]

In order to solve such a problem, Patent Literature (PTL) 1 discloses a technique of efficiently establishing communication between devices among limited optical spatial transmission devices which transmit information to a free space using light, by performing communication using plural single color light sources of illumination light.

[Citation List]

[Patent Literature]

[0004]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2002-290335

[Summary of Invention]

[Technical Problem]

[0005]

However, the conventional method is limited to a case in which a device to which the method is applied has three color light sources such as an illuminator. The present invention solves this problem, and provides an information communication method that enables communication between various devices including a device with low computational performance.

[Solution to Problem]

[0006]

An information communication method according to an aspect of the present invention is an information communication method of transmitting a signal using a change in luminance, the information communication method including: determining a pattern of the change in luminance, by modulating the signal to be transmitted; and transmitting the signal, by a plurality of light emitters changing in luminance according to the determined pattern of the change in luminance, wherein the plurality of light emitters are arranged on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.

[0007]

These general and specific aspects may be implemented using a system, a method, an integrated circuit, a computer program, or a computer-readable recording medium such as a CD-ROM, or any combination of systems, methods, integrated circuits, computer programs, or computer-readable recording media.

[Advantageous Effects of Invention]

[0008]

An information communication method according to the present invention enables communication between various devices including a device with low computational performance.

[Brief Description of Drawings]

[0009]

[FIG. 1]

FIG. 1 is a timing diagram of a transmission signal in an information communication device in Embodiment 1.

[FIG. 2]

FIG. 2 is a diagram illustrating relations between a transmission signal and a reception signal in Embodiment 1.

[FIG. 3]

FIG. 3 is a diagram illustrating relations between a transmission signal and a reception signal in Embodiment 1.

[FIG. 4]

FIG. 4 is a diagram illustrating relations between a transmission signal and a reception signal in Embodiment 1.

[FIG. 5]

FIG. 5 is a diagram illustrating relations between a transmission signal and a reception signal in Embodiment 1.

[FIG. 6]

FIG. 6 is a diagram illustrating relations between a transmission signal and a reception signal in Embodiment 1.

[FIG. 7]

FIG. 7 is a diagram illustrating a principle in Embodiment 2.

[FIG. 8]

FIG. 8 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 9]

FIG. 9 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 10]

FIG. 10 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 11]

FIG. 11 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 12A]

FIG. 12A is a diagram illustrating an example of operation in

Embodiment 2.

[FIG. 12B]

FIG. 12B is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 12C]

FIG. 12C is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 13]

FIG. 13 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 14]

FIG. 14 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 15]

FIG. 15 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 16]

FIG. 16 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 17]

FIG. 17 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 18]

FIG. 18 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 19]

FIG. 19 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 20]

FIG. 20 is a diagram illustrating an example of operation in Embodiment 2.

[FIG. 21]

FIG. 21 is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 22]

FIG. 22 is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 23]

FIG. 23 is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24A]

FIG. 24A is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24B]

FIG. 24B is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24C]

FIG. 24C is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24D]

FIG. 24D is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24E]

FIG. 24E is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24F]

FIG. 24F is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24G]

FIG. 24G is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24H]

FIG. 24H is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 24I]

FIG. 24I is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 25]

FIG. 25 is a diagram illustrating an example of an observation method of luminance of a light emitting unit in Embodiment 3.

[FIG. 26]

FIG. 26 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 27]

FIG. 27 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 28]

FIG. 28 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 29]

FIG. 29 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 30]

FIG. 30 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 31]

FIG. 31 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 32]

FIG. 32 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 33]

FIG. 33 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 34]

FIG. 34 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 35]

FIG. 35 is a diagram illustrating an example of a signal

modulation scheme in Embodiment 3.

[FIG. 36]

FIG. 36 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 37]

FIG. 37 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 38]

FIG. 38 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 39]

FIG. 39 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 40]

FIG. 40 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 41]

FIG. 41 is a diagram illustrating an example of a signal modulation scheme in Embodiment 3.

[FIG. 42]

FIG. 42 is a diagram illustrating an example of a light emitting unit detection method in Embodiment 3.

[FIG. 43]

FIG. 43 is a diagram illustrating an example of a light emitting unit detection method in Embodiment 3.

[FIG. 44]

FIG. 44 is a diagram illustrating an example of a light emitting unit detection method in Embodiment 3.

[FIG. 45]

FIG. 45 is a diagram illustrating an example of a light emitting unit detection method in Embodiment 3.

[FIG. 46]

FIG. 46 is a diagram illustrating an example of a light emitting unit detection method in Embodiment 3.

[FIG. 47]

FIG. 47 is a diagram illustrating transmission signal timelines and an image obtained by capturing light emitting units in Embodiment 3.

[FIG. 48]

FIG. 48 is a diagram illustrating an example of signal transmission using a position pattern in Embodiment 3.

[FIG. 49]

FIG. 49 is a diagram illustrating an example of a reception device in Embodiment 3.

[FIG. 50]

FIG. 50 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 51]

FIG. 51 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 52]

FIG. 52 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 53]

FIG. 53 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 54]

FIG. 54 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 55]

FIG. 55 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 56]

FIG. 56 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 57]

FIG. 57 is a diagram illustrating an example of a transmission device in Embodiment 3.

[FIG. 58]

FIG. 58 is a diagram illustrating an example of a structure of a

light emitting unit in Embodiment 3.

[FIG. 59]

FIG. 59 is a diagram illustrating an example of a signal carrier in Embodiment 3.

[FIG. 60]

FIG. 60 is a diagram illustrating an example of an imaging unit in Embodiment 3.

[FIG. 61]

FIG. 61 is a diagram illustrating an example of position estimation of a reception device in Embodiment 3.

[FIG. 62]

FIG. 62 is a diagram illustrating an example of position estimation of a reception device in Embodiment 3.

[FIG. 63]

FIG. 63 is a diagram illustrating an example of position estimation of a reception device in Embodiment 3.

[FIG. 64]

FIG. 64 is a diagram illustrating an example of position estimation of a reception device in Embodiment 3.

[FIG. 65]

FIG. 65 is a diagram illustrating an example of position estimation of a reception device in Embodiment 3.

[FIG. 66]

FIG. 66 is a diagram illustrating an example of transmission information setting in Embodiment 3.

[FIG. 67]

FIG. 67 is a diagram illustrating an example of transmission information setting in Embodiment 3.

[FIG. 68]

FIG. 68 is a diagram illustrating an example of transmission information setting in Embodiment 3.

[FIG. 69]

FIG. 69 is a block diagram illustrating an example of structural elements of a reception device in Embodiment 3.

[FIG. 70]

FIG. 70 is a block diagram illustrating an example of structural elements of a transmission device in Embodiment 3.

[FIG. 71]

FIG. 71 is a diagram illustrating an example of a reception procedure in Embodiment 3.

[FIG. 72]

FIG. 72 is a diagram illustrating an example of a self-position estimation procedure in Embodiment 3.

[FIG. 73]

FIG. 73 is a diagram illustrating an example of a transmission control procedure in Embodiment 3.

[FIG. 74]

FIG. 74 is a diagram illustrating an example of a transmission control procedure in Embodiment 3.

[FIG. 75]

FIG. 75 is a diagram illustrating an example of a transmission control procedure in Embodiment 3.

[FIG. 76]

FIG. 76 is a diagram illustrating an example of information provision inside a station in Embodiment 3.

[FIG. 77]

FIG. 77 is a diagram illustrating an example of a passenger service in Embodiment 3.

[FIG. 78]

FIG. 78 is a diagram illustrating an example of an in-store service in Embodiment 3.

[FIG. 79]

FIG. 79 is a diagram illustrating an example of wireless connection establishment in Embodiment 3.

[FIG. 80]

FIG. 80 is a diagram illustrating an example of communication range adjustment in Embodiment 3.

[FIG. 81]

FIG. 81 is a diagram illustrating an example of indoor use in Embodiment 3.

[FIG. 82]

FIG. 82 is a diagram illustrating an example of outdoor use in Embodiment 3.

[FIG. 83]

FIG. 83 is a diagram illustrating an example of route indication in Embodiment 3.

[FIG. 84]

FIG. 84 is a diagram illustrating an example of use of a plurality of imaging devices in Embodiment 3.

[FIG. 85]

FIG. 85 is a diagram illustrating an example of transmission device autonomous control in Embodiment 3.

[FIG. 86]

FIG. 86 is a diagram illustrating an example of transmission information setting in Embodiment 3.

[FIG. 87]

FIG. 87 is a diagram illustrating an example of transmission information setting in Embodiment 3.

[FIG. 88]

FIG. 88 is a diagram illustrating an example of transmission information setting in Embodiment 3.

[FIG. 89]

FIG. 89 is a diagram illustrating an example of combination with 2D barcode in Embodiment 3.

[FIG. 90]

FIG. 90 is a diagram illustrating an example of map generation and use in Embodiment 3.

[FIG. 91]

FIG. 91 is a diagram illustrating an example of electronic device state obtainment and operation in Embodiment 3.

[FIG. 92]

FIG. 92 is a diagram illustrating an example of electronic device recognition in Embodiment 3.

[FIG. 93]

FIG. 93 is a diagram illustrating an example of augmented

reality object display in Embodiment 3.

[FIG. 94]

FIG. 94 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 95]

FIG. 95 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 96]

FIG. 96 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 97]

FIG. 97 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 98]

FIG. 98 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 99]

FIG. 99 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 100]

FIG. 100 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 101]

FIG. 101 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 102]

FIG. 102 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 103]

FIG. 103 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 104]

FIG. 104 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 105]

FIG. 105 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 106]

FIG. 106 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 107]

FIG. 107 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 108]

FIG. 108 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 109]

FIG. 109 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 110]

FIG. 110 is a diagram illustrating an example of a user interface in Embodiment 3.

[FIG. 111]

FIG. 111 is a diagram illustrating an example of application to ITS in Embodiment 4.

[FIG. 112]

FIG. 112 is a diagram illustrating an example of application to ITS in Embodiment 4.

[FIG. 113]

FIG. 113 is a diagram illustrating an example of application to a position information reporting system and a facility system in Embodiment 4.

[FIG. 114]

FIG. 114 is a diagram illustrating an example of application to a supermarket system in Embodiment 4.

[FIG. 115]

FIG. 115 is a diagram illustrating an example of application to communication between a mobile phone terminal and a camera in Embodiment 4.

[FIG. 116]

FIG. 116 is a diagram illustrating an example of application to underwater communication in Embodiment 4.

[FIG. 117]

FIG. 117 is a diagram for describing an example of service provision to a user in Embodiment 5.

[FIG. 118]

FIG. 118 is a diagram for describing an example of service provision to a user in Embodiment 5.

[FIG. 119]

FIG. 119 is a flowchart illustrating the case where a receiver simultaneously processes a plurality of signals received from transmitters in Embodiment 5.

[FIG. 120]

FIG. 120 is a diagram illustrating an example of the case of realizing inter-device communication by two-way communication in Embodiment 5.

[FIG. 121]

FIG. 121 is a diagram for describing a service using directivity characteristics in Embodiment 5.

[FIG. 122]

FIG. 122 is a diagram for describing another example of service provision to a user in Embodiment 5.

[FIG. 123]

FIG. 123 is a diagram illustrating a format example of a signal included in a light source emitted from a transmitter in Embodiment 5.

[FIG. 124]

FIG. 124 is a diagram illustrating an example of an environment in a house in Embodiment 6.

[FIG. 125]

FIG. 125 is a diagram illustrating an example of communication between a smartphone and home electric appliances according to Embodiment 6.

[FIG. 126]

FIG. 126 is a diagram illustrating an example of a

configuration of a transmitter device according to Embodiment 6.

[FIG. 127]

FIG. 127 is a diagram illustrating an example of a configuration of a receiver device according to Embodiment 6.

[FIG. 128]

FIG. 128 is a diagram illustrating a flow of processing of transmitting information to the receiver device by blinking an LED of the transmitter device according to Embodiment 6.

[FIG. 129]

FIG. 129 is a diagram illustrating a flow of processing of transmitting information to the receiver device by blinking an LED of the transmitter device according to Embodiment 6.

[FIG. 130]

FIG. 130 is a diagram illustrating a flow of processing of transmitting information to the receiver device by blinking an LED of the transmitter device according to Embodiment 6.

[FIG. 131]

FIG. 131 is a diagram illustrating a flow of processing of transmitting information to the receiver device by blinking an LED of the transmitter device according to Embodiment 6.

[FIG. 132]

FIG. 132 is a diagram illustrating a flow of processing of transmitting information to the receiver device by blinking an LED of the transmitter device according to Embodiment 6.

[FIG. 133]

FIG. 133 is a diagram for describing a procedure of performing communication between a user and a device using visible light according to Embodiment 7.

[FIG. 134]

FIG. 134 is a diagram for describing a procedure of performing communication between the user and the device using visible light according to Embodiment 7.

[FIG. 135]

FIG. 135 is a diagram for describing a procedure from when a user purchases a device until when the user makes initial settings of

the device according to Embodiment 7.

[FIG. 136]

FIG. 136 is a diagram for describing service exclusively performed by a serviceman when a device fails according to Embodiment 7.

[FIG. 137]

FIG. 137 is a diagram for describing service for checking a cleaning state using a cleaner and visible light communication according to Embodiment 7.

[FIG. 138]

FIG. 138 is a schematic diagram of home delivery service support using optical communication according to Embodiment 8.

[FIG. 139]

FIG. 139 is a flowchart for describing home delivery service support using optical communication according to Embodiment 8.

[FIG. 140]

FIG. 140 is a flowchart for describing home delivery service support using optical communication according to Embodiment 8.

[FIG. 141]

FIG. 141 is a flowchart for describing home delivery service support using optical communication according to Embodiment 8.

[FIG. 142]

FIG. 142 is a flowchart for describing home delivery service support using optical communication according to Embodiment 8.

[FIG. 143]

FIG. 143 is a flowchart for describing home delivery service support using optical communication according to Embodiment 8.

[FIG. 144]

FIG. 144 is a flowchart for describing home delivery service support using optical communication according to Embodiment 8.

[FIG. 145]

FIG. 145 is a diagram for describing processing of registering a user and a mobile phone in use to a server according to Embodiment 9.

[FIG. 146]

FIG. 146 is a diagram for describing processing of analyzing user voice characteristics according to Embodiment 9.

[FIG. 147]

FIG. 147 is a diagram for describing processing of preparing sound recognition processing according to Embodiment 9.

[FIG. 148]

FIG. 148 is a diagram for describing processing of collecting sound by a sound collecting device in the vicinity according to Embodiment 9.

[FIG. 149]

FIG. 149 is a diagram for describing processing of analyzing environmental sound characteristics according to Embodiment 9.

[FIG. 150]

FIG. 150 is a diagram for describing processing of canceling sound from a sound output device which is present in the vicinity according to Embodiment 9.

[FIG. 151]

FIG. 151 is a diagram for describing processing of selecting what to cook and setting detailed operation of a microwave according to Embodiment 9.

[FIG. 152]

FIG. 152 is a diagram for describing processing of obtaining notification sound for the microwave from a DB of a server, for instance, and setting the sound in the microwave according to Embodiment 9.

[FIG. 153]

FIG. 153 is a diagram for describing processing of adjusting notification sound of the microwave according to Embodiment 9.

[FIG. 154]

FIG. 154 is a diagram illustrating examples of waveforms of notification sounds set in the microwave according to Embodiment 9.

[FIG. 155]

FIG. 155 is a diagram for describing processing of displaying details of cooking according to Embodiment 9.

[FIG. 156]

FIG. 156 is a diagram for describing processing of recognizing notification sound of the microwave according to Embodiment 9.

[FIG. 157]

FIG. 157 is a diagram for describing processing of collecting sound by a sound collecting device in the vicinity and recognizing notification sound of the microwave according to Embodiment 9.

[FIG. 158]

FIG. 158 is a diagram for describing processing of notifying a user of the end of operation of the microwave according to Embodiment 9.

[FIG. 159]

FIG. 159 is a diagram for describing processing of checking an operation state of a mobile phone according to Embodiment 9.

[FIG. 160]

FIG. 160 is a diagram for describing processing of tracking a user position according to Embodiment 9.

[FIG. 161]

FIG. 161 is a diagram illustrating that while canceling sound from a sound output device, notification sound of a home electric appliance is recognized, an electronic device which can communicate is caused to recognize a current position of a user (operator), and based on the recognition result of the user position, a device located near the user position is caused to give a notification to the user.

[FIG. 162]

FIG. 162 is a diagram illustrating content of a database held in the server, the mobile phone, or the microwave according to Embodiment 9.

[FIG. 163]

FIG. 163 is a diagram illustrating that a user cooks based on cooking processes displayed on a mobile phone, and further operates the display content of the mobile phone by saying "next", "return", and others, according to Embodiment 9.

[FIG. 164]

FIG. 164 is a diagram illustrating that the user has moved to another place while he/she is waiting until the operation of the

microwave ends after starting the operation or while he/she is stewing food according to Embodiment 9.

[FIG. 165]

FIG. 165 is a diagram illustrating that a mobile phone transmits an instruction to detect a user to a device which is connected to the mobile phone via a network, and can recognize a position of the user and the presence of the user, such as a camera, a microphone, or a human sensing sensor.

[FIG. 166]

FIG. 166 is a diagram illustrating that a user face is recognized using a camera included in a television, and further the movement and presence of the user are recognized using a human sensing sensor of an air-conditioner, as an example of user detection according to Embodiment 9.

[FIG. 167]

FIG. 167 is a diagram illustrating that devices which have detected the user transmit to the mobile phone the detection of the user and a relative position of the user to the devices which have detected the user.

[FIG. 168]

FIG. 168 is a diagram illustrating that the mobile phone recognizes microwave operation end sound according to Embodiment 9.

[FIG. 169]

FIG. 169 is a diagram illustrating that the mobile phone which has recognized the end of the operation of the microwave transmits an instruction to, among the devices which have detected the user, a device having a screen-display function and a sound output function to notify the user of the end of the microwave operation.

[FIG. 170]

FIG. 170 is a diagram illustrating that the device which has received an instruction notifies the user of the details of the notification.

[FIG. 171]

FIG. 171 is a diagram illustrating that a device which is

present near the microwave, is connected to the mobile phone via a network, and includes a microphone recognizes the microwave operation end sound.

[FIG. 172]

FIG. 172 is a diagram illustrating that the device which has recognized the end of operation of the microwave notifies the mobile phone thereof.

[FIG. 173]

FIG. 173 is a diagram illustrating that if the mobile phone is near the user when the mobile phone receives the notification indicating the end of the operation of the microwave, the user is notified of the end of the operation of the microwave, using screen display, sound output, and the like by the mobile phone.

[FIG. 174]

FIG. 174 is a diagram illustrating that the user is notified of the end of the operation of the microwave.

[FIG. 175]

FIG. 175 is a diagram illustrating that the user who has received the notification indicating the end of the operation of the microwave moves to a kitchen.

[FIG. 176]

FIG. 176 is a diagram illustrating that the microwave transmits information such as the end of operation to the mobile phone by wireless communication, the mobile phone gives a notification instruction to the television which the user is watching, and the user is notified by a screen display and sound of the television.

[FIG. 177]

FIG. 177 is a diagram illustrating that the microwave transmits information such as the end of operation to the television which the user is watching by wireless communication, and the user is notified thereof using the screen display and sound of the television.

[FIG. 178]

FIG. 178 is a diagram illustrating that the user is notified by the screen display and sound of the television.

[FIG. 179]

FIG. 179 is a diagram illustrating that a user who is at a remote place is notified of information.

[FIG. 180]

FIG. 180 is a diagram illustrating that if the microwave cannot directly communicate with the mobile phone serving as a hub, the microwave transmits information to the mobile phone via a personal computer, for instance.

[FIG. 181]

FIG. 181 is a diagram illustrating that the mobile phone which has received communication in FIG. 180 transmits information such as an operation instruction to the microwave, following the information-and-communication path in an opposite direction.

[FIG. 182]

FIG. 182 is a diagram illustrating that in the case where the air-conditioner which is an information source device cannot directly communicate with the mobile phone serving as a hub, the air-conditioner notifies the user of information.

[FIG. 183]

FIG. 183 is a diagram for describing a system utilizing a communication device which uses a 700 to 900 MHz radio wave.

[FIG. 184]

FIG. 184 is a diagram illustrating that a mobile phone at a remote place notifies a user of information.

[FIG. 185]

FIG. 185 is a diagram illustrating that the mobile phone at a remote place notifies the user of information.

[FIG. 186]

FIG. 186 is a diagram illustrating that in a similar case to that of FIG. 185, a television on the second floor serves as a relay device instead of a device which relays communication between a notification recognition device and an information notification device.

[FIG. 187]

FIG. 187 is a diagram illustrating an example of an environment in a house in Embodiment 10.

[FIG. 188]

FIG. 188 is a diagram illustrating an example of communication between a smartphone and home electric appliances according to Embodiment 10.

[FIG. 189]

FIG. 189 is a diagram illustrating a configuration of a transmitter device according to Embodiment 10.

[FIG. 190]

FIG. 190 is a diagram illustrating a configuration of a receiver device according to Embodiment 10.

[FIG. 191]

FIG. 191 is a sequence diagram for when a transmitter terminal (TV) performs wireless LAN authentication with a receiver terminal (tablet terminal), using optical communication in FIG. 187.

[FIG. 192]

FIG. 192 is a sequence diagram for when authentication is performed using an application according to Embodiment 10.

[FIG. 193]

FIG. 193 is a flowchart illustrating operation of the transmitter terminal according to Embodiment 10.

[FIG. 194]

FIG. 194 is a flowchart illustrating operation of the receiver terminal according to Embodiment 10.

[FIG. 195]

FIG. 195 is a sequence diagram in which a mobile AV terminal 1 transmits data to a mobile AV terminal 2 according to Embodiment 11.

[FIG. 196]

FIG. 196 is a diagram illustrating a screen changed when the mobile AV terminal 1 transmits data to the mobile AV terminal 2 according to Embodiment 11.

[FIG. 197]

FIG. 197 is a diagram illustrating a screen changed when the mobile AV terminal 1 transmits data to the mobile AV terminal 2 according to Embodiment 11.

[FIG. 198]

FIG. 198 is a system outline diagram for when the mobile AV terminal 1 is a digital camera according to Embodiment 11.

[FIG. 199]

FIG. 199 is a system outline diagram for when the mobile AV terminal 1 is a digital camera according to Embodiment 11.

[FIG. 200]

FIG. 200 is a system outline diagram for when the mobile AV terminal 1 is a digital camera according to Embodiment 11.

[FIG. 201]

FIG. 201 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 202]

FIG. 202 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 203]

FIG. 203 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 204]

FIG. 204 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 205]

FIG. 205 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 206]

FIG. 206 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 207]

FIG. 207 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 208]

FIG. 208 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 209]

FIG. 209 is a flowchart illustrating an example of processing

operation of a receiver and a transmitter in Embodiment 12.

[FIG. 210]

FIG. 210 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 211]

FIG. 211 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 212]

FIG. 212 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 213]

FIG. 213 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 214]

FIG. 214 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 215]

FIG. 215 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 216]

FIG. 216 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 217]

FIG. 217 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 218]

FIG. 218 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 219]

FIG. 219 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 220]

FIG. 220 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 221]

FIG. 221 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 222]

FIG. 222 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 223]

FIG. 223 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 224]

FIG. 224 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 225]

FIG. 225 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 226]

FIG. 226 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 227]

FIG. 227 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 228]

FIG. 228 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 229]

FIG. 229 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 230]

FIG. 230 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 231]

FIG. 231 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 232]

FIG. 232 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 233]

FIG. 233 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 234]

FIG. 234 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 235]

FIG. 235 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 236]

FIG. 236 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 237]

FIG. 237 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 238]

FIG. 238 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 239]

FIG. 239 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 240]

FIG. 240 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 241]

FIG. 241 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 242]

FIG. 242 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 243]

FIG. 243 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 244]

FIG. 244 is a diagram illustrating an example of application of

a receiver and a transmitter in Embodiment 12.

[FIG. 245]

FIG. 245 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 246]

FIG. 246 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 247]

FIG. 247 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 248]

FIG. 248 is a diagram illustrating a luminance change of a transmitter in Embodiment 12.

[FIG. 249]

FIG. 249 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 250]

FIG. 250 is a diagram illustrating a luminance change of a transmitter in Embodiment 12.

[FIG. 251]

FIG. 251 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 252]

FIG. 252 is a diagram illustrating a luminance change of a transmitter in Embodiment 12.

[FIG. 253]

FIG. 253 is a flowchart illustrating an example of processing operation of a transmitter in Embodiment 12.

[FIG. 254]

FIG. 254 is a diagram illustrating a luminance change of a transmitter in Embodiment 12.

[FIG. 255]

FIG. 255 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 256]

FIG. 256 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 257]

FIG. 257 is a flowchart illustrating an example of processing operation of a transmitter in Embodiment 12.

[FIG. 258]

FIG. 258 is a diagram illustrating an example of a structure of a transmitter in Embodiment 12.

[FIG. 259]

FIG. 259 is a diagram illustrating an example of a structure of a transmitter in Embodiment 12.

[FIG. 260]

FIG. 260 is a diagram illustrating an example of a structure of a transmitter in Embodiment 12.

[FIG. 261]

FIG. 261 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 262]

FIG. 262 is a diagram illustrating an example of display and imaging by a receiver and a transmitter in Embodiment 12.

[FIG. 263]

FIG. 263 is a flowchart illustrating an example of processing operation of a transmitter in Embodiment 12.

[FIG. 264]

FIG. 264 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 265]

FIG. 265 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 266]

FIG. 266 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 267]

FIG. 267 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 268]

FIG. 268 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 269]

FIG. 269 is a diagram illustrating a state of a receiver in Embodiment 12.

[FIG. 270]

FIG. 270 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 271]

FIG. 271 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 272]

FIG. 272 is a diagram illustrating an example of a wavelength of a transmitter in Embodiment 12.

[FIG. 273]

FIG. 273 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 274]

FIG. 274 is a diagram illustrating an example of a structure of a system including a receiver and a transmitter in Embodiment 12.

[FIG. 275]

FIG. 275 is a flowchart illustrating an example of processing operation of a system in Embodiment 12.

[FIG. 276]

FIG. 276 is a diagram illustrating an example of a structure of a system including a receiver and a transmitter in Embodiment 12.

[FIG. 277]

FIG. 277 is a flowchart illustrating an example of processing operation of a system in Embodiment 12.

[FIG. 278]

FIG. 278 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 279]

FIG. 279 is a flowchart illustrating an example of processing

operation of a receiver in Embodiment 12.

[FIG. 280]

FIG. 280 is a diagram illustrating an example of a structure of a system including a receiver and a transmitter in Embodiment 12.

[FIG. 281]

FIG. 281 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 282]

FIG. 282 is a diagram illustrating an example of application of a receiver and a transmitter in Embodiment 12.

[FIG. 283]

FIG. 283 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 284]

FIG. 284 is a diagram illustrating an example of a structure of a system including a receiver and a transmitter in Embodiment 12.

[FIG. 285]

FIG. 285 is a flowchart illustrating an example of processing operation of a system in Embodiment 12.

[FIG. 286]

FIG. 286 is a flowchart illustrating an example of processing operation of a receiver in Embodiment 12.

[FIG. 287A]

FIG. 287A is a diagram illustrating an example of a structure of a transmitter in Embodiment 12.

[FIG. 287B]

FIG. 287B is a diagram illustrating another example of a structure of a transmitter in Embodiment 12.

[FIG. 288]

FIG. 288 is a flowchart illustrating an example of processing operation of a receiver and a transmitter in Embodiment 12.

[FIG. 289]

FIG. 289 is a flowchart illustrating an example of processing operation relating to a receiver and a transmitter in Embodiment 13.

[FIG. 290]

FIG. 290 is a flowchart illustrating an example of processing operation relating to a receiver and a transmitter in Embodiment 13.

[FIG. 291]

FIG. 291 is a flowchart illustrating an example of processing operation relating to a receiver and a transmitter in Embodiment 13.

[FIG. 292]

FIG. 292 is a flowchart illustrating an example of processing operation relating to a receiver and a transmitter in Embodiment 13.

[FIG. 293]

FIG. 293 is a flowchart illustrating an example of processing operation relating to a receiver and a transmitter in Embodiment 13.

[FIG. 294]

FIG. 294 is a diagram illustrating an example of application of a transmitter in Embodiment 13.

[FIG. 295]

FIG. 295 is a diagram illustrating an example of application of a transmitter in Embodiment 13.

[FIG. 296]

FIG. 296 is a diagram illustrating an example of application of a transmitter in Embodiment 13.

[FIG. 297]

FIG. 297 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 13.

[FIG. 298]

FIG. 298 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 13.

[FIG. 299]

FIG. 299 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 13.

[FIG. 300]

FIG. 300 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 13.

[FIG. 301A]

FIG. 301A is a diagram illustrating an example of a transmission signal in Embodiment 13.

[FIG. 301B]

FIG. 301B is a diagram illustrating another example of a transmission signal in Embodiment 13.

[FIG. 302]

FIG. 302 is a diagram illustrating an example of a transmission signal in Embodiment 13.

[FIG. 303A]

FIG. 303A is a diagram illustrating an example of a transmission signal in Embodiment 13.

[FIG. 303B]

FIG. 303B is a diagram illustrating another example of a transmission signal in Embodiment 13.

[FIG. 304]

FIG. 304 is a diagram illustrating an example of a transmission signal in Embodiment 13.

[FIG. 305A]

FIG. 305A is a diagram illustrating an example of a transmission signal in Embodiment 13.

[FIG. 305B]

FIG. 305B is a diagram illustrating an example of a transmission signal in Embodiment 13.

[FIG. 306]

FIG. 306 is a diagram illustrating an example of application of a transmitter in Embodiment 13.

[FIG. 307]

FIG. 307 is a diagram illustrating an example of application of a transmitter in Embodiment 13.

[FIG. 308]

FIG. 308 is a diagram for describing an imaging element in Embodiment 13.

[FIG. 309]

FIG. 309 is a diagram for describing an imaging element in Embodiment 13.

[FIG. 310]

FIG. 310 is a diagram for describing an imaging element in

Embodiment 13.

[FIG. 311A]

FIG. 311A is a flowchart illustrating processing operation of a reception device (imaging device) in a variation of each embodiment.

[FIG. 311B]

FIG. 311B is a diagram illustrating a normal imaging mode and a macro imaging mode in a variation of each embodiment in comparison.

[FIG. 312]

FIG. 312 is a diagram illustrating a display device for displaying video and the like in a variation of each embodiment.

[FIG. 313]

FIG. 313 is a diagram illustrating an example of processing operation of a display device in a variation of each embodiment.

[FIG. 314]

FIG. 314 is a diagram illustrating an example of a part transmitting a signal in a display device in a variation of each embodiment.

[FIG. 315]

FIG. 315 is a diagram illustrating another example of processing operation of a display device in a variation of each embodiment.

[FIG. 316]

FIG. 316 is a diagram illustrating another example of a part transmitting a signal in a display device in a variation of each embodiment.

[FIG. 317]

FIG. 317 is a diagram illustrating yet another example of processing operation of a display device in a variation of each embodiment.

[FIG. 318]

FIG. 318 is a diagram illustrating a structure of a communication system including a transmitter and a receiver in a variation of each embodiment.

[FIG. 319]

FIG. 319 is a flowchart illustrating processing operation of a communication system in a variation of each embodiment.

[FIG. 320]

FIG. 320 is a diagram illustrating an example of signal transmission in a variation of each embodiment.

[FIG. 321]

FIG. 321 is a diagram illustrating an example of signal transmission in a variation of each embodiment.

[FIG. 322]

FIG. 322 is a diagram illustrating an example of signal transmission in a variation of each embodiment.

[FIG. 323A]

FIG. 323A is a diagram illustrating an example of signal transmission in a variation of each embodiment.

[FIG. 323B]

FIG. 323B is a diagram illustrating an example of signal transmission in a variation of each embodiment.

[FIG. 323C]

FIG. 323C is a diagram illustrating an example of signal transmission in a variation of each embodiment.

[FIG. 323D]

FIG. 323D is a flowchart illustrating processing operation of a communication system including a receiver and a display or a projector in a variation of each embodiment.

[FIG. 324]

FIG. 324 is a diagram illustrating an example of a transmission signal in a variation of each embodiment.

[FIG. 325]

FIG. 325 is a diagram illustrating an example of a transmission signal in a variation of each embodiment.

[FIG. 326]

FIG. 326 is a diagram illustrating an example of a transmission signal in a variation of each embodiment.

[FIG. 327A]

FIG. 327A is a diagram illustrating an example of an imaging

element of a receiver in a variation of each embodiment.

[FIG. 327B]

FIG. 327B is a diagram illustrating an example of a structure of an internal circuit of an imaging device of a receiver in a variation of each embodiment.

[FIG. 327C]

FIG. 327C is a diagram illustrating an example of a transmission signal in a variation of each embodiment.

[FIG. 327D]

FIG. 327D is a diagram illustrating an example of a transmission signal in a variation of each embodiment.

[FIG. 328A]

FIG. 328A is a diagram for describing an imaging mode of a receiver in a variation of each embodiment.

[FIG. 328B]

FIG. 328B is a flowchart illustrating processing operation of a receiver using a special imaging mode A in a variation of each embodiment.

[FIG. 329A]

FIG. 329A is a diagram for describing another imaging mode of a receiver in a variation of each embodiment.

[FIG. 329B]

FIG. 329B is a flowchart illustrating processing operation of a receiver using a special imaging mode B in a variation of each embodiment.

[FIG. 330A]

FIG. 330A is a diagram for describing yet another imaging mode of a receiver in a variation of each embodiment.

[FIG. 330B]

FIG. 330B is a flowchart illustrating processing operation of a receiver using a special imaging mode C in a variation of each embodiment.

[FIG. 331A]

FIG. 331A is a flowchart of an information communication method according to an aspect of the present invention.

[FIG. 331B]

FIG. 331B is a block diagram of an information communication device according to an aspect of the present invention.

[FIG. 331C]

FIG. 331C is a flowchart of an information communication method according to an aspect of the present invention.

[FIG. 331D]

FIG. 331D is a block diagram of an information communication device according to an aspect of the present invention.

[FIG. 332]

FIG. 332 is a diagram illustrating an example of an image obtained by an information communication method according to an aspect of the present invention.

[FIG. 333A]

FIG. 333A is a flowchart of an information communication method according to another aspect of the present invention.

[FIG. 333B]

FIG. 333B is a block diagram of an information communication device according to another aspect of the present invention.

[FIG. 334A]

FIG. 334A is a flowchart of an information communication method according to yet another aspect of the present invention.

[FIG. 334B]

FIG. 334B is a block diagram of an information communication device according to yet another aspect of the present invention.

[FIG. 335]

FIG. 335 is a diagram illustrating an example of each mode of a receiver in Embodiment 14.

[FIG. 336]

FIG. 336 is a diagram illustrating an example of imaging operation of a receiver in Embodiment 14.

[FIG. 337]

FIG. 337 is a diagram illustrating another example of imaging operation of a receiver in Embodiment 14.

[FIG. 338A]

FIG. 338A is a diagram illustrating another example of imaging operation of a receiver in Embodiment 14.

[FIG. 338B]

FIG. 338B is a diagram illustrating another example of imaging operation of a receiver in Embodiment 14.

[FIG. 338C]

FIG. 338C is a diagram illustrating another example of imaging operation of a receiver in Embodiment 14.

[FIG. 339A]

FIG. 339A is a diagram illustrating an example of camera arrangement of a receiver in Embodiment 14.

[FIG. 339B]

FIG. 339B is a diagram illustrating another example of camera arrangement of a receiver in Embodiment 14.

[FIG. 340]

FIG. 340 is a diagram illustrating an example of display operation of a receiver in Embodiment 14.

[FIG. 341]

FIG. 341 is a diagram illustrating an example of display operation of a receiver in Embodiment 14.

[FIG. 342]

FIG. 342 is a diagram illustrating an example of operation of a receiver in Embodiment 14.

[FIG. 343]

FIG. 343 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 344]

FIG. 344 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 345]

FIG. 345 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 346]

FIG. 346 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 347]

FIG. 347 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 348]

FIG. 348 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 349]

FIG. 349 is a diagram illustrating an example of operation of a receiver, a transmitter, and a server in Embodiment 14.

[FIG. 350]

FIG. 350 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 351]

FIG. 351 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 352]

FIG. 352 is a diagram illustrating an example of initial setting of a receiver in Embodiment 14.

[FIG. 353]

FIG. 353 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 354]

FIG. 354 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 355]

FIG. 355 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 356]

FIG. 356 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 357]

FIG. 357 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 358]

FIG. 358 is a diagram illustrating another example of

operation of a receiver in Embodiment 14.

[FIG. 359A]

FIG. 359A is a diagram illustrating a pen used to operate a receiver in Embodiment 14.

[FIG. 359B]

FIG. 359B is a diagram illustrating operation of a receiver using a pen in Embodiment 14.

[FIG. 360]

FIG. 360 is a diagram illustrating an example of appearance of a receiver in Embodiment 14.

[FIG. 361]

FIG. 361 is a diagram illustrating another example of appearance of a receiver in Embodiment 14.

[FIG. 362]

FIG. 362 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 363A]

FIG. 363A is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 363B]

FIG. 363B is a diagram illustrating an example of application using a receiver in Embodiment 14.

[FIG. 364A]

FIG. 364A is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 364B]

FIG. 364B is a diagram illustrating an example of application using a receiver in Embodiment 14.

[FIG. 365A]

FIG. 365A is a diagram illustrating an example of operation of a transmitter in Embodiment 14.

[FIG. 365B]

FIG. 365B is a diagram illustrating another example of operation of a transmitter in Embodiment 14.

[FIG. 366]

FIG. 366 is a diagram illustrating another example of operation of a transmitter in Embodiment 14.

[FIG. 367]

FIG. 367 is a diagram illustrating another example of operation of a transmitter in Embodiment 14.

[FIG. 368]

FIG. 368 is a diagram illustrating an example of communication form between a plurality of transmitters and a receiver in Embodiment 14.

[FIG. 369]

FIG. 369 is a diagram illustrating an example of operation of a plurality of transmitters in Embodiment 14.

[FIG. 370]

FIG. 370 is a diagram illustrating another example of communication form between a plurality of transmitters and a receiver in Embodiment 14.

[FIG. 371]

FIG. 371 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 372]

FIG. 372 is a diagram illustrating an example of application of a receiver in Embodiment 14.

[FIG. 373]

FIG. 373 is a diagram illustrating an example of application of a receiver in Embodiment 14.

[FIG. 374]

FIG. 374 is a diagram illustrating an example of application of a receiver in Embodiment 14.

[FIG. 375]

FIG. 375 is a diagram illustrating an example of application of a transmitter in Embodiment 14.

[FIG. 376]

FIG. 376 is a diagram illustrating an example of application of a transmitter in Embodiment 14.

[FIG. 377]

FIG. 377 is a diagram illustrating an example of application of a reception method in Embodiment 14.

[FIG. 378]

FIG. 378 is a diagram illustrating an example of application of a transmitter in Embodiment 14.

[FIG. 379]

FIG. 379 is a diagram illustrating an example of application of a transmitter in Embodiment 14.

[FIG. 380]

FIG. 380 is a diagram illustrating an example of application of a transmitter in Embodiment 14.

[FIG. 381]

FIG. 381 is a diagram illustrating another example of operation of a receiver in Embodiment 14.

[FIG. 382]

FIG. 382 is a flowchart illustrating an example of operation of a receiver in Embodiment 15.

[FIG. 383]

FIG. 383 is a flowchart illustrating another example of operation of a receiver in Embodiment 15.

[FIG. 384A]

FIG. 384A is a block diagram illustrating an example of a transmitter in Embodiment 15.

[FIG. 384B]

FIG. 384B is a block diagram illustrating another example of a transmitter in Embodiment 15.

[FIG. 385]

FIG. 385 is a diagram illustrating an example of a structure of a system including a plurality of transmitters in Embodiment 15.

[FIG. 386]

FIG. 386 is a block diagram illustrating another example of a transmitter in Embodiment 15.

[FIG. 387A]

FIG. 387A is a diagram illustrating an example of a transmitter in Embodiment 15.

[FIG. 387B]

FIG. 387B is a diagram illustrating an example of a transmitter in Embodiment 15.

[FIG. 387C]

FIG. 387C is a diagram illustrating an example of a transmitter in Embodiment 15.

[FIG. 388A]

FIG. 388A is a diagram illustrating an example of a transmitter in Embodiment 15.

[FIG. 388B]

FIG. 388B is a diagram illustrating an example of a transmitter in Embodiment 15.

[FIG. 389]

FIG. 389 is a diagram illustrating an example of processing operation of a receiver, a transmitter, and a server in Embodiment 15.

[FIG. 390]

FIG. 390 is a diagram illustrating an example of processing operation of a receiver, a transmitter, and a server in Embodiment 15.

[FIG. 391]

FIG. 391 is a diagram illustrating an example of processing operation of a receiver, a transmitter, and a server in Embodiment 15.

[FIG. 392A]

FIG. 392A is a diagram for describing synchronization between a plurality of transmitters in Embodiment 15.

[FIG. 392B]

FIG. 392B is a diagram for describing synchronization between a plurality of transmitters in Embodiment 15.

[FIG. 393]

FIG. 393 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 394]

FIG. 394 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 395]

FIG. 395 is a diagram illustrating an example of operation of a transmitter, a receiver, and a server in Embodiment 15.

[FIG. 396]

FIG. 396 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 397]

FIG. 397 is a diagram illustrating an example of appearance of a receiver in Embodiment 15.

[FIG. 398]

FIG. 398 is a diagram illustrating an example of operation of a transmitter, a receiver, and a server in Embodiment 15.

[FIG. 399]

FIG. 399 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 400]

FIG. 400 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 401]

FIG. 401 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 402]

FIG. 402 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[FIG. 403A]

FIG. 403A is a diagram illustrating an example of a structure of information transmitted by a transmitter in Embodiment 15.

[FIG. 403B]

FIG. 403B is a diagram illustrating another example of a structure of information transmitted by a transmitter in Embodiment 15.

[FIG. 404]

FIG. 404 is a diagram illustrating an example of a 4-value PPM modulation scheme by a transmitter in Embodiment 15.

[FIG. 405]

FIG. 405 is a diagram illustrating an example of a PPM modulation scheme by a transmitter in Embodiment 15.

[FIG. 406]

FIG. 406 is a diagram illustrating an example of a PPM modulation scheme by a transmitter in Embodiment 15.

[FIG. 407A]

FIG. 407A is a diagram illustrating an example of a luminance change pattern corresponding to a header (preamble unit) in Embodiment 15.

[FIG. 407B]

FIG. 407B is a diagram illustrating an example of a luminance change pattern in Embodiment 15.

[FIG. 408A]

FIG. 408A is a diagram illustrating an example of a luminance change pattern in Embodiment 15.

[FIG. 408B]

FIG. 408B is a diagram illustrating an example of a luminance change pattern in Embodiment 15.

[FIG. 409]

FIG. 409 is a diagram illustrating an example of operation of a receiver in an in-front-of-store situation in Embodiment 16.

[FIG. 410]

FIG. 410 is a diagram illustrating another example of operation of a receiver in an in-front-of-store situation in Embodiment 16.

[FIG. 411]

FIG. 411 is a diagram illustrating an example of next operation of a receiver in an in-front-of-store situation in Embodiment 16.

[FIG. 412]

FIG. 412 is a diagram illustrating an example of next operation of a receiver in an in-front-of-store situation in Embodiment 16.

[FIG. 413]

FIG. 413 is a diagram illustrating an example of next operation of a receiver in an in-front-of-store situation in Embodiment 16.

[FIG. 414]

FIG. 414 is a diagram illustrating an example of operation of a display device in an in-store situation in Embodiment 16.

[FIG. 415]

FIG. 415 is a diagram illustrating an example of next operation of a display device in an in-store situation in Embodiment 16.

[FIG. 416]

FIG. 416 is a diagram illustrating an example of next operation of a display device in an in-store situation in Embodiment 16.

[FIG. 417]

FIG. 417 is a diagram illustrating an example of next operation of a receiver in an in-store situation in Embodiment 16.

[FIG. 418]

FIG. 418 is a diagram illustrating an example of next operation of a receiver in an in-store situation in Embodiment 16.

[FIG. 419]

FIG. 419 is a diagram illustrating an example of next operation of a receiver in an in-store situation in Embodiment 16.

[FIG. 420]

FIG. 420 is a diagram illustrating an example of next operation of a receiver in an in-store situation in Embodiment 16.

[FIG. 421]

FIG. 421 is a diagram illustrating an example of next operation of a receiver in an in-store situation in Embodiment 16.

[FIG. 422]

FIG. 422 is a diagram illustrating an example of next operation of a receiver in an in-store situation in Embodiment 16.

[FIG. 423]

FIG. 423 is a diagram illustrating an example of operation of a receiver in a store search situation in Embodiment 16.

[FIG. 424]

FIG. 424 is a diagram illustrating an example of next operation of a receiver in a store search situation in Embodiment 16.

[FIG. 425]

FIG. 425 is a diagram illustrating an example of next operation of a receiver in a store search situation in Embodiment 16.

[FIG. 426]

FIG. 426 is a diagram illustrating an example of operation of a receiver in a movie advertisement situation in Embodiment 16.

[FIG. 427]

FIG. 427 is a diagram illustrating an example of next operation of a receiver in a movie advertisement situation in Embodiment 16.

[FIG. 428]

FIG. 428 is a diagram illustrating an example of next operation of a receiver in a movie advertisement situation in Embodiment 16.

[FIG. 429]

FIG. 429 is a diagram illustrating an example of next operation of a receiver in a movie advertisement situation in Embodiment 16.

[FIG. 430]

FIG. 430 is a diagram illustrating an example of operation of a receiver in a museum situation in Embodiment 16.

[FIG. 431]

FIG. 431 is a diagram illustrating an example of next operation of a receiver in a museum situation in Embodiment 16.

[FIG. 432]

FIG. 432 is a diagram illustrating an example of next operation of a receiver in a museum situation in Embodiment 16.

[FIG. 433]

FIG. 433 is a diagram illustrating an example of next operation of a receiver in a museum situation in Embodiment 16.

[FIG. 434]

FIG. 434 is a diagram illustrating an example of next operation of a receiver in a museum situation in Embodiment 16.

[FIG. 435]

FIG. 435 is a diagram illustrating an example of next operation of a receiver in a museum situation in Embodiment 16.

[FIG. 436]

FIG. 436 is a diagram illustrating an example of operation of a receiver in a bus stop situation in Embodiment 16.

[FIG. 437]

FIG. 437 is a diagram illustrating an example of next operation

of a receiver in a bus stop situation in Embodiment 16.

[FIG. 438]

FIG. 438 is a diagram for describing imaging in Embodiment 16.

[FIG. 439]

FIG. 439 is a diagram for describing transmission and imaging in Embodiment 16.

[FIG. 440]

FIG. 440 is a diagram for describing transmission in Embodiment 16.

[FIG. 441]

FIG. 441 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 442]

FIG. 442 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 443]

FIG. 443 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 444]

FIG. 444 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 445]

FIG. 445 is a diagram illustrating an example of operation of a receiver in Embodiment 17.

[FIG. 446]

FIG. 446 is a diagram illustrating an example of operation of a receiver in Embodiment 17.

[FIG. 447]

FIG. 447 is a diagram illustrating an example of operation of a system including a transmitter, a receiver, and a server in Embodiment 17.

[FIG. 448]

FIG. 448 is a block diagram illustrating a structure of a transmitter in Embodiment 17.

[FIG. 449]

FIG. 449 is a block diagram illustrating a structure of a receiver in Embodiment 17.

[FIG. 450]

FIG. 450 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 451]

FIG. 451 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 452]

FIG. 452 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 453]

FIG. 453 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 454]

FIG. 454 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 455]

FIG. 455 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 456]

FIG. 456 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[FIG. 457]

FIG. 457 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 458]

FIG. 458 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 459]

FIG. 459 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 460]

FIG. 460 is a diagram illustrating an example of operation of a

transmitter and a receiver in Embodiment 17.

[FIG. 461]

FIG. 461 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 462]

FIG. 462 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 463]

FIG. 463 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 464]

FIG. 464 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 465]

FIG. 465 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 466]

FIG. 466 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 467]

FIG. 467 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 468]

FIG. 468 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 469]

FIG. 469 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 470]

FIG. 470 is a diagram illustrating a coding scheme in Embodiment 17.

[FIG. 471]

FIG. 471 is a diagram illustrating a coding scheme that can receive light even in the case of capturing an image in an oblique direction in Embodiment 17.

[FIG. 472]

FIG. 472 is a diagram illustrating a coding scheme that differs in information amount depending on distance in Embodiment 17.

[FIG. 473]

FIG. 473 is a diagram illustrating a coding scheme that differs in information amount depending on distance in Embodiment 17.

[FIG. 474]

FIG. 474 is a diagram illustrating a coding scheme that divides data in Embodiment 17.

[FIG. 475]

FIG. 475 is a diagram illustrating an opposite-phase image insertion effect in Embodiment 17.

[FIG. 476]

FIG. 476 is a diagram illustrating an opposite-phase image insertion effect in Embodiment 17.

[FIG. 477]

FIG. 477 is a diagram illustrating a superresolution process in Embodiment 17.

[FIG. 478]

FIG. 478 is a diagram illustrating a display indicating visible light communication capability in Embodiment 17.

[FIG. 479]

FIG. 479 is a diagram illustrating information obtainment using a visible light communication signal in Embodiment 17.

[FIG. 480]

FIG. 480 is a diagram illustrating a data format in Embodiment 17.

[FIG. 481]

FIG. 481 is a diagram illustrating reception by estimating a stereoscopic shape in Embodiment 17.

[FIG. 482]

FIG. 482 is a diagram illustrating reception by estimating a stereoscopic shape in Embodiment 17.

[FIG. 483]

FIG. 483 is a diagram illustrating stereoscopic projection in

Embodiment 17.

[FIG. 484]

FIG. 484 is a diagram illustrating stereoscopic projection in Embodiment 17.

[FIG. 485]

FIG. 485 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 486]

FIG. 486 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[FIG. 487]

FIG. 487 is a diagram illustrating an example of a transmission signal in Embodiment 18.

[FIG. 488]

FIG. 488 is a diagram illustrating an example of a transmission signal in Embodiment 18.

[FIG. 489A]

FIG. 489A is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 489B]

FIG. 489B is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 489C]

FIG. 489C is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 490A]

FIG. 490A is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 490B]

FIG. 490B is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 491A]

FIG. 491A is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 491B]

FIG. 491B is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 491C]

FIG. 491C is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 492]

FIG. 492 is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[FIG. 493]

FIG. 493 is a diagram illustrating an example of a transmission signal in Embodiment 18.

[FIG. 494]

FIG. 494 is a diagram illustrating an example of operation of a receiver in Embodiment 18.

[FIG. 495]

FIG. 495 is a diagram illustrating an example of an instruction to a user displayed on a screen of a receiver in Embodiment 18.

[FIG. 496]

FIG. 496 is a diagram illustrating an example of an instruction to a user displayed on a screen of a receiver in Embodiment 18.

[FIG. 497]

FIG. 497 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[FIG. 498]

FIG. 498 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[FIG. 499]

FIG. 499 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[FIG. 500]

FIG. 500 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[FIG. 501]

FIG. 501 is a diagram for describing a use case in Embodiment 18.

[FIG. 502]

FIG. 502 is a diagram illustrating an information table transmitted from a smartphone to a server in Embodiment 18.

[FIG. 503]

FIG. 503 is a block diagram of a server in Embodiment 18.

[FIG. 504]

FIG. 504 is a flowchart illustrating an overall process of a system in Embodiment 18.

[FIG. 505]

FIG. 505 is a diagram illustrating an information table transmitted from a server to a smartphone in Embodiment 18.

[FIG. 506]

FIG. 506 is a diagram illustrating flow of screen displayed on a wearable device from when a user receives information from a server in front of a store to when the user actually buys a product in Embodiment 18.

[FIG. 507]

FIG. 507 is a diagram for describing another use case in Embodiment 18.

[FIG. 508]

FIG. 508 is a diagram illustrating a service provision system using the reception method described in any of the foregoing embodiments.

[FIG. 509]

FIG. 509 is a flowchart illustrating flow of service provision.

[FIG. 510]

FIG. 510 is a flowchart illustrating service provision in another example.

[FIG. 511]

FIG. 511 is a flowchart illustrating service provision in another example.

[FIG. 512A]

FIG. 512A is a diagram for describing a modulation scheme that facilitates reception in Embodiment 20.

[FIG. 512B]

FIG. 512B is a diagram for describing a modulation scheme that facilitates reception in Embodiment 20.

[FIG. 513]

FIG. 513 is a diagram for describing a modulation scheme that facilitates reception in Embodiment 20.

[FIG. 514]

FIG. 514 is a diagram for describing communication using bright lines and image recognition in Embodiment 20.

[FIG. 515A]

FIG. 515A is a diagram for describing an imaging element use method suitable for visible light signal reception in Embodiment 20.

[FIG. 515B]

FIG. 515B is a diagram for describing an imaging element use method suitable for visible light signal reception in Embodiment 20.

[FIG. 515C]

FIG. 515C is a diagram for describing an imaging element use method suitable for visible light signal reception in Embodiment 20.

[FIG. 515D]

FIG. 515D is a diagram for describing an imaging element use method suitable for visible light signal reception in Embodiment 20.

[FIG. 515E]

FIG. 515E is a flowchart for describing an imaging element use method suitable for visible light signal reception in Embodiment 20.

[FIG. 516]

FIG. 516 is a diagram illustrating a captured image size suitable for visible light signal reception in Embodiment 20.

[FIG. 517A]

FIG. 517A is a diagram illustrating a captured image size suitable for visible light signal reception in Embodiment 20.

[FIG. 517B]

FIG. 517B is a flowchart illustrating operation for switching to a captured image size suitable for visible light signal reception in Embodiment 20.

[FIG. 517C]

FIG. 517C is a flowchart illustrating operation for switching to

a captured image size suitable for visible light signal reception in Embodiment 20.

[FIG. 518]

FIG. 518 is a diagram for describing visible light signal reception using zoom in Embodiment 20.

[FIG. 519]

FIG. 519 is a diagram for describing an image data size reduction method suitable for visible light signal reception in Embodiment 20.

[FIG. 520]

FIG. 520 is a diagram for describing a modulation scheme with high reception error detection accuracy in Embodiment 20.

[FIG. 521]

FIG. 521 is a diagram for describing a change of operation of a receiver according to situation in Embodiment 20.

[FIG. 522]

FIG. 522 is a diagram for describing notification of visible light communication to humans in Embodiment 20.

[FIG. 523]

FIG. 523 is a diagram for describing expansion in reception range by a diffusion plate in Embodiment 20.

[FIG. 524]

FIG. 524 is a diagram for describing a method of synchronizing signal transmission from a plurality of projectors in Embodiment 20.

[FIG. 525]

FIG. 525 is a diagram for describing a method of synchronizing signal transmission from a plurality of displays in Embodiment 20.

[FIG. 526]

FIG. 526 is a diagram for describing visible light signal reception by an illuminance sensor and an image sensor in Embodiment 20.

[FIG. 527]

FIG. 527 is a diagram for describing a reception start trigger in Embodiment 20.

[FIG. 528]

FIG. 528 is a diagram for describing a reception start gesture in Embodiment 20.

[FIG. 529]

FIG. 529 is a diagram for describing an example of application to a car navigation system in Embodiment 20.

[FIG. 530]

FIG. 530 is a diagram for describing an example of application to a car navigation system in Embodiment 20.

[FIG. 531]

FIG. 531 is a diagram for describing an example of application to content protection in Embodiment 20.

[FIG. 532]

FIG. 532 is a diagram for describing an example of application to an electronic lock in Embodiment 20.

[FIG. 533]

FIG. 533 is a diagram for describing an example of application to store visit information transmission in Embodiment 20.

[FIG. 534]

FIG. 534 is a diagram for describing an example of application to location-dependent order control in Embodiment 20.

[FIG. 535]

FIG. 535 is a diagram for describing an example of application to route guidance in Embodiment 20.

[FIG. 536]

FIG. 536 is a diagram for describing an example of application to location notification in Embodiment 20.

[FIG. 537]

FIG. 537 is a diagram for describing an example of application to use log storage and analysis in Embodiment 20.

[FIG. 538]

FIG. 538 is a diagram for describing an example of application to screen sharing in Embodiment 20.

[FIG. 539]

FIG. 539 is a diagram for describing an example of application to screen sharing in Embodiment 20.

[FIG. 540]

FIG. 540 is a diagram for describing an example of application to position estimation using a wireless access point in Embodiment 20.

[FIG. 541]

FIG. 541 is a diagram illustrating a structure of performing position estimation by visible light communication and wireless communication in Embodiment 20.

[FIG. 542A]

FIG. 542A is a flowchart of an information communication method according to an aspect of the present invention.

[FIG. 542B]

FIG. 542B is a block diagram of an information communication device according to an aspect of the present invention.

[FIG. 543]

FIG. 543 is a diagram illustrating a watch including light sensors.

[FIG. 544]

FIG. 544 is a diagram illustrating an example of application of an information communication method according to an aspect of the present invention.

[FIG. 545]

FIG. 545 is a diagram illustrating an example of application of an information communication method according to an aspect of the present invention.

[FIG. 546]

FIG. 546 is a diagram illustrating an example of application of an information communication method according to an aspect of the present invention.

[FIG. 547]

FIG. 547 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[FIG. 548]

FIG. 548 is a diagram illustrating an example of application of a transmitter in Embodiment 21.

[FIG. 549A]

FIG. 549A is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[FIG. 549B]

FIG. 549B is a flowchart illustrating operation of a receiver in Embodiment 21.

[FIG. 550]

FIG. 550 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[FIG. 551]

FIG. 551 is a diagram illustrating an example of application of a transmitter in Embodiment 21.

[FIG. 552A]

FIG. 552A is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[FIG. 552B]

FIG. 552B is a flowchart illustrating operation of a receiver in Embodiment 21.

[FIG. 553]

FIG. 553 is a diagram illustrating operation of a receiver in Embodiment 21.

[FIG. 554]

FIG. 554 is a diagram illustrating an example of application of a transmitter in Embodiment 21.

[FIG. 555]

FIG. 555 is a diagram illustrating an example of application of a receiver in Embodiment 21.

[FIG. 556A]

FIG. 556A is a flowchart illustrating an example of operation of a transmitter in Embodiment 21.

[FIG. 556B]

FIG. 556B is a flowchart illustrating an example of operation of a transmitter in Embodiment 21.

[FIG. 557]

FIG. 557 is a flowchart illustrating an example of operation of

a transmitter in Embodiment 21.

[FIG. 558]

FIG. 558 is a flowchart illustrating an example of operation of an imaging device in Embodiment 21.

[FIG. 559]

FIG. 559 is a flowchart illustrating an example of operation of an imaging device in Embodiment 21.

[FIG. 560]

FIG. 560 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[FIG. 561]

FIG. 561 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[FIG. 562]

FIG. 562 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[FIG. 563]

FIG. 563 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[FIG. 564]

FIG. 564 is a diagram illustrating an example of a structure of a system including a transmitter and a receiver in Embodiment 21.

[FIG. 565]

FIG. 565 is a diagram illustrating an example of a structure of a system including a transmitter and a receiver in Embodiment 21.

[FIG. 566]

FIG. 566 is a diagram illustrating an example of a structure of a system including a transmitter and a receiver in Embodiment 21.

[FIG. 567A]

FIG. 567A is a flowchart of an information communication method according to an aspect of the present invention.

[FIG. 567B]

FIG. 567B is a block diagram of an information communication device according to an aspect of the present invention.

[FIG. 568A]

FIG. 568A is a flowchart of an information communication method according to an aspect of the present invention.

[FIG. 568B]

FIG. 568B is a block diagram of an information communication device according to an aspect of the present invention.

[FIG. 569]

FIG. 569 is a diagram illustrating an example of operation of a transmitter in Embodiment 21.

[FIG. 570]

FIG. 570 is a diagram illustrating an example of operation of a transmitter in Embodiment 21.

[FIG. 571]

FIG. 571 is a diagram illustrating an example of operation of a transmitter in Embodiment 21.

[FIG. 572]

FIG. 572 is a diagram illustrating an example of operation of a transmitter in Embodiment 21.

[FIG. 573]

FIG. 573 is a diagram illustrating an example of a receiver in Embodiment 21.

[FIG. 574]

FIG. 574 is a diagram illustrating an example of a receiver in Embodiment 21.

[FIG. 575]

FIG. 575 is a diagram illustrating an example of a reception system in Embodiment 21.

[FIG. 576]

FIG. 576 is a diagram illustrating an example of a reception system in Embodiment 21.

[FIG. 577A]

FIG. 577A is a diagram illustrating an example of a modulation scheme in Embodiment 21.

[FIG. 577B]

FIG. 577B is a diagram illustrating an example of a modulation scheme in Embodiment 21.

[FIG. 577C]

FIG. 577C is a diagram illustrating an example of separation of a mixed signal in Embodiment 21.

[FIG. 577D]

FIG. 577D is a diagram illustrating an example of separation of a mixed signal in Embodiment 21.

[FIG. 578]

FIG. 578 is a diagram illustrating an example of a visible light communication system in Embodiment 21.

[FIG. 579]

FIG. 579 is a flowchart illustrating a reception method in which interference is eliminated in Embodiment 21.

[FIG. 580]

FIG. 580 is a flowchart illustrating a transmitter direction estimation method in Embodiment 21.

[FIG. 581]

FIG. 581 is a flowchart illustrating a reception start method in Embodiment 21.

[FIG. 582]

FIG. 582 is a flowchart illustrating a method of generating an ID additionally using information of another medium in Embodiment 21.

[FIG. 583]

FIG. 583 is a flowchart illustrating a reception scheme selection method by frequency separation in Embodiment 21.

[FIG. 584]

FIG. 584 is a flowchart illustrating a signal reception method in the case of a long exposure time in Embodiment 21.

[FIG. 585]

FIG. 585 is a schematic diagram illustrating a use scene in Embodiment 22.

[FIG. 586]

FIG. 586 is a schematic diagram of a mobile terminal in Embodiment 22.

[FIG. 587]

FIG. 587 is a schematic diagram of when holding a mobile terminal horizontally in Embodiment 22.

[FIG. 588]

FIG. 588 is a schematic diagram of when holding a mobile terminal vertically in Embodiment 22.

[FIG. 589]

FIG. 589 is a schematic diagram of an in-store map in Embodiment 22.

[FIG. 590]

FIG. 590 is a schematic diagram of a product UI in Embodiment 22.

[FIG. 591]

FIG. 591 is a schematic diagram of when operating a product UI in Embodiment 22.

[FIG. 592]

FIG. 592 is a schematic diagram of when holding a mobile terminal and moving it from right to left in Embodiment 22.

[FIG. 593]

FIG. 593 is a schematic diagram of a watch-type device in Embodiment 22.

[FIG. 594]

FIG. 594 is a diagram of an overall structure in Embodiment 22.

[FIG. 595]

FIG. 595 is a diagram of a structure of a product information storage unit A11016 in Embodiment 22.

[FIG. 596]

FIG. 596 is a schematic diagram of a layout of a product UI in Embodiment 22.

[FIG. 597]

FIG. 597 is a diagram of a structure of a map information storage unit A11017 in Embodiment 22.

[FIG. 598]

FIG. 598 is a flowchart of a lighting device A11002 in Embodiment 22.

[FIG. 599]

FIG. 599 is a flowchart of a mobile terminal A11001 in Embodiment 22.

[FIG. 600]

FIG. 600 is a diagram of a structure of a state management unit A11019 in Embodiment 22.

[FIG. 601]

FIG. 601 is a flowchart of a ceiling light-related process in Embodiment 22.

[FIG. 602]

FIG. 602 is a flowchart of a base light-related process in Embodiment 22.

[FIG. 603]

FIG. 603 is a flowchart of a UI-related process in Embodiment 22.

[FIG. 604]

FIG. 604 is a flowchart of a map information UI process in Embodiment 22.

[FIG. 605]

FIG. 605 is a flowchart of a product information UI process in Embodiment 22.

[FIG. 606]

FIG. 607 is a flowchart of an overall display process in Embodiment 22.

[FIG. 607]

FIG. 607 is a flowchart of a display update preliminary process in Embodiment 22.

[FIG. 608]

FIG. 608 is a flowchart of a display update process in Embodiment 22.

[FIG. 609]

FIG. 609 is a diagram of a structure of a light reception control unit in Embodiment 23.

[FIG. 610]

FIG. 610 is a flowchart of illuminance pattern detection in

Embodiment 23.

[FIG. 611]

FIG. 611 is a diagram of a structure of a light reception control unit in Embodiment 24.

[FIG. 612]

FIG. 612 is a flowchart of illuminance pattern detection in Embodiment 24.

[FIG. 613]

FIG. 613 is a schematic diagram of gaze movement in Embodiment 25.

[FIG. 614]

FIG. 614 is a diagram of a structure of a mobile terminal in Embodiment 25.

[FIG. 615]

FIG. 615 is a schematic diagram of a structure of a shelf identifier DB in Embodiment 25.

[FIG. 616]

FIG. 616 is a flowchart of when inquiring of a server in Embodiment 25.

[FIG. 617]

FIG. 617 is a diagram of a structure of a light reception control unit in Embodiment 26.

[FIG. 618]

FIG. 618 is a diagram of a structure of a light reception control unit in Embodiment 27.

[FIG. 619]

FIG. 619 is a diagram for describing a use case in Embodiment 28.

[FIG. 620]

FIG. 620 is a diagram illustrating system components in Embodiment 29.

[FIG. 621]

FIG. 621 is a flowchart of an area detection process for a mobile terminal (B0101) in Embodiment 29.

[FIG. 622]

FIG. 622 is a flowchart of a process in an area ID information server (B0411) in the case where the mobile terminal (B0101) requests area ID information in Embodiment 29.

[FIG. 623]

FIG. 623 is a flowchart of a process when the mobile terminal (B0101) receives area ID information from the area ID information server (B0411) in Embodiment 29.

[FIG. 624]

FIG. 624 is a flowchart of a process when the mobile terminal (B0101) receives an ID from a visible light transmitter (B0120) in Embodiment 29.

[FIG. 625]

FIG. 625 is a flowchart of a process when the mobile terminal (B0101) requests visible light ID correspondence information in Embodiment 29.

[FIG. 626]

FIG. 626 is a flowchart of a process in the case where an ID correspondence information server (B0111) receives an ID correspondence information request from the mobile terminal (B0101) in Embodiment 29.

[FIG. 627]

FIG. 627 is a flowchart of a process when the mobile terminal (B0101) receives a short ID from the visible light transmitter (B0120) in Embodiment 29.

[FIG. 628]

FIG. 628 is a flowchart of a process upon display by the mobile terminal (B0101) in Embodiment 29.

[FIG. 629]

FIG. 629 is a flowchart of a process in which interpolation ID generation means (B0110) generates an interpolation ID based on a user attribute in Embodiment 29.

[FIG. 630]

FIG. 630 is a flowchart of a process in which the interpolation ID generation means (B0110) specifies the position of the visible light transmitter (B0120) based on sensing means (B0103) and

receiving camera information in Embodiment 29.

[FIG. 631]

FIG. 631 is a flowchart of a process in which the interpolation ID generation means (B0110) generates an interpolation ID based on the position of the visible light transmitter in Embodiment 29.

[FIG. 632]

FIG. 632 is a diagram illustrating an example in which the interpolation ID generation means (B0110) specifies the position of the visible light transmitter (B0120) in Embodiment 29.

[FIG. 633]

FIG. 633 is a diagram illustrating an example in which the interpolation ID generation means (B0110) detects the orientation of the mobile terminal (B0101) in Embodiment 29.

[FIG. 634]

FIG. 634 is a diagram illustrating an example of a table used by the interpolation ID generation means (B0110) to select an interpolation ID based on a device position in Embodiment 29.

[FIG. 635]

FIG. 635 is a diagram illustrating an example of a user attribute table held in user information holding means (B0151) in Embodiment 29.

[FIG. 636]

FIG. 636 is a diagram illustrating an example of a table used by the interpolation ID generation means (B0110) to select an interpolation ID based on a user attribute in Embodiment 29.

[FIG. 637]

FIG. 637 is a diagram illustrating an example of a data table held in visible light ID correspondence information data holding means (B0114) in Embodiment 29.

[FIG. 638]

FIG. 638 is a diagram illustrating an example of an area ID information table held in the area ID information server (B0141) in Embodiment 29.

[FIG. 639]

FIG. 639 is a diagram illustrating a use case in Embodiment

29.

[FIG. 640]

FIG. 640 is a diagram illustrating an example of an internal structure of an inquiry ID from the mobile terminal (B0101) to the ID correspondence information conversion server (B0111) in Embodiment 29.

[FIG. 641]

FIG. 641 is a diagram illustrating an example in which the mobile terminal (B0101) generates an inquiry ID in Embodiment 29.

[FIG. 642]

FIG. 642 is a diagram illustrating a detailed use case of example 2 in FIG. 641 in Embodiment 29.

[FIG. 643]

FIG. 643 is a diagram illustrating a detailed use case of example 3 in FIG. 641 in Embodiment 29.

[Description of Embodiments]

[0010]

An information communication method according to an aspect of the present invention is an information communication method of transmitting a signal using a change in luminance, the information communication method including: determining a pattern of the change in luminance, by modulating the signal to be transmitted; and transmitting the signal, by a plurality of light emitters changing in luminance according to the determined pattern of the change in luminance, wherein the plurality of light emitters are arranged on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.

[0011]

In this way, the bright line area can be made continuous in the captured image obtained by capturing the surface (display) by the image sensor included in the receiver, for instance as illustrated in FIG. 548. This eases the reception of the transmission signal, and

enables communication between various devices including a device with low computational performance. The information communication method may also include arranging the plurality of light emitters on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.

[0012]

For example, the transmitting may include determining whether or not a level of brightness of at least one light emitter of the plurality of light emitters is less than or equal to a reference level which is predetermined brightness, and in the transmitting, the transmission of the signal from the at least one light emitter may be stopped in the case of determining that the level of brightness of the at least one light emitter is less than or equal to the reference level.

[0013]

In this way, no signal transmission is performed when the light emitter is dark, for instance as illustrated in FIG. 556A. Unnatural light emission of the light emitter for luminance change can thus be prevented, and also a reception failure caused when the light emitter changes in luminance in a dark state can be avoided.

[0014]

For example, the transmitting may include determining whether or not a level of brightness of at least one light emitter of the plurality of light emitters is greater than or equal to a reference level which is predetermined brightness, and in the transmitting, the transmission of the signal from the at least one light emitter may be started in the case of determining that the level of brightness of the at least one light emitter is greater than or equal to the reference level.

[0015]

In this way, signal transmission is performed when the light emitter is bright, for instance as illustrated in FIG. 556B. Signal

transmission by luminance change can thus be carried out unnoticeably to humans, and also a reception failure can be prevented by the light emitter changing in luminance in a bright state.

[0016]

For example, in the determining, a first luminance change pattern corresponding to a body which is a part of the signal and a second luminance change pattern indicating a header for specifying the body may be determined, and in the transmitting, the header and the body may be transmitted by the plurality of light emitters changing in luminance according to the first luminance change pattern, the second luminance change pattern, and the first luminance change pattern in the stated order.

[0017]

In this way, even in the case where the whole body after the header cannot be received, concatenating the part of the body received before the header and the part of the body received after the header enables the reception of the whole body, for instance as illustrated in FIG. 512A. This widens the range of timings at which the transmission signal can be appropriately received.

[0018]

For example, in the determining, a third luminance change pattern indicating an other header different from the header may be determined, and in the transmitting, the header, the body, and the other header may be transmitted by the plurality of light emitters changing in luminance according to the first luminance change pattern, the second luminance change pattern, the first luminance change pattern, and the third luminance change pattern in the stated order.

[0019]

In this way, even when the body is variable in length, the signal length of the body can be specified if the header, the body, and the other header are continuously received at one time, for instance as illustrated in FIG. 513. The body parts before and after the header can then be appropriately concatenated based on the signal length. In the case where the other header is not available, the

signal length of the body cannot be specified unless the header, the two bodies, and the header are continuously received at one time. By transmitting the other header as mentioned above, however, the signal that needs to be continuously received at one time in order to specify the signal length of the body can be shortened.

[0020]

For example, in the determining: luminance change patterns between which a timing at which a predetermined luminance value occurs is different may be assigned to different signal units beforehand, to prevent two luminance change patterns from being assigned to signal units of a same parity, the timing at which the predetermined luminance value occurs in one of the two luminance change patterns being adjacent to the timing at which the predetermined luminance value occurs in the other one of the two luminance change patterns; and for each signal unit included in the signal, a luminance change pattern assigned to the signal unit may be determined.

[0021]

In this way, the luminance change pattern "H (high luminance value), L (low luminance value), H, H" and the luminance change pattern "H, H, L, H" are adjacent to each other in the timing at which L occurs, and accordingly are assigned to signal units of different parities, for instance as illustrated in FIG. 520. This enhances the reliability of parity check on the received signal.

[0022]

For example, the information communication method may further include: setting an exposure time of an image sensor so that, in an image obtained by capturing at least one light emitter of the plurality of light emitters by the image sensor, bright lines corresponding to exposure lines included in the image sensor appear according to the change in luminance of the at least one light emitter; obtaining a bright line image including the bright lines, by capturing the at least one light emitter changing in luminance by the image sensor with the set exposure time; and obtaining information by demodulating data specified by a pattern of the bright lines

included in the obtained bright line image, wherein the obtaining of information includes: specifying, in the pattern of the bright lines, a second part and a third part between which a first part corresponding to the second luminance change pattern is interposed in a direction perpendicular to the bright lines; and obtaining the body by demodulating data specified by the second part and the third part, and in the specifying, the second part and the third part are specified so that a sum of a length of the second part and a length of the third part in the direction perpendicular to the bright lines is a length associated with the body.

[0023]

In this way, the body can be obtained appropriately, for instance as illustrated in FIGS. 512A and 512B.

[0024]

For example, the information communication method may further include determining whether or not a flash emitted in a predetermined rhythm is received, wherein in the transmitting, the plurality of light emitters change in higher luminance, in the case of determining that the flash is received.

[0025]

In this way, in the case where the receiver that captures the plurality of light emitters to receive the signal from the plurality of light emitters cannot receive the signal, the receiver emits the above-mentioned flash to increase the luminance of the plurality of light emitters, for instance as illustrated in FIG. 549. As a result, the receiver can receive the signal appropriately.

[0026]

For example, the information communication method may further include at least one light emitter of the plurality of light emitters blinking to be visible to a human eye, wherein the at least one light emitter repeatedly alternates between the transmitting and the blinking.

[0027]

In this way, the light emitter repeatedly alternates between the blinking visible to the human eye and the signal transmission, for

instance as illustrated in FIG. 522. From the blinking, the user can easily recognize that the signal transmission is performed intermittently. Having noticed the blinking, the user points the image sensor of the receiver at the plurality of light emitters to capture the plurality of light emitters, as a result of which the signal can be received.

[0028]

These general and specific aspects may be implemented using a system, a method, an integrated circuit, a computer program, or a computer-readable recording medium such as a CD-ROM, or any combination of systems, methods, integrated circuits, computer programs, or computer-readable recording media.

[0029]

Hereinafter, embodiments are specifically described with reference to the Drawings.

[0030]

Each of the embodiments described below shows a general or specific example. The numerical values, shapes, materials, structural elements, the arrangement and connection of the structural elements, steps, the processing order of the steps etc. shown in the following embodiments are mere examples, and therefore do not limit the scope of the present invention. Therefore, among the structural elements in the following embodiments, structural elements not recited in any one of the independent claims representing the broadest concepts are described as arbitrary structural elements.

[0031]

[Embodiment 1]

(Signal transmission by phase modulation)

FIG. 1 is a timing diagram of a transmission signal in an information communication device in Embodiment 1.

[0032]

In FIG. 1, a reference waveform (a) is a clock signal of period T, which serves as the reference for the timing of the transmission signal. A transmission symbol (b) represents a symbol string

generated based on a data string to be transmitted. Here, the case of one bit per symbol is illustrated as an example, which is the same binary as the transmission data. A transmission waveform (c) is a transmission waveform phase-modulated according to the transmission symbol with respect to the reference waveform. The transmission light source is driven according to this waveform. The phase modulation is performed by phase-shifting the reference waveform in correspondence with the symbol. In this example, symbol 0 is assigned phase 0°, and symbol 1 is assigned phase 180°.

[0033]

FIG. 2 is a diagram illustrating the relations between the transmission signal and the reception signal in Embodiment 1.

[0034]

The transmission signal is the same as in FIG. 1. The light source emits light only when the transmission signal is 1, with the light emission time being indicated by the diagonally right down shaded area. The diagonally right up shaded band represents the time during which the pixels of the image sensor are exposed (exposure time tE). The signal charge of the pixels of the image sensor is generated in the area overlapping with the diagonally right down shaded area indicating the light emission time. A pixel value p is proportional to the overlapping area. Here, the relation of Expression 1 holds between the exposure time tE and the period T.

[0035]

$$tE = T/2 \times (2n + 1) \quad \text{(where n is a natural number)} \qquad \text{(Expression 1).}$$

Note that FIGS. 2 to 6 illustrate the case where $n = 2$, that is, $tE = 2.5\ T$.

[0036]

The reception waveform indicates the pixel value p of each line. Here, the value of the pixel value axis is normalized with the intensity of received light per period being set as 1. As mentioned above, the exposure time tE has the section of $T(n + 1/2)$, so that the pixel value p is always in the range of $n \leq p \leq n + 1$. In the example in FIG. 2, $2 \leq p \leq 3$.

[0037]

FIGS. 3 to 5 are each a diagram illustrating the relations between the transmission signal and the reception signal for a symbol string different from that in FIG. 2.

[0038]

The transmission signal has a preamble including a consecutive same-symbol string (e.g. string of consecutive symbols 0) (not illustrated). The receiver generates the reference (fundamental) signal for reception from the consecutive symbol string in the preamble, and uses it as the timing signal for reading the symbol string from the reception waveform. In detail, for consecutive symbols 0, the reception waveform returns a fixed waveform repeating $2 \rightarrow 3 \rightarrow 2$, and the clock signal is generated as the reference signal based on the output timing of the pixel value 3, as illustrated in FIG. 2.

[0039]

Next, the symbol reading from the reception waveform can be performed in such a manner that the reception signal in one section of the reference signal is read where the pixel value 3 is read as symbol 0 and the pixel value 2 is read as symbol 1. FIGS. 3 to 5 illustrate the state of reading symbols in the fourth period.

[0040]

FIG. 6 is a diagram summarizing FIGS. 2 to 5. Since the lines are closely aligned, the pixel boundary in the line direction is omitted so that the pixels are continuous in the drawing. The state of reading symbols in the fourth to eighth periods is illustrated here.

[0041]

According to such a structure, in this embodiment, the average of the intensity of the light signal taken for a sufficiently longer time than the period of the reference wave is always constant. By setting the frequency of the reference wave appropriately high, it is possible to set the time to be shorter than the time in which humans perceive a change in light intensity. Hence, the transmission light emitting source observed by the human eye appears to be emitting light uniformly. Since no flicker of the light

source is perceived, there is an advantageous effect of causing no annoyance on the user as in the previous embodiment.

[0042]

In a situation where the exposure time of each line is long and the time overlapping with the exposure time of the adjacent line is long, the amplitude modulation (ON/OFF modulation) in the previous embodiment has the problem that the signal frequency (symbol rate) cannot be increased and so the sufficient signal transmission speed cannot be attained. In this embodiment, on the other hand, the signal leading and trailing edges are detectable even in such a situation, with it being possible to increase the signal frequency and attain the high signal transmission speed.

[0043]

The term "phase modulation" used here means the phase modulation for the reference signal waveform. In the original sense, a carrier is light, which is amplitude-modulated (ON/OFF modulated) and transmitted. Therefore, the modulation scheme in this signal transmission is one type of amplitude modulation.

[0044]

Note that the transmission signal mentioned above is merely an example, and the number of bits per symbol may be set to 2 or more. Besides, the correspondence between the symbol and the phase shift is not limited to 0° and 180°, and an offset may be provided.

[0045]

Though not mentioned above, the structures and operations of the light signal generating means and light signal receiving means described later in Embodiments 6 to 11 with reference to FIGS. 124 to 200 may be replaced with the structures and operations of the high-speed light emitting means and light signal receiving means described in Embodiment 3 and its subsequent embodiments with reference to FIG. 21 onward, to achieve the same advantageous effects. Conversely, the high-speed light emitting means and receiving means in Embodiment 3 and its subsequent embodiments may equally be replaced with the low-speed light emitting means and

receiving means.

[0046]

For instance, in the above-mentioned example where the data such as position information in the light signal from the lighting is received using the face camera which is the display-side camera of the mobile phone in FIG. 17 or using the opposite in camera in FIG. 16, the up/down direction can be detected based on gravity through the use of the 9-axis sensor.

[0047]

Consider the case of receiving the light signal by the mobile phone placed on the table in the restaurant, as illustrated in FIG. 19. The light signal may be received by operating the face camera when the front side of the mobile phone is facing upward, and operating the in camera when the front side is facing downward, according to the signal of the 9-axis sensor. This contributes to lower power consumption and faster light signal reception, as unnecessary camera operations can be stopped. The same operation may be performed by detecting the orientation of the camera on the table from the brightness of the camera. Moreover, when the camera switches from the imaging mode to the light signal reception mode, a shutter speed increase command and an imaging element sensitivity increase command may be issued to the imaging circuit unit. This has an advantageous effect of enhancing the sensitivity and making the image brighter. Though noise increases with the increase in sensitivity, such noise is white noise. Since the light signal is in a specific frequency band, the detection sensitivity can be enhanced by separation or removal using a frequency filter. This enables detection of a light signal from a dark lighting device.

[0048]

In the present invention, a lighting device in a space which is mainly indoors is caused to emit a light signal, and a camera unit of a mobile terminal including a communication unit, a microphone, a speaker, a display unit, and the camera unit with the in camera and the face camera receives the light signal to obtain position information and the like. When the mobile terminal is moved from

indoors to outdoors, the position information can be detected by GPS using satellite. Accordingly, by obtaining the position information of the boundary of the light signal area and automatically switching to the signal reception from GPS, an advantageous effect of seamless position detection can be achieved.

[0049]

When moving from outdoors to indoors, the boundary is detected based on the position information of GPS or the like, to automatically switch to the position information of the light signal. In the case where barcode is displayed on the display unit of the mobile phone for authentication by a POS terminal at an airplane boarding gate or a store, the use of a server causes a long response time and is not practical, and therefore only one-way authentication is possible.

[0050]

According to the present invention, on the other hand, mutual authentication can be carried out by transmitting the light signal from the light emitting unit of the reader of the POS terminal or the like to the face camera unit of the mobile phone. This contributes to enhanced security.

[0051]

[Embodiment 2]

FIG. 7 is a diagram illustrating a principle in Embodiment 2. FIGS. 8 to 20 are each a diagram illustrating an example of operation in Embodiment 2.

[0052]

An image sensor illustrated in (a) in FIG. 7 has a delay in exposure time of each line 1. At a normal shutter speed, the lines have temporally overlapping parts, and so the light signal of the same time is mixed in each line and cannot be identified. When decreasing the shutter open time, no overlap occurs as in (a) in FIG. 7 if the exposure time is reduced to less than or equal to a predetermined shutter speed, as a result of which the light signal can be temporally separated and read on a line basis.

[0053]

When the light signal "1011011" as in the upper part of (a) in FIG. 7 is given in this state, the first light signal "1" enters in the shutter open time of line 1 and so is photoelectrically converted in line 1, and output as "1" of an electrical signal 2a in (b) in FIG. 7. Likewise, the next light signal "0" is output as the electrical signal "0" in (b). Thus, the 7-bit light signal "1011011" is accurately converted to the electrical signal.

[0054]

In actuality, there is a dead time due to a vertical blanking time as in (b) in FIG. 7, so that the light signal in some time slot cannot be extracted. In this embodiment, this blanking time problem is solved by changing, when switching from "normal imaging mode" to "light signal reading mode", the access address of the imaging device such as CMOS to read the first read line 1a following the last read line 1h at the bottom. Though this has a slight adverse effect on the image quality, an advantageous effect of capable of continuous (seamless) reading can be achieved, which contributes to significantly improved transmission efficiency.

[0055]

In this embodiment, one symbol at the maximum can be assigned to one line. In the case of employing the below-mentioned synchronization method, transmission of 30 kbps at the maximum is theoretically possible when using an imaging element of 30 fps and 1000 lines.

[0056]

Note that synchronization can be established by, with reference to the signal of the light receiving element of the camera as in FIG. 8, vertically changing the line access clock so as to attain the maximum contrast or reduce the data error rate. In the case where the line clock of the image sensor is faster than the light signal, synchronization can be established by receiving one symbol of the light signal in n lines which are 2 or 3 lines as in FIG. 8.

[0057]

Moreover, when a display of a TV in FIG. 9 or a TV in the left part of FIG. 10 or a light source vertically divided into n which is 10

as an example is captured by the camera of the mobile phone by switching to the detection mode of non-blanking, high-speed electronic shutter, and the like according to the present invention, ten stripe patterns specific to this embodiment can be detected independently of each other as in the right part of FIG. 10. Thus, a 10-times (n-times) transfer rate can be achieved.

[0058]

For example, dividing an image sensor of 30 fps and 1000 lines into 10 results in 300 kbps. In HD video, there are 1980 pixels in the horizontal direction, so that the division into 50 is possible. This yields 1.5 Mbps, enabling reception of video data. If the number is 200, HD video can be transmitted.

[0059]

To achieve the advantageous effects in this embodiment, it is necessary to decrease the shutter time to less than or equal to T_0 where T_0 is the detectable longest exposure time. As in the upper right part of FIG. 7, the shutter time needs to be less than or equal to half of 1/fp where fp is the frame frequency, for the following reason. Blanking during imaging is half of one frame at the maximum. That is, the blanking time is less than or equal to half of the imaging time. The actual imaging time is therefore 1/2fp at the shortest.

[0060]

However, 4-value PPM or the like is necessary to suppress flicker, so that the shutter time is less than or equal to $1/1(fp \times 2 \times 4)$, i.e. 1/8fp. Since the camera of the mobile phone typically has fp = 30, 60, by setting the shutter speed less than or equal to 1/240, 1/480, i.e. the shutter speed less than or equal to 1/480, visible light communication according to this embodiment can be received using the camera of the mobile phone or the like while maintaining compatibility.

[0061]

There are actually a large number of mobile phones that do not employ the synchronization method according to this embodiment, and so asynchronous communication is initially performed. In this

case, by receiving one symbol using scan lines greater than or equal to 2 times the clock of the light signal, in more detail, 2 to 10 times the clock of the light signal, compatible communication can be realized though with a decrease in information rate.

[0062]

In the case of a lighting device in which flicker needs to be suppressed, light emission is performed by turning OFF or reducing light during one time slot of 4-value PPM, i.e. one time slot of four bits. In this case, though the bitrate decreases by half, flicker is eliminated. Accordingly, the device can be used as a lighting device and transmit light and data.

[0063]

FIG. 11 illustrates a situation of light signal reception in a state where all lightings indoors transmit a common signal during a common time slot and an individual lighting L_4 transmits individual sub-information during an individual time slot. L_4 has a small area, and so takes time to transmit a large amount of data. Hence, only an ID of several bits is transmitted during the individual time slot, while all of L_1, L_2, L_3, L_4, and L_5 transmit the same common information during the common time slot.

[0064]

This is described in detail, with reference to FIG. 12A. In time slot A in the lower part of FIG. 12A, two lightings in a main area M which are all lightings in a room and S_1, S_2, S_3, and S_4 at parts of the lightings transmit the same light signal simultaneously, to transmit common information "room reference position information, arrangement information of individual device of each ID (difference position information from reference position), server URL, data broadcasting, LAN transmission data". Since the whole room is illuminated with the same light signal, there is an advantageous effect that the camera unit of the mobile phone can reliably receive data during the common time slot.

[0065]

In time slot B, on the other hand, the main area M does not blink but continuously emits light with 1/n of the normal light

intensity, as illustrated in the upper right part of FIG. 12A. In the case of 4-value PPM, the average light intensity is unchanged when emitting light with 3/4, i.e. 75%, of the normal light intensity, as a result of which flicker can be prevented. Blinking in the range where the average light intensity is unchanged causes no flicker, but is not preferable because noise occurs in the reception of the partial areas S_1, S_2, S_3, and S_4 in time slot B. In time slot B, S_1, S_2, S_3, and S_4 each transmit a light signal of different data. The main area M does not transmit a modulated signal, and so is separated in position as in the screen of the mobile phone in the upper right part of FIG. 12A. Therefore, for example in the case of extracting the image of the area S_1, stripes appearing in the area can be easily detected because there is little noise, with it being possible to obtain data stably.

[0066]

FIG. 12B is a diagram for describing operation of a transmitter and a receiver in this embodiment.

[0067]

A transmitter 8161 such as a signage changes luminance of an area A showing "A shop" and an area B showing "B shop". As a result, signals A and B are transmitted from the respective areas. For example, each of the signals A and B includes a common part indicating common information and an individual part indicating different information. The common parts of the signals A and B are transmitted simultaneously. Having received at least one of the common parts of the signals A and B, a receiver 8162 displays an image of the entire signage. The transmitter may transmit the individual parts of the signals A and B simultaneously or at different times. For example, having received the individual part of the signal B, the receiver 8162 displays detailed shop information or the like corresponding to the area B.

[0068]

FIG. 12C is a diagram for describing operation of a transmitter and a receiver in this embodiment.

[0069]

For example, the transmitter 8161 transmits the common

parts of the signals A and B simultaneously as mentioned above, and then transmits the individual parts of the signals A and B indicating different information simultaneously. The receiver 8162 receives the signals from the transmitter 8161, by capturing the transmitter 8161.

[0070]

When the transmitter 8161 is transmitting the common parts of the signals A and B, the transmitter 8161 can be captured as one large area without being divided into two areas. The receiver 8162 can accordingly receive the common part, even when situated far from the transmitter 8161. The receiver 8162 then obtains information associated with the common part from a server, and displays the information. For instance, the server transmits information of all shops shown on the signage which is the transmitter 8161, to the receiver 8162. Alternatively, the server selects information of an arbitrary shop from the shops, and transmits the selected information to the receiver 8162. The server transmits, for example, information of a shop that pays the largest registration fee of all shops, to the receiver 8162. As an alternative, the server transmits information of a shop corresponding to an area (area A or B) at the center of the range captured by the camera of the receiver 8162. As another alternative, the server randomly selects a shop, and transmits information of the shop to the receiver 8162.

[0071]

In the case where the receiver 8162 is situated near the transmitter 8161, the receiver 8162 can receive the individual part of the signal A or B. The receiver 8162 then obtains information associated with the individual part, from the server.

[0072]

For instance, in the case of 4-value PPM, when the camera scans in the lateral direction (horizontal direction) as illustrated in FIG. 13, a lighting L_2 is captured by a face camera, and "0101", i.e. 4-bit data per frame, can be demodulated as a result of three stripes appearing as illustrated on the right side. ID data is included in this data. Accordingly, there is an advantageous effect that the position

of the mobile terminal can be detected at high speed, i.e. in a short time, by computing the distance difference information between the reference position information of the common data and each ID of the individual data or the arrangement information of each ID of the individual data. Thus, for example, the data and positions of four light sources can be instantaneously recognized in one frame information, merely by transmitting 2-bit ID information.

[0073]

An example of using low-bit ID information of individual light sources is described below, with reference to FIG. 14.

[0074]

In this embodiment, in common data 101 in FIG. 14, a large amount of data including a reference position, a server URL, arrangement information of each ID, and area-specific data broadcasting are transmitted in a common time slot using all lightings as illustrated.

[0075]

Individual IDs of L_1, L_2, L_3, and L_4 to L_8 in (a) in FIG. 14 can be 3-bit demodulated as mentioned earlier.

[0076]

As illustrated in (b) in FIG. 14, by transmitting signals of a frequency f1 and a frequency f2, too, one or more stripes that are specific to the present invention are detected in each lighting unit and converted to ID data corresponding to the frequency or ID data corresponding to the modulated data. Computing this pattern using the arrangement information makes it possible to recognize from which position the image is captured. That is, the position of the terminal can be specified as the arrangement information of each ID and the reference position information can be obtained from L_0.

[0077]

In (b) in FIG. 14, by assigning the frequencies f1 and f2 to IDs and setting, for example, f1 = 1000 Hz, f2 = 1100 Hz, …, f16 = 2500 Hz, a hexadecimal value, i.e. a 4-bit value, can be expressed by the frequency. Moreover, a 16-bit value can be expressed by setting the first bit to 1 if the signal includes a component of f1 = 1000 Hz

and 0 if the signal does not include a component of f1 = 1000 Hz, setting the second bit to 1 if the signal includes a component of f2 = 1100 Hz and 0 if the signal does not include a component of f2 = 1100 Hz, …, and setting the sixteenth bit to 1 if the signal includes a component of f16 = 2500 Hz and 0 if the signal does not include a component of f16 = 2500 Hz. Changing the transmission frequency at predetermined time intervals enables more signals to be transmitted. When changing the frequency or starting/ending the modulation, the average luminance is kept constant before and after the change. This has an advantageous effect of causing no flicker perceivable by the human eye. This modulation scheme has an advantageous effect of causing no flicker perceivable by the human eye even in the case where a lower modulation frequency than when expressing a signal by pulse position is used, and so is applicable to many frequency bands.

[0078]

Note that, since the receiver detects frequencies from signal periods, reception errors can be reduced by assigning signals so that the inverses or logarithms of frequencies are at regular intervals, rather than by assigning frequencies to signals at regular intervals.

[0079]

For example, changing the signal per 1/15 second enables transmission of 60 bits per second. A typical imaging device captures 30 frames per second. Accordingly, by transmitting the signal at the same frequency for 1/15 second, the transmitter can be reliably captured even if the transmitter is shown only in one part of the captured image.

[0080]

Moreover, by transmitting the signal at the same frequency for 1/15 second, the signal can be received even in the case where the receiver is under high load and unable to process some frame or in the case where the imaging device is capable of capturing only 15 frames per second.

[0081]

When frequency analysis is conducted by, for example, Fourier

transforming the luminance in the direction perpendicular to the exposure lines, the frequency of the transmission signal appears as a peak. In the case where a plurality of frequencies, as in a frequency change part, are captured in one frame, a plurality of peaks weaker than in the case of Fourier transforming the single frequency signal are obtained. The frequency change part may be provided with a protection part so as to prevent adjacent frequencies from being mixed with each other.

[0082]

According to this method, the transmission frequency can be analyzed even in the case where light transmitted at a plurality of frequencies in sequence is captured in one frame, and the transmission signal can be received even when the frequency of the transmission signal is changed at time intervals shorter than 1/15 second or 1/30 second.

[0083]

The transmission signal sequence can be recognized by performing Fourier transform in a range shorter than one frame. Alternatively, captured frames may be concatenated to perform Fourier transform in a range longer than one frame. In this case, the luminance in the blanking time in imaging is treated as unknown. The protection part is a signal of a specific frequency, or is unchanged in luminance (frequency of 0 Hz).

[0084]

In (b) in FIG. 14, the FM modulated signal of the frequency f2 is transmitted and then the PPM modulated signal is transmitted. As a result of alternately transmitting the FM modulated signal and the PPM modulated signal in this way, even a receiver that supports only one of the methods can receive the information. Besides, more important information can be transmitted with higher priority, by assigning the more important information to the FM modulated signal which is relatively easy to receive.

[0085]

In this embodiment, since the ID of each device and its position on the screen are simultaneously obtained, it is possible to

download image information, position information, and an application program linked with each ID of the lighting in a database of a cloud server at an URL linked with the lighting, and superimpose and display an image of a related product or the like on the video of the device having the lighting of the ID according to AR. In such a case, switching the demodulation mode to the imaging mode in this embodiment produces an advantageous effect that an AR image superimposed on beautiful video can be attained.

[0086]

As illustrated in FIG. 11, by transmitting distance difference d in east, west, south, and north between the light source of each ID and the reference position in time slot A, the accurate position of the lighting L_4 in cm is known. Next, height h is calculated from ceiling height H and the height of the user of the mobile phone, and the orientation information of the mobile phone is corrected using a 9-axis sensor, to obtain accurate camera direction angle θ2 and angle θ1 between the lighting and the mobile phone. d is calculated according to, for example, $d = (H - h) \times \arctan \cdot \theta 1$.

[0087]

The position of the mobile phone can be calculated with high accuracy in this way. By transmitting the common light signal in time slot A and the individual light signal in time slot B, an advantageous effect of ensuring that the large amount of common information and the small amount of individual information such as IDs are substantially simultaneously transmitted can be achieved.

[0088]

The individual light sources S_1 to S_4 are captured as in the mobile terminal in the upper light part of FIG. 12A. As illustrated in the time chart in the lower part of FIG. 12A, only S_1 transmits the light signal in time C. There is an advantageous effect that the detection can be made without influence of noise, because only one stripe appears as in t = C in FIG. 15.

[0089]

Two pieces of individual data may be transmitted as in t = D, E. Transmitting most spatially separate individual data as in t = H,

I has an advantageous effect of a reduction in error rate because they are easily separated on the screen.

[0090]

In t = C in FIG. 15, only S_1 needs to be demodulated, and accordingly the scan of the image sensor for the other areas is unnecessary. Hence, by reducing the number of scan lines so as to include the area of S_1 as in t = C, it is possible to scan only the area of S_1 and demodulate the data. This has an advantageous effect that not only a speedup can be achieved but also a large amount of data can be demodulated only in the narrow area of S_1.

[0091]

In such a case, however, there is a possibility that the area S_1 deviates from the scan range of the image sensor due to hand movement.

[0092]

Hence, image stabilization as illustrated in FIG. 16 is important. The gyroscope included in the mobile phone is typically unable to detect fine rotation in a narrow range such as hand movement.

[0093]

Accordingly, in the case of receiving the light signal of L_2 by the face camera as in the left part of FIG. 16, it is difficult to detect blur due to hand movement from the image captured by the face camera when, for example, the scan is limited. In view of this, the in camera is turned ON, and blur is detected from the image of the in camera to correct the scan range or the detection range. Thus, the effect of hand movement can be reduced. This is because the hand movement of the face camera and the hand movement of the in camera are the same.

[0094]

When the shutter speed of the scan area other than the light signal pattern in the face camera is decreased and the normal image is obtained from this area, image stabilization can be performed using this image. In this case, blur detection and signal detection are possible with one camera. The same advantageous effect can be

achieved in the case of using the in camera in the right part of FIG. 16.

[0095]

In FIG. 17, the light signal is detected by the face camera to first obtain the position information of the terminal.

[0096]

In the case of calculating the moving distance l_2 from this point, the 9-axis sensor for the mobile phone is not useful because of poor accuracy. In such a case, the moving distance l_2 can be calculated from the orientation of the terminal and the change in the pattern of the floor surface using the in camera opposite to the face camera, as in FIG. 17. The pattern of the ceiling may be detected using the face camera.

[0097]

Actual example of applications are described below.

[0098]

FIG. 18 is a diagram illustrating a situation of receiving data broadcasting which is common data from the ceiling lighting and obtaining the position of the user itself from individual data, inside a station.

[0099]

In FIG. 19, after a mobile terminal on which barcode is displayed displays authentication information and a terminal of a coffee shop reads the authentication information, a light emitting unit in the terminal of the shop emits light and the mobile terminal receives the light according to the present invention to perform mutual authentication. The security can be enhanced in this way. The authentication may be performed in reverse order.

[0100]

The customer carrying the mobile terminal sits at a table and transmits obtained position information to the terminal of the shop via a wireless LAN or the like, as a result of which the position of the customer is displayed on the shop staff's terminal. This enables the shop staff to bring the ordered drink to the table of the position information of the customer ordering the drink.

[0101]

In FIG. 20, the passenger detects his or her position in a train or an airplane according to the method of this embodiment, and orders a product such as food through his/her terminal. The crew has a terminal according to the present invention on the cart and, since the ID number of the ordered product is displayed at the position of the customer on the screen, properly delivers the ordered product of the ID to the customer.

[0102]

FIG. 10 is a diagram illustrating the case of using the method or device of this embodiment for a backlight of a display of a TV or the like. Since a fluorescent lamp, an LED, or an organic EL device is capable of low luminance modulation, transmission can be performed according to this embodiment. In terms of characteristics, however, the scan direction is important. In the case of portrait orientation as in a smartphone, the scan is horizontally performed. Hence, by providing a horizontally long light emitting area at the bottom of the screen and reducing the contrast of video of the TV or the like to be closer to white, there is an advantageous effect that the signal can be received easily.

[0103]

In the case of scanning in the vertical direction as in a digital camera, a vertically long display is provided as in the right side of the screen in FIG. 9.

[0104]

By providing these two areas in one screen and emitting the same light signal from both areas, the signal can be received by an image sensor of either scan direction.

[0105]

In the case where a horizontal scan image sensor is receiving light of a vertical light emitting unit, a message such as "please rotate to horizontal" may be displayed on the terminal screen to prompt the user to receive the light more accurately and faster.

[0106]

Note that the communication speed can be significantly

increased by controlling the scan line read clock of the image sensor of the camera to synchronize with the light emission pattern of the light emitting unit as in FIG. 8.

[0107]

In the case of detecting one symbol of the light emission pattern in 2 lines as in (a) in FIG. 8, synchronization is established in the pattern in the left part. In the pattern in the middle part, the image sensor reading is fast, so that the read clock of the imaging element is slowed down for synchronization. In the pattern in the right part, the read clock is speeded up for synchronization.

[0108]

In the case of detecting one symbol in 3 lines as in (b) in FIG. 8, the read clock is slowed down in the pattern in the middle part, and speeded up in the pattern in the right part.

[0109]

Thus, high speed optical communication can be realized.

[0110]

In bidirectional communication, an infrared light receiving unit provided in the lighting device of the light emitting unit as a motion sensor may be used for reception, with it being possible to perform bidirectional reception in the lighting device with no additional component. The terminal may perform transmission using the electronic flash for the camera, or may be additionally provided with an inexpensive infrared light emitting unit. Thus, bidirectional communication is realized without significant component addition.

[0111]

[Embodiment 3]

The following describes Embodiment 3.

[0112]

(Observation of luminance of light emitting unit)

The following proposes an imaging method in which, when capturing one image, all imaging elements are not exposed simultaneously but the times of starting and ending the exposure differ between the imaging elements. FIG. 21 illustrates an example of imaging where imaging elements arranged in a line are

exposed simultaneously, with the exposure start time being shifted in order of lines. Here, the simultaneously exposed imaging elements are referred to as "exposure line", and the line of pixels in the image corresponding to the imaging elements is referred to as "bright line".

[0113]

In the case of capturing a blinking light source shown on the entire imaging elements using this imaging method, bright lines (lines of brightness in pixel value) along exposure lines appear in the captured image as illustrated in FIG. 22. By recognizing this bright line pattern, the luminance change of the light source at a speed higher than the imaging frame rate can be estimated. Hence, transmitting a signal as the luminance change of the light source enables communication at a speed not less than the imaging frame rate. In the case where the light source takes two luminance values to express a signal, the lower luminance value is referred to as "low" (LO), and the higher luminance value is referred to as "high" (HI). The low may be a state in which the light source emits no light, or a state in which the light source emits weaker light than in the high.

[0114]

By this method, information transmission is performed at a speed higher than the imaging frame rate.

[0115]

In the case where the number of exposure lines whose exposure times do not overlap each other is 20 in one captured image and the imaging frame rate is 30 fps, it is possible to recognize a luminance change in a period of 1.67 millisecond. In the case where the number of exposure lines whose exposure times do not overlap each other is 1000, it is possible to recognize a luminance change in a period of 1/30000 second (about 33 microseconds). Note that the exposure time is set to less than 10 milliseconds, for example.

[0116]

FIG. 22 illustrates a situation where, after the exposure of one exposure line ends, the exposure of the next exposure line starts.

[0117]

In this situation, when transmitting information based on whether or not each exposure line receives at least a predetermined amount of light, information transmission at a speed of fl bits per second at the maximum can be realized where f is the number of frames per second (frame rate) and l is the number of exposure lines constituting one image.

[0118]

Note that faster communication is possible in the case of performing time-difference exposure not on a line basis but on a pixel basis.

[0119]

In such a case, when transmitting information based on whether or not each pixel receives at least a predetermined amount of light, the transmission speed is flm bits per second at the maximum, where m is the number of pixels per exposure line.

[0120]

If the exposure state of each exposure line caused by the light emission of the light emitting unit is recognizable in a plurality of levels as illustrated in FIG. 23, more information can be transmitted by controlling the light emission time of the light emitting unit in a shorter unit of time than the exposure time of each exposure line.

[0121]

In the case where the exposure state is recognizable in Elv levels, information can be transmitted at a speed of flElv bits per second at the maximum.

[0122]

Moreover, a fundamental period of transmission can be recognized by causing the light emitting unit to emit light with a timing slightly different from the timing of exposure of each exposure line.

[0123]

FIG. 24A illustrates a situation where, before the exposure of one exposure line ends, the exposure of the next exposure line starts. That is, the exposure times of adjacent exposure lines partially overlap each other. This structure has the feature (1): the number

of samples in a predetermined time can be increased as compared with the case where, after the exposure of one exposure line ends, the exposure of the next exposure line starts. The increase of the number of samples in the predetermined time leads to more appropriate detection of the light signal emitted from the light transmitter which is the subject. In other words, the error rate when detecting the light signal can be reduced. The structure also has the feature (2): the exposure time of each exposure line can be increased as compared with the case where, after the exposure of one exposure line ends, the exposure of the next exposure line starts. Accordingly, even in the case where the subject is dark, a brighter image can be obtained, i.e. the S/N ratio can be improved. Here, the structure in which the exposure times of adjacent exposure lines partially overlap each other does not need to be applied to all exposure lines, and part of the exposure lines may not have the structure of partially overlapping in exposure time. By keeping part of the exposure lines from partially overlapping in exposure time, the occurrence of an intermediate color caused by exposure time overlap is suppressed on the imaging screen, as a result of which bright lines can be detected more appropriately.

[0124]

In this situation, the exposure time is calculated from the brightness of each exposure line, to recognize the light emission state of the light emitting unit.

[0125]

Note that, in the case of determining the brightness of each exposure line in a binary fashion of whether or not the luminance is greater than or equal to a threshold, it is necessary for the light emitting unit to continue the state of emitting no light for at least the exposure time of each line, to enable the no light emission state to be recognized.

[0126]

FIG. 24B illustrates the influence of the difference in exposure time in the case where the exposure start time of each exposure line is the same. In 7500a, the exposure end time of one exposure line

and the exposure start time of the next exposure line are the same. In 7500b, the exposure time is longer than that in 7500a. The structure in which the exposure times of adjacent exposure lines partially overlap each other as in 7500b allows a longer exposure time to be used. That is, more light enters the imaging element, so that a brighter image can be obtained. In addition, since the imaging sensitivity for capturing an image of the same brightness can be reduced, an image with less noise can be obtained. Communication errors are prevented in this way.

[0127]

FIG. 24C illustrates the influence of the difference in exposure start time of each exposure line in the case where the exposure time is the same. In 7501a, the exposure end time of one exposure line and the exposure start time of the next exposure line are the same. In 7501b, the exposure of one exposure line ends after the exposure of the next exposure line starts. The structure in which the exposure times of adjacent exposure lines partially overlap each other as in 7501b allows more lines to be exposed per unit time. This increases the resolution, so that more information can be obtained. Since the sample interval (i.e. the difference in exposure start time) is shorter, the luminance change of the light source can be estimated more accurately, contributing to a lower error rate. Moreover, the luminance change of the light source in a shorter time can be recognized. By exposure time overlap, light source blinking shorter than the exposure time can be recognized using the difference of the amount of exposure between adjacent exposure lines.

[0128]

As described with reference to FIGS. 24B and 24C, in the structure in which each exposure line is sequentially exposed so that the exposure times of adjacent exposure lines partially overlap each other, the communication speed can be dramatically improved by using, for signal transmission, the bright line pattern generated by setting the exposure time shorter than in the normal imaging mode. Setting the exposure time in visible light communication to less than

or equal to 1/480 second enables an appropriate bright line pattern to be generated. Here, it is necessary to set (exposure time) < 1/8 × f, where f is the frame frequency. Blanking during imaging is half of one frame at the maximum. That is, the blanking time is less than or equal to half of the imaging time. The actual imaging time is therefore 1/2f at the shortest. Besides, since 4-value information needs to be received within the time of 1/2f, it is necessary to at least set the exposure time to less than 1/(2f × 4). Given that the normal frame rate is less than or equal to 60 frames per second, by setting the exposure time to less than or equal to 1/480 second, an appropriate bright line pattern is generated in the image data and thus fast signal transmission is achieved.

[0129]

FIG. 24D illustrates the advantage of using a short exposure time in the case where each exposure line does not overlap in exposure time. In the case where the exposure time is long, even when the light source changes in luminance in a binary fashion as in 7502a, an intermediate-color part tends to appear in the captured image as in 7502e, making it difficult to recognize the luminance change of the light source. By providing a predetermined non-exposure blank time (predetermined wait time) t_{D2} from when the exposure of one exposure line ends to when the exposure of the next exposure line starts as in 7502d, however, the luminance change of the light source can be recognized more easily. That is, a more appropriate bright line pattern can be detected as in 7502f. The provision of the predetermined non-exposure blank time is possible by setting a shorter exposure time t_E than the time difference t_D between the exposure start times of the exposure lines, as in 7502d. In the case where the exposure times of adjacent exposure lines partially overlap each other in the normal imaging mode, the exposure time is shortened from the normal imaging mode so as to provide the predetermined non-exposure blank time. In the case where the exposure end time of one exposure line and the exposure start time of the next exposure line are the same in the normal imaging mode, too, the exposure time is shortened so as to

provide the predetermined non-exposure time. Alternatively, the predetermined non-exposure blank time (predetermined wait time) t_{D2} from when the exposure of one exposure line ends to when the exposure of the next exposure line starts may be provided by increasing the interval t_D between the exposure start times of the exposure lines, as in 7502g. This structure allows a longer exposure time to be used, so that a brighter image can be captured. Moreover, a reduction in noise contributes to higher error tolerance. Meanwhile, this structure is disadvantageous in that the number of samples is small as in 7502h, because fewer exposure lines can be exposed in a predetermined time. Accordingly, it is desirable to use these structures depending on circumstances. For example, the estimation error of the luminance change of the light source can be reduced by using the former structure in the case where the imaging object is bright and using the latter structure in the case where the imaging object is dark.

[0130]

Here, the structure in which the exposure times of adjacent exposure lines partially overlap each other does not need to be applied to all exposure lines, and part of the exposure lines may not have the structure of partially overlapping in exposure time. Moreover, the structure in which the predetermined non-exposure blank time (predetermined wait time) is provided from when the exposure of one exposure line ends to when the exposure of the next exposure line starts does not need to be applied to all exposure lines, and part of the exposure lines may have the structure of partially overlapping in exposure time. This makes it possible to take advantage of each of the structures. Furthermore, the same reading method or circuit may be used to read a signal in the normal imaging mode in which imaging is performed at the normal frame rate (30 fps, 60 fps) and the visible light communication mode in which imaging is performed with the exposure time less than or equal to 1/480 second for visible light communication. The use of the same reading method or circuit to read a signal eliminates the need to employ separate circuits for the normal imaging mode and the

visible light communication mode. The circuit size can be reduced in this way.

[0131]

FIG. 24E illustrates the relation between the minimum change time t_S of light source luminance, the exposure time t_E, the time difference t_D between the exposure start times of the exposure lines, and the captured image. In the case where $t_E + t_D < t_S$, imaging is always performed in a state where the light source does not change from the start to end of the exposure of at least one exposure line. As a result, an image with clear luminance is obtained as in 7503d, from which the luminance change of the light source is easily recognizable. In the case where $2t_E > t_S$, a bright line pattern different from the luminance change of the light source might be obtained, making it difficult to recognize the luminance change of the light source from the captured image.

[0132]

FIG. 24F illustrates the relation between the transition time t_T of light source luminance and the time difference t_D between the exposure start times of the exposure lines. When t_D is large as compared with t_T, fewer exposure lines are in the intermediate color, which facilitates estimation of light source luminance. It is desirable that $t_D > t_T$, because the number of exposure lines in the intermediate color is two or less consecutively. Since t_T is less than or equal to 1 microsecond in the case where the light source is an LED and about 5 microseconds in the case where the light source is an organic EL device, setting t_D to greater than or equal to 5 microseconds facilitates estimation of light source luminance.

[0133]

FIG. 24G illustrates the relation between the high frequency noise t_{HT} of light source luminance and the exposure time t_E. When t_E is large as compared with t_{HT}, the captured image is less influenced by high frequency noise, which facilitates estimation of light source luminance. When t_E is an integral multiple of t_{HT}, there is no influence of high frequency noise, and estimation of light source luminance is easiest. For estimation of light source luminance, it is

desirable that $t_E > t_{HT.}$ High frequency noise is mainly caused by a switching power supply circuit. Since t_{HT} is less than or equal to 20 microseconds in many switching power supplies for lightings, setting t_E to greater than or equal to 20 microseconds facilitates estimation of light source luminance.

[0134]

FIG. 24H is a graph representing the relation between the exposure time t_E and the magnitude of high frequency noise when t_{HT} is 20 microseconds. Given that t_{HT} varies depending on the light source, the graph demonstrates that it is efficient to set t_E to greater than or equal to 15 microseconds, greater than or equal to 35 microseconds, greater than or equal to 54 microseconds, or greater than or equal to 74 microseconds, each of which is a value equal to the value when the amount of noise is at the maximum. Though t_E is desirably larger in terms of high frequency noise reduction, there is also the above-mentioned property that, when t_E is smaller, an intermediate-color part is less likely to occur and estimation of light source luminance is easier. Therefore, t_E may be set to greater than or equal to 15 microseconds when the light source luminance change period is 15 to 35 microseconds, to greater than or equal to 35 microseconds when the light source luminance change period is 35 to 54 microseconds, to greater than or equal to 54 microseconds when the light source luminance change period is 54 to 74 microseconds, and to greater than or equal to 74 microseconds when the light source luminance change period is greater than or equal to 74 microseconds.

[0135]

FIG. 24I illustrates the relation between the exposure time t_E and the recognition success rate. Since the exposure time t_E is relative to the time during which the light source luminance is constant, the horizontal axis represents the value (relative exposure time) obtained by dividing the light source luminance change period t_S by the exposure time t_E. It can be understood from the graph that the recognition success rate of approximately 100% can be attained by setting the relative exposure time to less than or equal to 1.2.

For example, the exposure time may be set to less than or equal to approximately 0.83 millisecond in the case where the transmission signal is 1 kHz. Likewise, the recognition success rate greater than or equal to 95% can be attained by setting the relative exposure time to less than or equal to 1.25, and the recognition success rate greater than or equal to 80% can be attained by setting the relative exposure time to less than or equal to 1.4. Moreover, since the recognition success rate sharply decreases when the relative exposure time is about 1.5 and becomes roughly 0% when the relative exposure time is 1.6, it is necessary to set the relative exposure time not to exceed 1.5. After the recognition rate becomes 0% at 7507c, it increases again at 7507d, 7507e, and 7507f. Accordingly, for example to capture a bright image with a longer exposure time, the exposure time may be set so that the relative exposure time is 1.9 to 2.2, 2.4 to 2.6, or 2.8 to 3.0. Such an exposure time may be used, for instance, as an intermediate mode in FIG. 335.

[0136]

Depending on imaging devices, there is a time (blanking) during which no exposure is performed, as illustrated in FIG. 25.

[0137]

In the case where there is blanking, the luminance of the light emitting unit during the time cannot be observed.

[0138]

A transmission loss caused by blanking can be prevented by the light emitting unit repeatedly transmitting the same signal two or more times or adding error correcting code.

[0139]

To prevent the same signal from being transmitted during blanking every time, the light emitting unit transmits the signal in a period that is relatively prime to the period of image capture or a period that is shorter than the period of image capture.

[0140]

(Signal modulation scheme)

In the case of using visible light as a carrier, by causing the

light emitting unit to emit light so as to keep a constant moving average of the luminance of the light emitting unit when the temporal resolution (about 5 milliseconds to 20 milliseconds) of human vision is set as a window width, the light emitting unit of the transmission device appears to be emitting light with uniform luminance to the person (human) while the luminance change of the light emitting unit is observable by the reception device, as illustrated in FIG. 26.

[0141]

A modulation method illustrated in FIG. 27 is available as a modulation scheme for causing the light emitting unit to emit light so as to keep the constant moving average of the luminance of the light emitting unit when the temporal resolution of human vision is set as the window width. Suppose a modulated signal "0" indicates no light emission and a modulated signal "1" indicates light emission, and there is no bias in a transmission signal. Then, the average of the luminance of the light emitting unit is about 50% of the luminance at the time of light emission.

[0142]

It is assumed here that the switching between light emission and no light emission is sufficiently fast as compared with the temporal resolution of human vision.

[0143]

A modulation method illustrated in FIG. 28 is available as a modulation scheme for causing the light emitting unit to emit light so as to keep the constant moving average of the luminance of the light emitting unit when the temporal resolution of human vision is set as the window width. Suppose a modulated signal "0" indicates no light emission and a modulated signal "1" indicates light emission, and there is no bias in a transmission signal. Then, the average of the luminance of the light emitting unit is about 75% of the luminance at the time of light emission.

[0144]

When compared with the modulation scheme in FIG. 27, the coding efficiency is equal at 0.5, but the average luminance can be increased.

[0145]

A modulation method illustrated in FIG. 29 is available as a modulation scheme for causing the light emitting unit to emit light so as to keep the constant moving average of the luminance of the light emitting unit when the temporal resolution of human vision is set as the window width. Suppose a modulated signal "0" indicates no light emission and a modulated signal "1" indicates light emission, and there is no bias in a transmission signal. Then, the average of the luminance of the light emitting unit is about 87.5% of the luminance at the time of light emission.

[0146]

When compared with the modulation schemes in FIGS. 27 and 28, the coding efficiency is lower at 0.375, but high average luminance can be maintained.

[0147]

Likewise, such modulation that trades off the coding efficiency for increased average luminance is further available.

[0148]

A modulation method illustrated in FIG. 30 is available as a modulation scheme for causing the light emitting unit to emit light so as to keep the constant moving average of the luminance of the light emitting unit when the temporal resolution of human vision is set as the window width.

[0149]

Suppose a modulated signal "0" indicates no light emission and a modulated signal "1" indicates light emission, and there is no bias in a transmission signal. Then, the average of the luminance of the light emitting unit is about 25% of the luminance at the time of light emission.

[0150]

By combining this with the modulation scheme in FIG. 28 or the like and periodically switching between the modulation schemes, it is possible to cause the light emitting unit to appear to be blinking to the person or the imaging device whose exposure time is long.

[0151]

Likewise, by changing the modulation method, it is possible to cause the light emitting unit to appear to be emitting light with an arbitrary luminance change to the person or the imaging device whose exposure time is long.

[0152]

In the case of using visible light as a carrier, by causing the light emitting unit to emit light so as to periodically change the moving average of the luminance of the light emitting unit when the temporal resolution of human vision is set as the window width, the light emitting unit of the transmission device appears to be blinking or changing with an arbitrary rhythm to the person while the light emission signal is observable by the reception device, as illustrated in FIG. 31.

[0153]

The same advantageous effect can be obtained even in the case where an LED unit of a liquid crystal television which uses an LED light source as a backlight is caused to emit light. In this case, at least by reducing the contrast of the screen portion of an optical communication unit to be closer to white, optical communication with a low error rate can be achieved. Making the entire surface or the screen portion used for communication white contributes to a higher communication speed.

[0154]

In the case of using a television display or the like as the light emitting unit, by adjusting, to the luminance of an image desired to be seen by the person, the moving average of the luminance of the light emitting unit when the temporal resolution of human vision is set as the window width, normal television video is seen by the person while the light emission signal is observable by the reception device, as illustrated in FIG. 32.

[0155]

By adjusting, to a signal value in the case of performing signal transmission per frame, the moving average of the luminance of the light emitting unit when a substantial time per frame of the captured image is set as the window width, signal propagation can be carried

out at two different speeds in such a manner that observes the light emission state of the transmission device per exposure line in the case of image capture at a short distance and observes the light emission state of the transmission device per frame in the case of image capture at a long distance, as illustrated in FIG. 33.

[0156]

Note that, in the case of image capture at a short distance, the signal receivable in the case of image capture at a long distance can be received, too.

[0157]

FIG. 34 is a diagram illustrating how light emission is observed for each exposure time.

[0158]

The luminance of each capture pixel is proportional to the average luminance of the imaging object in the time during which the imaging element is exposed. Accordingly, if the exposure time is short, a light emission pattern 2217a itself is observed as illustrated in 2217b. If the exposure time is longer, the light emission pattern 2217a is observed as illustrated in 2217c, 2217d, or 2217e.

[0159]

Note that 2217a corresponds to a modulation scheme that repeatedly uses the modulation scheme in FIG. 28 in a fractal manner.

[0160]

The use of such a light emission pattern enables simultaneous transmission of more information to a reception device that includes an imaging device of a shorter exposure time and less information to a reception device that includes an imaging device of a longer exposure time.

[0161]

The reception device recognizes that "1" is received if the luminance of pixels at the estimated position of the light emitting unit is greater than or equal to predetermined luminance and that "0" is received if the luminance of pixels at the estimated position of the light emitting unit is less than or equal to the predetermined

luminance, for one exposure line or for a predetermined number of exposure lines.

[0162]

In the case where "1" continues, it is indistinguishable from an ordinary light emitting unit (which constantly emits light without transmitting a signal). In the case where "0" continues, it is indistinguishable from the case where no light emitting unit is present.

[0163]

Therefore, the transmission device may transmit a different numeric when the same numeric continues for a predetermined number of times.

[0164]

Alternatively, transmission may be performed separately for a header unit that always includes "1" and "0" and a body unit for transmitting a signal, as illustrated in FIG. 35. In this case, the same numeric never appears more than five successive times.

[0165]

In the case where the light emitting unit is situated at a position not shown on part of exposure lines or there is blanking, it is impossible to capture the whole state of the light emitting unit by the imaging device of the reception device.

[0166]

This makes it necessary to indicate which part of the whole signal the transmitted signal corresponds to.

[0167]

In view of this, there is a method whereby a data unit and an address unit indicating the position of the data are transmitted together, as illustrated in FIG. 36.

[0168]

For easier signal reception at the reception device, it is desirable to set the length of the light emission pattern combining the data unit and the address unit to be sufficiently short so that the light emission pattern is captured within one image in the reception device.

[0169]

There is also a method whereby the transmission device transmits a reference unit and a data unit and the reception device recognizes the position of the data based on the difference from the time of receiving the reference unit, as illustrated in FIG. 37.

[0170]

There is also a method whereby the transmission device transmits a reference unit, an address pattern unit, and a data unit and the reception device obtains each set of data of the data unit and the pattern of the position of each set of data from the address pattern unit following the reference unit, and recognizes the position of each set of data based on the obtained pattern and the difference between the time of receiving the reference unit and the time of receiving the data, as illustrated in FIG. 38.

[0171]

When a plurality of types of address patterns are available, not only data can be transmitted uniformly, but also important data or data to be processed first can be transmitted earlier than other data or repeatedly transmitted a larger number of times than other data.

[0172]

In the case where the light emitting unit is not shown on all exposure lines or there is blanking, it is impossible to capture the whole state of the light emitting unit by the imaging device of the reception device.

[0173]

Adding a header unit allows a signal separation to be detected and an address unit and a data unit to be detected, as illustrated in FIG. 39.

[0174]

Here, a pattern not appearing in the address unit or the data unit is used as the light emission pattern of the header unit.

[0175]

For example, the light emission pattern of the header unit may be “0011” in the case of using the modulation scheme of table 2200.2a.

[0176]

Moreover, when the header unit pattern is "11110011", the average luminance is equal to the other parts, with it being possible to suppress flicker when seen with the human eye. Since the header unit has a high redundancy, information can be superimposed on the header unit. As an example, it is possible to indicate, with the header unit pattern "11100111", that data for communication between transmission devices is transmitted.

[0177]

For easier signal reception at the reception device, it is desirable to set the length of the light emission pattern combining the data unit, the address unit, and the header unit to be sufficiently short so that the light emission pattern is captured within one image in the reception device.

[0178]

In FIG. 40, the transmission device determines the information transmission order according to priority.

[0179]

For example, the number of transmissions is set in proportion to the priority.

[0180]

In the case where the light emitting unit of the transmission device is not wholly shown on the imaging unit of the reception device or there is blanking, the reception device cannot receive signals continuously. Accordingly, information with higher transmission frequency is likely to be received earlier.

[0181]

FIG. 41 illustrates a pattern in which a plurality of transmission devices located near each other transmit information synchronously.

[0182]

When the plurality of transmission devices simultaneously transmit common information, the plurality of transmission devices can be regarded as one large transmission device. Such a transmission device can be captured in a large size by the imaging

unit of the reception device, so that information can be received faster from a longer distance.

[0183]

Each transmission device transmits individual information during a time slot when the light emitting unit of the nearby transmission device emits light uniformly (transmits no signal), to avoid confusion with the light emission pattern of the nearby transmission device.

[0184]

Each transmission device may receive, at its light receiving unit, the light emission pattern of the nearby transmission signal to learn the light emission pattern of the nearby transmission device, and determine the light emission pattern of the transmission device itself. Moreover, each transmission device may receive, at its light receiving unit, the light emission pattern of the nearby transmission signal, and determine the light emission pattern of the transmission device itself according to an instruction from the other transmission device. Alternatively, each transmission device may determine the light emission pattern according to an instruction from a centralized control device.

[0185]

(Light emitting unit detection)

As a method of determining in which part of the image the light emitting unit is captured, there is a method whereby the number of lines on which the light emitting unit is captured is counted in the direction perpendicular to the exposure lines and the column in which the light emitting unit is captured most is set as the column where the light emitting unit is present, as illustrated in FIG. 42.

[0186]

The decree of light reception fluctuates in the parts near the edges of the light emitting unit, which tends to cause wrong determination of whether or not the light emitting unit is captured. Therefore, signals are extracted from the imaging results of the pixels in the center column of all columns in each of which the light emitting unit is captured most.

[0187]

As a method of determining in which part of the image the light emitting unit is captured, there is a method whereby the midpoint of the part in which the light emitting unit is captured is calculated for each exposure line and the light emitting unit is estimated to be present on an approximate line (straight line or quadratic curve) connecting the calculated points, as illustrated in FIG. 43.

[0188]

Moreover, as illustrated in FIG. 44, the estimated position of the light emitting unit may be updated from the information of the current frame, by using the estimated position of the light emitting unit in the previous frame as a prior probability.

[0189]

Here, the current estimated position of the light emitting unit may be updated based on values of a 9-axis sensor and a gyroscope during the time.

[0190]

In FIG. 45, when capturing a light emitting unit 2212b in an imaging range 2212a, images such as captured images 2212c, 2212d, and 2212e are obtained.

[0191]

Summing the light emission parts of the captured images 2212c, 2212d, and 2212e yields a synthetic image 2212f. The position of the light emitting unit in the captured image can thus be specified.

[0192]

The reception device detects ON/OFF of light emission of the light emitting unit, from the specified position of the light emitting unit.

[0193]

In the case of using the modulation scheme in FIG. 28, the light emission probability is 0.75, so that the probability of the light emitting unit in the synthetic image 2212f appearing to emit light when summing n images is $1 - 0.25^n$. For example, when n = 3, the probability is about 0. 984.

[0194]

Here, higher accuracy is attained when the orientation of the imaging unit is estimated from sensor values of a gyroscope and a 9-axis sensor and the imaging direction is compensated for before the image synthesis. In the case where the number of images to be synthesized is small, however, the imaging time is short, and so there is little adverse effect even when the imaging direction is not compensated for.

[0195]

FIG. 46 is a diagram illustrating a situation where the reception device captures a plurality of light emitting units.

[0196]

In the case where the plurality of light emitting units transmit the same signal, the reception device obtains one transmission signal from both light emission patterns. In the case where the plurality of light emitting units transmit different signals, the reception device obtains different transmission signals from different light emission patterns.

[0197]

The difference in data value at the same address between the transmission signals means different signals are transmitted. Whether the signal same as or different from the nearby transmission device is transmitted may be determined based on the pattern of the header unit of the transmission signal.

[0198]

It may be assumed that the same signal is transmitted in the case where the light emitting units are substantially adjacent to each other.

[0199]

FIG. 47 illustrates transmission signal timelines and an image obtained by capturing the light emitting units in this case.

[0200]

(Signal transmission using position pattern)

In FIG. 48, light emitting units 2216a, 2216c, and 2216e are emitting light uniformly, while light emitting units 2216b, 2216d, and

2216f are transmitting signals using light emission patterns. Note that the light emitting units 2216b, 2216d, and 2216f may be simply emitting light so as to appear as stripes when captured by the reception device on an exposure line basis.

[0201]

In FIG. 48, the light emitting units 2216a to 2216f may be light emitting units of the same transmission device or separate transmission devices.

[0202]

The transmission device expresses the transmission signal by the pattern (position pattern) of the positions of the light emitting units engaged in signal transmission and the positions of the light emitting units not engaged in signal transmission.

[0203]

In FIG. 48, there are six light emitting units, so that signals of $2^6 = 64$ values are transmittable. Though position patterns that appear to be the same when seen from different directions should not be used, such patterns can be discerned by specifying the imaging direction by the 9-axis sensor or the like in the reception device. Here, more signals may be transmitted by changing, according to time, which light emitting units are engaged in signal transmission.

[0204]

The transmission device may perform signal transmission using the position pattern during one time slot and perform signal transmission using the light emission pattern during another time slot. For instance, all light emitting units may be synchronized during a time slot to transmit the ID or position information of the transmission device using the light emission pattern.

[0205]

Since there are nearly an infinite number of light emitting unit arrangement patterns, it is difficult for the reception device to store all position patterns beforehand.

[0206]

Hence, the reception device obtains a list of nearby position patterns from a server and analyzes the position pattern based on

the list, using the ID or position information of the transmission device transmitted from the transmission device using the light emission pattern, the position of the reception device estimated by a wireless base station, and the position information of the reception device estimated by a GPS, a gyroscope, or a 9-axis sensor as a key.

[0207]

According to this method, the signal expressed by the position pattern does not need to be unique in the whole world, as long as the same position pattern is not situated nearby (radius of about several meters to 300 meters). This solves the problem that a transmission device with a small number of light emitting units can express only a small number of position patterns.

[0208]

The position of the reception device can be estimated from the size, shape, and position information of the light emitting units obtained from the server, the size and shape of the captured position pattern, and the lens characteristics of the imaging unit.

[0209]

(Reception device)

Examples of a communication device that mainly performs reception include a mobile phone, a digital still camera, a digital video camera, a head-mounted display, a robot (cleaning, nursing care, industrial, etc.), and a surveillance camera as illustrated in FIG. 49, though the reception device is not limited to such.

[0210]

Note that the reception device is a communication device that mainly receives signals, and may also transmit signals according to the method in this embodiment or other methods.

[0211]

(Transmission device)

Examples of a communication device that mainly performs transmission include a lighting (household, store, office, underground city, street, etc.), a flashlight, a home appliance, a robot, and other electronic devices as illustrated in FIG. 50, though the transmission device is not limited to such.

[0212]

Note that the transmission device is a communication device that mainly transmits signals, and may also receive signals according to the method in this embodiment or other methods.

[0213]

The light emitting unit is desirably a device that switches between light emission and no light emission at high speed such as an LED lighting or a liquid crystal display using an LED backlight as illustrated in FIG. 51, though the light emitting unit is not limited to such.

[0214]

Other examples of the light emitting unit include lightings such as a fluorescent lamp, an incandescent lamp, a mercury vapor lamp, and an organic EL display.

[0215]

Since the transmission efficiency increases when the light emitting unit is captured in a larger size, the transmission device may include a plurality of light emitting units that emit light synchronously as illustrated in FIG. 52. Moreover, since the transmission efficiency increases when the light emitting unit is shown in a larger size in the direction perpendicular to the exposure lines of the imaging element, the light emitting units may be arranged in a line. The light emitting units may also be arranged so as to be perpendicular to the exposure lines when the reception device is held normally. In the case where the light emitting unit is expected to be captured in a plurality of directions, the light emitting units may be arranged in the shape of a cross as illustrated in FIG. 53. Alternatively, in the case where the light emitting unit is expected to be captured in a plurality of directions, a circular light emitting unit may be used or the light emitting units may be arranged in the shape of a circle as illustrated in FIG. 54. Since the transmission efficiency increases when the light emitting unit is captured in a larger size, the transmission device may cover the light emitting unit(s) with a diffusion plate as illustrated in FIG. 55.

[0216]

Light emitting units that transmit different signals are positioned away from each other so as not to be captured at the same time, as illustrated in FIG. 56. As an alternative, light emitting units that transmit different signals have a light emitting unit, which transmits no signal, placed therebetween so as not to be captured at the same time, as illustrated in FIG. 57.

[0217]

(Structure of light emitting unit)

FIG. 58 is a diagram illustrating a desirable structure of the light emitting unit.

[0218]

In 2311a, the light emitting unit and its surrounding material have low reflectance. This eases the recognition of the light emission state by the reception device even when light impinges on or around the light emitting unit. In 2311b, a shade for blocking external light is provided. This eases the recognition of the light emission state by the reception device because light is kept from impinging on or around the light emitting unit. In 2311c, the light emitting unit is provided in a more recessed part. This eases the recognition of the light emission state by the reception device because light is kept from impinging on or around the light emitting unit.

[0219]

(Signal carrier)

Light (electromagnetic wave) in frequency bands from near infrared, visible light, to near ultraviolet illustrated in FIG. 59, which can be received by the reception device, is used as light (electromagnetic wave) for carrying signals.

[0220]

(Imaging unit)

In FIG. 60, an imaging unit in the reception device detects a light emitting unit 2310b emitting light in a pattern, in an imaging range 2310a.

[0221]

An imaging control unit obtains a captured image 2310d by

repeatedly using an exposure line 2310c at the center position of the light emitting unit, instead of using the other exposure lines.

[0222]

The captured image 2310d is an image of the same area at different exposure times. The light emission pattern of the light emitting unit can be observed by scanning, in the direction perpendicular to the exposure lines, the pixels where the light emitting unit is shown in the captured image 2310d.

[0223]

According to this method, even in the case where the light emitting unit is present only in one part of the captured image, the luminance change of the light emitting unit can be observed for a longer time. Hence, the signal can be read even when the light emitting unit is small or the light emitting unit is captured from a long distance.

[0224]

In the case where there is no blanking, the method allows every luminance change of the light emitting unit to be observed so long as the light emitting unit is shown in at least one part of the imaging device.

[0225]

In the case where the time for exposing one line is longer than the time from when the exposure of the line starts to when the exposure of the next line starts, the same advantageous effect can be achieved by capturing the image using a plurality of exposure lines at the center of the light emitting unit.

[0226]

Note that, in the case where pixel-by-pixel control is possible, the image is captured using only a point closest to the center of the light emitting unit or only a plurality of points closest to the center of the light emitting unit. Here, by making the exposure start time of each pixel different, the light emission state of the light emitting unit can be detected in smaller periods.

[0227]

When, while mainly using the exposure line 2310c, other

exposure lines are occasionally used and the captured images are synthesized, the synthetic image (video) that is similar to the normally captured image though lower in resolution or frame rate can be obtained. The synthetic image is then displayed to the user, so that the user can operate the reception device or perform image stabilization using the synthetic image.

[0228]

The image stabilization may be performed using sensor values of a gyroscope, a 9-axis sensor, and the like, or using an image captured by an imaging device other than the imaging device capturing the light emitting unit.

[0229]

It is desirable to use exposure lines or exposure pixels in a part near the center of the light emitting unit rather than near the edges of the light emitting unit, because the light emitting unit is less likely to be displaced from such exposure lines or exposure pixels upon hand movement.

[0230]

Since the periphery of the light emitting unit is low in luminance, it is desirable to use exposure lines or exposure pixels in a part that is as far from the periphery of the light emitting unit as possible and is high in luminance.

[0231]

(Position estimation of reception device)

In FIG. 61, the transmission device transmits the position information of the transmission device, the size of the light emitting device, the shape of the light emitting device, and the ID of the transmission device. The position information includes the latitude, longitude, altitude, height from the floor surface, and the like of the center part of the light emitting device.

[0232]

The reception device estimates the imaging direction based on information obtained from the 9-axis sensor and the gyroscope. The reception device estimates the distance from the reception device to the light emitting device, from the size and shape of the

light emitting device transmitted from the transmission device, the size and shape of the light emitting device in the captured image, and information about the imaging device. The information about the imaging device includes the focal length of a lens, the distortion of the lens, the size of the imaging element, the distance between the lens and the imaging element, a comparative table of the size of an object of a reference size in the captured image and the distance from the imaging device to the imaging object, and so on.

[0233]

The reception device also estimates the position information of the reception device, from the information transmitted from the transmission device, the imaging direction, and the distance from the reception device to the light emitting device.

[0234]

In FIG. 62, the transmission device transmits the position information of the transmission device, the size of the light emitting unit, the shape of the light emitting unit, and the ID of the transmission device. The position information includes the latitude, longitude, altitude, height from the floor surface, and the like of the center part of the light emitting unit.

[0235]

The reception device estimates the imaging direction based on information obtained from the 9-axis sensor and the gyroscope. The reception device estimates the distance from the reception device to the light emitting unit, from the size and shape of the light emitting unit transmitted from the transmission device, the size and shape of the light emitting unit in the captured image, and information about the imaging device. The information about the imaging device includes the focal length of a lens, the distortion of the lens, the size of the imaging element, the distance between the lens and the imaging element, a comparative table of the size of an object of a reference size in the captured image and the distance from the imaging device to the imaging object, and so on.

[0236]

The reception device also estimates the position information of

the reception device, from the information transmitted from the transmission device, the imaging direction, and the distance from the reception device to the light emitting unit. The reception device estimates the moving direction and the moving distance, from the information obtained from the 9-axis sensor and the gyroscope. The reception device estimates the position information of the reception device, using position information estimated at a plurality of points and the position relation between the points estimated from the moving direction and the moving distance.

[0237]

For example, suppose the random field of the position information of the reception device estimated at point [Math. 1] x_1 is [Math. 2] P_{x1}, and the random field of the moving direction and the moving distance estimated when moving from point [Math. 3] x_1 to point [Math. 4] x_2 is [Math. 5] M_{x1x2}. Then, the random field of the eventually estimated position information can be calculated at

[Math. 6]

$$\prod_k^{n-1}\left(P_{x_k} \times M_{x_k x_{k+1}}\right) \times P_{x_n}$$

[0238]

Moreover, in FIG. 62, the transmission device may transmit the position information of the transmission device and the ID of the transmission device. The position information includes the latitude, longitude, altitude, height from the floor surface, and the like of the center part of the light emitting device.

[0239]

In this case, the reception device estimates the imaging direction based on information obtained from the 9-axis sensor and the gyroscope. The reception device estimates the position information of the reception device by trilateration.

[0240]

In FIG. 63, the transmission device transmits the ID of the transmission device.

[0241]

The reception device receives the ID of the transmission

device, and obtains the position information of the transmission device, the size of the light emitting device, the shape of the light emitting device, and the like from the Internet. The position information includes the latitude, longitude, altitude, height from the floor surface, and the like of the center part of the light emitting device.

[0242]

The reception device estimates the imaging direction based on information obtained from the 9-axis sensor and the gyroscope. The reception device estimates the distance from the reception device to the light emitting device, from the size and shape of the light emitting device transmitted from the transmission device, the size and shape of the light emitting device in the captured image, and information about the imaging device. The information about the imaging device includes the focal length of a lens, the distortion of the lens, the size of the imaging element, the distance between the lens and the imaging element, a comparative table of the size of an object of a reference size in the captured image and the distance from the imaging device to the imaging object, and so on.

[0243]

The reception device also estimates the position information of the reception device, from the information obtained from the Internet, the imaging direction, and the distance from the reception device to the light emitting device.

[0244]

In FIG. 64, the transmission device transmits the position information of the transmission device and the ID of the transmission device. The position information includes the latitude, longitude, altitude, height from the floor surface, and the like of the center part of the light emitting device.

[0245]

The reception device estimates the imaging direction based on information obtained from the 9-axis sensor and the gyroscope. The reception device estimates the position information of the reception device by triangulation.

[0246]

In FIG. 65, the transmission device transmits the position information of the transmission device and the ID of the transmission device. The position information includes the latitude, longitude, altitude, height from the floor surface, and the like of the center part of the light emitting device.

[0247]

The reception device estimates the imaging direction based on information obtained from the 9-axis gyroscope. The reception device estimates the position information of the reception device by triangulation. The reception device also estimates the orientation change and movement of the reception device, from the gyroscope and the 9-axis sensor. The reception device may perform zero point adjustment or calibration of the 9-axis sensor simultaneously.

[0248]

(Transmission information setting)

In FIG. 66, a reception device 2606c obtains a transmitted signal by capturing a light emission pattern of a transmission device 2606b, and estimates the position of the reception device.

[0249]

The reception device 2606c estimates the moving distance and direction from the change in captured image and the sensor values of the 9-axis sensor and the gyroscope, during movement.

[0250]

The reception device captures a light receiving unit of a transmission device 2606a, estimates the center position of the light emitting unit, and transmits the position to the transmission device.

[0251]

Since the size information of the light emitting device is necessary for estimating the position of the light emitting unit, the transmission device desirably transmits the size information of the light emitting unit even in the case where part of the transmission information is missing. In the case where the size of the light emitting unit is unknown, the reception device estimates the height of the ceiling from the distance between the transmission device

2606b and the reception device 2606c used in the position estimation and, through the use of this estimation result, estimates the distance between the transmission device 2606a and the reception device 2606c.

[0252]

There are transmission methods such as transmission using a light emission pattern, transmission using a sound pattern, and transmission using a radio wave. The light emission pattern of the transmission device and the corresponding time may be stored and later transmitted to the transmission device or the centralized control device.

[0253]

The transmission device or the centralized control device specifies, based on the light emission pattern and the time, the transmission device captured by the reception device, and stores the position information in the transmission device.

[0254]

In FIG. 67, a position setting point is designated by designating one point of the transmission device as a point in the image captured by the reception device.

[0255]

The reception device calculates the position relation to the center of the light emitting unit of the transmission device from the position setting point, and transmits, to the transmission device, the position obtained by adding the position relation to the setting point.

[0256]

In FIG. 68, the reception device receives the transmitted signal by capturing the image of the transmission device. The reception device communicates with a server or an electronic device based on the received signal.

[0257]

As an example, the reception device obtains the information of the transmission device, the position and size of the transmission device, service information relating to the position, and the like from the server, using the ID of the transmission device included in the

signal as a key.

[0258]

As another example, the reception device estimates the position of the reception device from the position of the transmission device included in the signal, and obtains map information, service information relating to the position, and the like from the server.

[0259]

As yet another example, the reception device obtains a modulation scheme of a nearby transmission device from the server, using the rough current position as a key.

[0260]

As yet another example, the reception device registers, in the server, the position information of the reception device or the transmission device, neighborhood information, and information of any process performed by the reception device in the neighborhood, using the ID of the transmission device included in the signal as a key.

[0261]

As yet another example, the reception device operates the electronic device, using the ID of the transmission device included in the signal as a key.

[0262]

(Block diagram of reception device)

FIG. 69 is a block diagram illustrating the reception device. The reception device includes all of the structure or part of the structure including an imaging unit and a signal analysis unit. In FIG. 69, blocks having the same name may be realized by the same structural element or different structural elements.

[0263]

The reception device in a narrow sense is included in a smartphone, a digital camera, or the like. An input unit 2400h includes all or part of: a user operation input unit 2400i; a light meter 2400j; a microphone 2400k; a timer unit 2400n; a position estimation unit 2400m; and a communication unit 2400p.

[0264]

An imaging unit 2400a includes all or part of: a lens 2400b; an

imaging element 2400c; a focus control unit 2400d; an imaging control unit 2400e; a signal detection unit 2400f; and an imaging information storage unit 2400g. The imaging unit 2400a starts imaging according to a user operation, an illuminance change, or a sound or voice pattern, when a specific time is reached, when the reception device moves to a specific position, or when instructed by another device via a communication unit.

[0265]

The focus control unit 2400d performs control such as adjusting the focus to a light emitting unit 2400ae of the transmission device or adjusting the focus so that the light emitting unit 2400ae of the transmission device is shown in a large size in a blurred state.

[0266]

An exposure control unit 2400ak sets an exposure time and an exposure gain.

[0267]

The imaging control unit 2400e limits the position to be captured, to specific pixels.

[0268]

The signal detection unit 2400f detects pixels including the light emitting unit 2400ae of the transmission device or pixels including the signal transmitted using light emission, from the captured image.

[0269]

The imaging information storage unit 2400g stores control information of the focus control unit 2400d, control information of the imaging control unit 2400e, and information detected by the signal detection unit 2400f. In the case where there are a plurality of imaging devices, imaging may be simultaneously performed by the plurality of imaging devices so that one of the captured images is put to use in estimating the position or orientation of the reception device.

[0270]

A light emission control unit 2400ad transmits a signal by

controlling the light emission pattern of the light emitting unit 2400ae according to the input from the input unit 2400h. The light emission control unit 2400ad obtains, from a timer unit 2400ac, the time at which the light emitting unit 2400ae emits light, and records the obtained time.

[0271]

A captured image storage unit 2400w stores the image captured by the imaging unit 2400a.

[0272]

A signal analysis unit 2400y obtains the transmitted signal from the captured light emission pattern of the light emitting unit 2400ae of the transmission device through the use of the difference between exposure times of lines in the imaging element, based on a modulation scheme stored in the modulation scheme storage unit 2400af.

[0273]

A received signal storage unit 2400z stores the signal analyzed by the signal analysis unit 2400y.

[0274]

A sensor unit 2400q includes all or part of: a GPS 2400r; a magnetic sensor 2400t; an accelerometer 2400s; and a gyroscope 2400u. The magnetic sensor 2400t and the accelerometer 2400s may each be a 9-axis sensor.

[0275]

A position estimation unit estimates the position or orientation of the reception device, from the information from the sensor unit, the captured image, and the received signal.

[0276]

A computation unit 2400aa causes a display unit 2400ab to display the received signal, the estimated position of the reception device, and information (e.g. information relating to a map or locations, information relating to the transmission device) obtained from a network 2400ah based on the received signal or the estimated position of the reception device.

[0277]

The computation unit 2400aa controls the transmission device based on the information input to the input unit 2400h from the received signal or the estimated position of the reception device.

[0278]

A communication unit 2400ag performs communication between terminals without via the network 2400ah, in the case of using a peer-to-peer connection scheme (e.g. Bluetooth).

[0279]

An electronic device 2400aj is controlled by the reception device.

[0280]

A server 2400ai stores the information of the transmission device, the position of the transmission device, and information relating to the position of the transmission device, in association with the ID of the transmission device.

[0281]

The server 2400ai stores the modulation scheme of the transmission device in association with the position.

[0282]

(Block diagram of transmission device)

FIG. 70 is a block diagram illustrating the transmission device.

[0283]

The transmission device includes all of the structure or part of the structure including a light emitting unit, a transmission signal storage unit, a modulation scheme storage unit, and a computation unit.

[0284]

A transmission device 2401ab in a narrow sense is included in an electric light, an electronic device, or a robot.

[0285]

A lighting control switch 2401n is a switch for switching the lighting ON and OFF.

[0286]

A diffusion plate 2401p is a member attached near a light emitting unit 2401q in order to diffuse light of the light emitting unit

2401q.

[0287]

The light emitting unit 2401q is turned ON and OFF at a speed that allows the light emission pattern to be detected on a line basis, through the use of the difference between exposure times of lines in the imaging element of the reception device in FIG. 69.

[0288]

The light emitting unit 2401q is composed of a light source, such as an LED or a fluorescent lamp, capable of turning ON and OFF at high speed.

[0289]

A light emission control unit 2401r controls ON and OFF of the light emitting unit 2401q.

[0290]

A light receiving unit 2401s is composed of a light receiving element or an imaging element. The light receiving unit 2401s converts the intensity of received light to an electric signal. An imaging unit may be used instead of the light receiving unit 2401s.

[0291]

A signal analysis unit 2401t obtains the signal from the pattern of the light received by the light receiving unit 2401s.

[0292]

A computation unit 2401u converts a transmission signal stored in a transmission signal storage unit 2401d to a light emission pattern according to a modulation scheme stored in a modulation scheme storage unit 2401e. The computation unit 2401u controls communication by editing information in the storage unit 2401a or controlling the light emission control unit 2401r, based on the signal obtained from the signal analysis unit 2401t. The computation unit 2401u controls communication by editing information in the storage unit 2401a or controlling the light emission control unit 2401r, based on a signal from an attachment unit 2401w. The computation unit 2401u edits information in the storage unit 2401a or controls the light emission control unit 2401r, based on a signal from a communication unit 2401v.

[0293]

The computation unit 2401u also edits information in a storage unit 2401b in an attachment device 2401h. The computation unit 2401u copies the information in the storage unit 2401b in the attachment device 2401h, to a storage unit 2401a.

[0294]

The computation unit 2401u controls the light emission control unit 2401r at a specified time. The computation unit 2401u controls an electronic device 2401zz via a network 2401aa.

[0295]

The storage unit 2401a includes all or part of: the transmission signal storage unit 2401d; a shape storage unit 2401f; the modulation scheme storage unit 2401e; and a device state storage unit 2401g.

[0296]

The transmission signal storage unit 2401d stores the signal to be transmitted from the light emitting unit 2401q.

[0297]

The modulation scheme storage unit 2401e stores the modulation scheme for converting the transmission signal to the light emission pattern.

[0298]

The shape storage unit 2401f stores the shapes of the transmission device and light emitting unit 2401q.

[0299]

The device state storage unit 2401g stores the state of the transmission device.

[0300]

The attachment unit 2401w is composed of an attachment bracket or a power supply port.

[0301]

The storage unit 2401b in the attachment device 2401h stores information stored in the storage unit 2401a. Here, the storage unit 2401b in the attachment device 2401h or a storage unit 2401c in a centralized control device 2401m may be used, while omitting the

storage unit 2401a.

[0302]

A communication unit 2401v performs communication between terminals without via the network 2400aa, in the case of using a peer-to-peer connection scheme (e.g. Bluetooth).

[0303]

A server 2401y stores the information of the transmission device, the position of the transmission device, and information relating to the position of the transmission device, in association with the ID of the transmission device. The server 2401y also stores the modulation scheme of the transmission device in association with the position.

[0304]

(Reception procedure)

FIG. 71 is explained below. In Step 2800a, whether or not there are a plurality of imaging devices in the reception device is determined. In the case of No, the procedure proceeds to Step 2800b to select an imaging device to be used, and then proceeds to Step 2800c. In the case of Yes, on the other hand, the procedure proceeds to Step 2800c.

[0305]

In Step 2800c, an exposure time (= shutter speed) is set (the exposure time is desirably shorter).

[0306]

Next, in Step 2800d, an exposure gain is set.

[0307]

Next, in Step 2800e, an image is captured.

[0308]

Next, in Step 2800f, a part having at least a predetermined number of consecutive pixels whose luminance exceeds a predetermined threshold is determined for each exposure line, and the center position of the part is calculated.

[0309]

Next, in Step 2800g, a linear or quadratic approximate line connecting the above center positions is calculated.

[0310]

Next, in Step 2800h, the luminance of the pixel on the approximate line in each exposure line is set as the signal value of the exposure line.

[0311]

Next, in Step 2800i, an assigned time per exposure line is calculated from imaging information including an imaging frame rate, a resolution, a blanking time, and the like.

[0312]

Next, in Step 2800j, in the case where the blanking time is less than or equal to a predetermined time, it is determined that the exposure line following the last exposure line of one frame is the first exposure line of the next frame. In the case where the blanking time is greater than the predetermined time, it is determined that unobservable exposure lines as many as the number obtained by dividing the blanking time by the assigned time per exposure line are present between the last exposure line of one frame and the first exposure line of the next frame.

[0313]

Next, in Step 2800k, a reference position pattern and an address pattern are read from decoded information.

[0314]

Next, in Step 2800m, a pattern indicating a reference position of the signal is detected from the signal of each exposure line.

[0315]

Next, in Step 2800n, a data unit and an address unit are calculated based on the detected reference position.

[0316]

Next, in Step 2800p, a transmission signal is obtained.

[0317]

(Self-position estimation procedure)

FIG. 72 is explained below. First, in Step 2801a, a position recognized as the current position of the reception device or a current position probability map is set as self-position prior information.

[0318]

Next, in Step 2801b, the imaging unit of the reception device is pointed to the light emitting unit of the transmission device.

[0319]

Next, in Step 2801c, the pointing direction and elevation angle of the imaging device are calculated from the sensor values of the 9-axis sensor and the gyroscope.

[0320]

Next, in Step 2801d, the light emission pattern is captured and the transmission signal is obtained.

[0321]

Next, in Step 2801e, the distance between the imaging device and the light emitting unit is calculated from information of the size and shape of the light emitting unit included in the transmission signal, the size of the captured light emitting unit, and the imaging magnification factor of the imaging device.

[0322]

Next, in Step 2801f, the relative angle between the direction from the imaging unit to the light emitting unit and the normal line of the imaging plane is calculated from the position of the light emitting unit in the captured image and the lens characteristics.

[0323]

Next, in Step 2801g, the relative position relation between the imaging device and the light emitting unit is calculated from the hitherto calculated values.

[0324]

Next, in Step 2801h, the position of the reception device is calculated from the position of the light emitting unit included in the transmission signal and the relative position relation between the imaging device and the light emitting unit. Note that, when a plurality of transmission devices can be observed, the position of the reception device can be calculated with high accuracy by calculating the coordinates of the imaging device from the signal included in each transmission device. When a plurality of transmission devices can be observed, triangulation is applicable.

[0325]

Next, in Step 2801i, the current position or current position probability map of the reception device is updated from the self-position prior information and the calculation result of the position of the reception device.

[0326]

Next, in Step 2801j, the imaging device is moved.

[0327]

Next, in Step 2801k, the moving direction and distance are calculated from the sensor values of the 9-axis sensor and the gyroscope.

[0328]

Next, in Step 2801m, the moving direction and distance are calculated from the captured image and the orientation of the imaging device. The procedure then returns to Step 2801a.

[0329]

(Transmission control procedure 1)

FIG. 73 is explained below. First, in Step 2802a, the user presses a button.

[0330]

Next, in Step 2802b, the light emitting unit is caused to emit light. Here, a signal may be expressed by the light emission pattern.

[0331]

Next, in Step 2802c, the light emission start time and end time and the time of transmission of a specific pattern are recorded.

[0332]

Next, in Step 2802d, the image is captured by the imaging device.

[0333]

Next, in Step 2802e, the image of the light emission pattern of the transmission device present in the captured image is captured, and the transmitted signal is obtained. Here, the light emission pattern may be synchronously analyzed using the recorded time. The procedure then ends.

[0334]

(Transmission control procedure 2)

FIG. 74 is explained below. First, in Step 2803a, light is received by the light receiving device or the image is captured by the imaging device.

[0335]

Next, in Step 2803b, whether or not the pattern is a specific pattern is determined.

[0336]

In the case of No, the procedure returns to Step 2803a. In the case of Yes, on the other hand, the procedure proceeds to Step 2803c to record the start time and end time of light reception or image capture of the reception pattern and the time of appearance of the specific pattern.

[0337]

Next, in Step 2803d, the transmission signal is read from the storage unit and converted to the light emission pattern.

[0338]

Next, in Step 2803e, the light emitting unit is caused to emit light according to the light emission pattern, and the procedure ends. Here, the light emission may be started after a predetermined time period from the recorded time, with the procedure ending thereafter.

[0339]

(Transmission control procedure 3)

FIG. 75 is explained below. First, in Step 2804a, light is received by the light receiving device, and the received light energy is converted to electricity and accumulated.

[0340]

Next, in Step 2804b, whether or not the accumulated energy is greater than or equal to a predetermined amount is determined.

[0341]

In the case of No, the procedure returns to Step 2804a. In the case of Yes, on the other hand, the procedure proceeds to Step 2804c to analyze the received light and record the time of appearance of the specific pattern.

[0342]

Next, in Step 2804d, the transmission signal is read from the storage unit and converted to the light emission pattern.

[0343]

Next, in Step 2804e, the light emitting unit is caused to emit light according to the light emission pattern, and the procedure ends. Here, the light emission may be started after a predetermined time period from the recorded time, with the procedure ending thereafter.

[0344]

(Information provision inside station)

FIG. 76 is a diagram for describing a situation of receiving information provision inside a station.

[0345]

A reception device 2700a captures an image of a lighting disposed in a station facility and reads a light emission pattern or a position pattern, to receive information transmitted from the lighting device.

[0346]

The reception device 2700a obtains information of the lighting or the facility from a server based on the reception information, and further estimates the current position of the reception device 2700a from the size or shape of the captured lighting.

[0347]

For example, the reception device 2700a displays information obtained based on a facility ID or position information (2700b). The reception device 2700a downloads a map of the facility based on the facility ID, and navigates to a boarding place using ticket information purchased by the user (2700c).

[0348]

Though FIG. 76 illustrates the example inside the train station, the same applies to facilities such as an airport, a harbor, a bus stop, and so on.

[0349]

(Passenger service)

FIG. 77 is a diagram illustrating a situation of use inside a vehicle.

[0350]

A reception device 2704a carried by a passenger and a reception device 2704b carried by a salesperson each receive a signal transmitted from a lighting 2704e, and estimates the current position of the reception device itself.

[0351]

Note that each reception device may obtain necessary information for self-position estimation from the lighting 2704e, obtain the information from a server using the information transmitted from the lighting 2704e as a key, or obtain the information beforehand based on position information of a train station, a ticket gate, or the like.

[0352]

The reception device 2704a may recognize that the current position is inside the vehicle from ride time information of a ticket purchased by the user (passenger) and the current time, and download information associated with the vehicle.

[0353]

Each reception device notifies a server of the current position of the reception device. The reception device 2704a notifies the server of a user (passenger) ID, a reception device ID, and ticket information purchased by the user (passenger), as a result of which the server recognizes that the person in the seat is a person entitled to riding or reserved seating.

[0354]

The reception device 2704a displays the current position of the salesperson, to enable the user (passenger) to decide the purchase timing for sales aboard the train.

[0355]

When the passenger orders an item sold aboard the train through the reception device 2704a, the reception device 2704a notifies the reception device 2704b of the salesperson or the server of the position of the reception device 2704a, order details, and billing information. The reception device 2704b of the salesperson displays a map 2704d indicating the position of the customer.

[0356]

The passenger may also purchase a seat reservation ticket or a transfer ticket through the reception device 2704a.

[0357]

The reception device 2704a displays available seat information 2704c. The reception device 2704a notifies the server of reserved seat ticket or transfer ticket purchase information and billing information, based on travel section information of the ticket purchased by the user (passenger) and the current position of the reception device 2704a.

[0358]

Though FIG. 77 illustrates the example inside the train, the same applies to vehicles such as an airplane, a ship, a bus, and so on.

[0359]

(In-store service)

FIG. 78 is a diagram illustrating a situation of use inside a store or a shop.

[0360]

Reception devices 2707b, 2707c, and 2707d each receive a signal transmitted from a lighting 2707a, estimate the current position of the reception device itself, and notify a server of the current position.

[0361]

Note that each reception device may obtain necessary information for self-position estimation and a server address from the lighting 2707a, obtain the necessary information and the server address from another server using information transmitted from the lighting 2707a as a key, or obtain the necessary information and the server address from an accounting system.

[0362]

The accounting system associates accounting information with the reception device 2707d, displays the current position of the reception device 2707d (2707c), and delivers the ordered item.

[0363]

The reception device 2707b displays item information based

on the information transmitted from the lighting 2707a. When the customer orders from the displayed item information, the reception device 2707b notifies the server of item information, billing information, and the current position.

[0364]

Thus, the seller can deliver the ordered item based on the position information of the reception device 2707b, and the purchaser can purchase the item while remaining seated.

[0365]

(Wireless connection establishment)

FIG. 79 is a diagram illustrating a situation of communicating wireless connection authentication information to establish wireless connection.

[0366]

An electronic device (digital camera) 2701b operates as a wireless connection access point and, as information necessary for the connection, transmits an ID or a password as a light emission pattern.

[0367]

An electronic device (smartphone) 2701a obtains the transmission information from the light emission pattern, and establishes the wireless connection.

[0368]

Though the wireless connection is mentioned here, the connection to be established may be a wired connection network.

[0369]

The communication between the two electronic devices may be performed via a third electronic device.

[0370]

(Communication range adjustment)

FIG. 80 is a diagram illustrating a range of communication using a light emission pattern or a position pattern.

[0371]

In a communication scheme using a radio wave, it is difficult to limit the communication range because the radio wave also reaches

an adjacent room separated by a wall.

[0372]

In communication using a light emission pattern or a position pattern, on the other hand, the communication range can be easily limited using an obstacle because visible light and its surrounding area wavelengths are used. Moreover, the use of visible light has an advantage that the communication range is recognizable even by the human eye.

[0373]

(Indoor use)

FIG. 81 is a diagram illustrating a situation of indoor use such as an underground city.

[0374]

A reception device 2706a receives a signal transmitted from a lighting 2706b, and estimates the current position of the reception device 2706a. The reception device 2706a also displays the current position on a map to provide directions, or displays nearby shop information.

[0375]

By transmitting disaster information or evacuation information from the lighting 2706b in the event of an emergency, such information can be obtained even in the case of communication congestion, in the case of a failure of a communication base station, or in the case of being situated in a place where it is difficult for a radio wave from a communication base station to penetrate. This is beneficial to people who missed hearing emergency broadcasting or hearing-impaired people who cannot hear emergency broadcasting.

[0376]

(Outdoor use)

FIG. 82 is a diagram illustrating a situation of outdoor use such as a street.

[0377]

A reception device 2705a receives a signal transmitted from a street lighting 2705b, and estimates the current position of the reception device 2705a. The reception device 2705a also displays

the current position on a map to provide directions, or displays nearby shop information.

[0378]

By transmitting disaster information or evacuation information from the lighting 2705b in the event of an emergency, such information can be obtained even in the case of communication congestion, in the case of a failure of a communication base station, or in the case of being situated in a place where it is difficult for a radio wave from a communication base station to penetrate.

[0379]

Moreover, displaying the movements of other vehicles and pedestrians on the map and notifying the user of any approaching vehicles or pedestrians contributes to accident prevention.

[0380]

(Route indication)

FIG. 83 is a diagram illustrating a situation of route indication.

[0381]

A reception device 2703e can download a neighborhood map or estimate the position of the reception device 2703a with an accuracy error of 1 cm to tens of cm, through the use of information transmitted from transmission devices 2703a, 2703b, and 2703c.

[0382]

When the accurate position of the reception device 2703e is known, it is possible to automatically drive a wheelchair 2703d or ensure safe passage of visually impaired people.

[0383]

(Use of a plurality of imaging devices)

A reception device in FIG. 84 includes an in camera 2710a, a touch panel 2710b, a button 2710c, an out camera 2710d, and a flash 2710e.

[0384]

When capturing the transmission device by the out camera, image stabilization can be performed by estimating the movement or orientation of the reception device from an image captured by the in camera.

[0385]

By receiving a signal from another transmission device using the in camera, it is possible to simultaneously receive the signals from the plurality of devices or enhance the self-position estimation accuracy of the reception device.

[0386]

(Transmission device autonomous control)

In FIG. 85, a transmission device 1 receives light of a light emitting unit of a transmission device 2 by a light receiving unit, to obtain a signal transmitted from the transmission device 2 and its transmission timing.

[0387]

In the case where no transmission signal is stored in a storage unit of the transmission device 1, the transmission device 1 transmits a signal by emitting light in the same pattern synchronously with the light emission of the transmission device 2.

[0388]

In the case where a transmission signal is stored in the storage unit of the transmission device 1, on the other hand, the transmission device 1 transmits a part common with the transmission signal of the transmission device 2 by emitting light in the same pattern synchronously with the light emission of the transmission device 2. The transmission device 1 also transmits a part not common with the transmission signal of the transmission device 2, during a time in which the transmission device 2 transmits no signal. In the case where there is no time in which the transmission device 2 transmits no signal, the transmission device 1 specifies a period appropriately and transmits the uncommon part according to the period. In this case, the transmission device 2 receives the light emitted from the transmission device 1 by a light receiving unit, detects that a different signal is transmitted at the same time, and transmits an uncommon part of signal during a time in which the transmission device 1 transmits no signal.

[0389]

CSMA/CD (Carrier Sense Multiple Access with Collision

Detection) is used for avoiding collisions in signal transmission using light emission.

[0390]

The transmission device 1 causes the light emitting unit to emit light using its own information as a light emission pattern.

[0391]

The transmission device 2 obtains the information of the transmission device 1 by the light receiving unit.

[0392]

The transmission device generates a transmission device arrangement map by exchanging, between communicable transmission devices, their information. The transmission device also calculates an optimal light emission pattern as a whole so as to avoid collisions in signal transmission using light emission. Further, the transmission device obtains information obtained by the other transmission device(s), through communication between the transmission devices.

[0393]

(Transmission information setting)

In FIG. 86, a transmission device stores information stored in a storage unit of an attachment device into a storage unit of the transmission device, when the transmission device is attached to the attachment device or the information stored in the storage unit of the attachment device is changed. The information stored in the storage unit of the attachment device or the transmission device includes a transmission signal and its transmission timing.

[0394]

In the case where the information stored in the storage unit is changed, the transmission device stores the information into the storage unit of the attachment device. The information in the storage unit of the attachment device or the storage unit of the transmission device is edited from a centralized control device or a switchboard. Power line communication is used when operating from the switchboard.

[0395]

A shape storage unit in the transmission device stores a position relation between a center position of a light emitting unit and an attachment unit of the transmission device.

[0396]

When transmitting position information, the transmission device transmits position information obtained by adding the position relation to position information stored in the storage unit.

[0397]

Information is stored into the storage unit of the attachment device upon building construction or the like. In the case of storing position information, the accurate position is stored through the use of a design or CAD data of the building. Transmitting the position information from the transmission device upon building construction enables position identification, which may be utilized for construction automation, material use position identification, and the like.

[0398]

The attachment device notifies the centralized control device of the information of the transmission device. The attachment device notifies the centralized control device that a device other than the transmission device is attached.

[0399]

In FIG. 87, a transmission device receives light by a light receiving unit, obtains information from the light pattern by a signal analysis unit, and stores the information into a storage unit. Upon light reception, the transmission device converts information stored in the storage unit to a light emission pattern and causes a light emitting unit to emit light.

[0400]

Information about the shape of the transmission device is stored in a shape storage unit.

[0401]

In FIG. 88, a transmission device stores a signal received by a communication unit, into a storage unit. Upon reception, the transmission device converts information stored in the storage unit to a light emission pattern and causes a light emitting unit to emit

light.

[0402]

Information about the shape of the transmission device is stored in a shape storage unit.

[0403]

In the case where no transmission signal is stored in the storage unit, the transmission device converts an appropriate signal to a light emission pattern and causes the light emitting unit to emit light.

[0404]

A reception device obtains the signal transmitted from the transmission device by an imaging unit, and notifies a transmission device or a centralized control device of the signal and information to be stored in the transmission device, via a communication unit.

[0405]

The transmission device or the centralized control device stores the transmitted information into the storage unit of the transmission device transmitting the same signal as the signal obtained by the imaging unit of the reception device.

[0406]

Here, the reception device may transmit the signal transmitted from the transmission device according to the time of image capture so that the transmission device or the centralized control device specifies the transmission device captured by the reception device using the time.

[0407]

Note that the information may be transmitted from the reception device to the transmission device using a light emission pattern, where the communication unit of the reception device is a light emitting unit and the communication unit of the transmission device is a light receiving unit or an imaging unit.

[0408]

Alternatively, the information may be transmitted from the reception device to the transmission device using a sound pattern, where the communication unit of the reception device is a sound

emitting unit and the communication unit of the transmission device is a sound receiving unit.

[0409]

(Combination with 2D barcode)

FIG. 89 is a diagram illustrating a situation of use in combination with 2D (two-dimensional) barcode.

[0410]

The user sets a communication device 2714a and a communication device 2714d opposed to each other.

[0411]

The communication device 2714a displays transmission information on a display as 2D barcode 2714c.

[0412]

The communication device 2714d reads the 2D barcode 2714c by a 2D barcode reading unit 2714f. The communication device 2714d expresses transmission information as a light emission pattern of a light emitting unit 2714e.

[0413]

The communication device 2714a captures the light emitting unit by an imaging unit 2714b, and reads the signal. According to this method, two-way direct communication is possible. In the case where the amount of data to be transmitted is small, faster communication can be performed than communication via a server.

[0414]

(Map generation and use)

FIG. 90 is a diagram illustrating a situation of map generation and use.

[0415]

A robot 2715a creates a room map 2715f by performing self-position estimation based on signals transmitted from a lighting 2715d and an electronic device 2715c, and stores the map information, the position information, and the IDs of the lighting 2715d and the electronic device 2715c into a server 2715e.

[0416]

Likewise, a reception device 2715b creates the room map

2715f from the signals transmitted from the lighting 2715d and the electronic device 2715c, an image captured during movement, and sensor values of the gyroscope and the 9-axis sensor, and stores the map information, the position information, and the IDs of the lighting 2715d and the electronic device 2715c into the server 2715e.

[0417]

The robot 2715a performs cleaning or serving efficiently, based on the map 2715f obtained from the server 2715e.

[0418]

The reception device 2715b indicates the cleaning area or the moving destination to the robot 2715a or operates an electronic device in the pointing direction of the reception device, based on the map 2715f obtained from the server 2715e.

[0419]

(Electronic device state obtainment and operation)

FIG. 91 is a diagram illustrating a situation of electronic device state obtainment and operation.

[0420]

A communication device 2716a converts control information to a light emission pattern, and causes a light emitting unit to emit light to a light receiving unit 2716d of an electronic device 2716b.

[0421]

The electronic device 2716b reads the control information from the light emission pattern, and operates according to the control information. Upon light reception by the light receiving unit 2716d, the electronic device 2716b converts information indicating the state of the electronic device to a light emission pattern, and causes a light emitting unit 2716c to emit light. Moreover, in the case where there is information to be notified to the user such as when the operation ends or when an error occurs, the electronic device 2716b converts the information to a light emission pattern and causes the light emitting unit 2716c to emit light.

[0422]

The communication device 2716a captures the image of the light emitting unit 2716c, and obtains the transmitted signal.

[0423]

(Electronic device recognition)

FIG. 92 is a diagram illustrating a situation of recognizing a captured electronic device.

[0424]

A communication device 2717a has communication paths to an electronic device 2717b and an electronic device 2717e, and transmits an ID display instruction to each electronic device.

[0425]

The electronic device 2717b receives the ID display instruction, and transmits an ID signal using a light emission pattern of a light emitting unit 2717c.

[0426]

The electronic device 2717e receives the ID display instruction, and transmits an ID signal using a position pattern with light emitting units 2717f, 2717g, 2717h, and 2717i.

[0427]

Here, the ID signal transmitted from each electronic device may be an ID held in the electronic device or the details of indication by the communication device 2717a.

[0428]

The communication device 2717a recognizes the captured electronic device and the position relation between the electronic device and the reception device, from the light emission pattern or the position pattern of the light emitting unit(s) in the captured image.

[0429]

Note that the electronic device desirably includes three or more light emitting units to enable the recognition of the position relation between the electronic device and the reception device.

[0430]

(Augmented reality object display)

FIG. 93 is a diagram illustrating a situation of displaying an augmented reality (AR) object.

[0431]

A stage 2718e for augmented reality display is a light emission pattern or a position pattern of light emitting units 2718a, 2718b, 2718c, and 2718d, to transmit information of the augmented reality object and a reference position for displaying the augmented reality object.

[0432]

A reception device superimposes an augmented reality object 2718f on a captured image and displays it, based on the received information.

[0433]

(User interface)

In the case where the light emitting unit is not within the center area of the imaging range, such display that prompts the user to point the center of the imaging range to the light emitting unit is made in order to point the center of the imaging range to the light emitting unit, as illustrated in FIG. 94.

[0434]

In the case where the light emitting unit is not within the center area of the imaging range, such display that prompts the user to point the center of the imaging range to the light emitting unit is made in order to point the center of the imaging range to the light emitting unit, as illustrated in FIG. 95.

[0435]

Even when the light emitting unit is not recognized within the imaging range, if the position of the light emitting unit can be estimated from the previous imaging result or the information of the 9-axis sensor, gyroscope, microphone, position sensor, and the like equipped in the imaging terminal, such display that prompts the user to point the center of the imaging range to the light emitting unit is made as illustrated in FIG. 96.

[0436]

To point the center of the imaging range to the light emitting unit, the size of a figure displayed according to the moving distance of the imaging range is adjusted as illustrated in FIG. 97.

[0437]

In the case where the light emitting unit is captured small, such display that prompts the user to get closer to the light emitting unit to capture the image is made in order to capture the light emitting unit larger, as illustrated in FIG. 98.

[0438]

In the case where the light emitting unit is not within the center of the imaging range and also the light emitting unit is not captured in a sufficiently large size, such display that prompts the user to point the center of the imaging range to the light emitting unit and also prompts the user to get closer to the light emitting unit to capture the image is made as illustrated in FIG. 99.

[0439]

In the case where the signal of the light emitting unit can be more easily received by changing the angle between the light emitting unit and the imaging range, such display that prompts the user to rotate the imaging range is made as illustrated in FIG. 100.

[0440]

In the case where the light emitting unit is not within the center of the imaging range and also the signal of the light emitting unit can be more easily received by changing the angle between the light emitting unit and the imaging range, such display that prompts the user to point the center of the imaging range to the light emitting unit and also prompts the user to rotate the imaging range is made as illustrated in FIG. 101.

[0441]

In the case where the light emitting unit is not captured in a sufficiently large size and also the signal of the light emitting unit can be more easily received by changing the angle between the light emitting unit and the imaging range, such display that prompts the user to get closer to the light emitting unit to capture the image and also prompts the user to rotate the imaging range is made as illustrated in FIG. 102.

[0442]

In the case where the light emitting unit is not within the center of the imaging range, the light emitting unit is not captured in

a sufficiently large size, and also the signal of the light emitting unit can be more easily received by changing the angle between the light emitting unit and the imaging range, such display that prompts the user to point the center of the imaging range to the light emitting unit, prompts the user to get closer to the light emitting unit to capture the image, and also prompts the user to rotate the imaging range is made as illustrated in FIG. 103.

[0443]

During signal reception, information that the signal is being received and the information amount of the received signal are displayed as illustrated in FIG. 104.

[0444]

In the case where the size of the signal to be received is known, during signal reception, the proportion of the signal the reception of which has been completed and the information amount are displayed with a progress bar, as illustrated in FIG. 105.

[0445]

During signal reception, the proportion of the signal the reception of which has been completed, the received parts, and the information amount of the received signal are displayed with a progress bar, as illustrated in FIG. 106.

[0446]

During signal reception, the proportion of the signal the reception of which has been completed and the information amount are displayed so as to superimpose on a light emitting unit, as illustrated in FIG. 107.

[0447]

In the case where a light emitting unit is detected, information that the object is a light emitting unit is displayed by, for example, displaying the light emitting unit as blinking, as illustrated in FIG. 108.

[0448]

While receiving a signal from a light emitting unit, information that the signal is being received from the light emitting unit is displayed by, for example, displaying the light emitting unit as

blinking, as illustrated in FIG. 109.

[0449]

In FIG. 110, in the case where a plurality of light emitting units are detected, the user is prompted to designate a transmission device from which a signal is to be received or which is to be operated, by tapping any of the plurality of light emitting units.

[0450]

[Embodiment 4]

(Application to ITS)

The following describes ITS (Intelligent Transport Systems) as an example of application of the present invention. In this embodiment, high-speed communication of visible light communication is realized, which is adaptable to the field of ITS.

[0451]

FIG. 111 is a diagram for describing communication between a transport system having the visible light communication function and a vehicle or a pedestrian. A traffic light 6003 has the visible light communication function according to this embodiment, and is capable of communicating with a vehicle 6001 and a pedestrian 6002.

[0452]

Information transmission from the vehicle 6001 or the pedestrian 6002 to the traffic light 6003 is performed using, for example, a headlight or a flash light emitting unit of a mobile terminal carried by the pedestrian. Information transmission from the traffic light 6003 to the vehicle 6001 or the pedestrian 6002 is performed by signal illumination using a camera sensor of the traffic light 6003 or a camera sensor of the vehicle 6001.

[0453]

The function of communication between a traffic assistance object disposed on the road, such as a road lighting or a road information board, and the vehicle 6001 or the pedestrian 6002 is also described below. Here, since the communication method is the same, the description of other objects is omitted.

[0454]

As illustrated in FIG. 111, the traffic light 6003 provides road

traffic information to the vehicle 6001. The road traffic information mentioned here is information for helping driving, such as congestion information, accident information, and nearby service area information.

[0455]

The traffic light 6003 includes an LED lighting. Communication using this LED lighting enables information to be provided to the vehicle 6001 with no need for addition of a new device. Since the vehicle 6001 usually moves at high speed, only a small amount of data can be transmitted in conventional visible light communication techniques. However, the improvement in communication speed according to this embodiment produces an advantageous effect that a larger size of data can be transmitted to the vehicle.

[0456]

Moreover, the traffic light 6003 or a lighting 6004 is capable of providing different information depending on signal or light. It is therefore possible to transmit information according to the vehicle position, such as transmitting information only to each vehicle running in a right turn lane.

[0457]

Regarding the pedestrian 6002, too, it is possible to provide information only to each pedestrian 6002 at a specific spot. For example, only each pedestrian waiting at a crosswalk signal at a specific intersection may be provided with information that the intersection is accident-prone, city spot information, and the like.

[0458]

The traffic light 6003 is also capable of communicating with another traffic light 6005. For example, in the case of changing information provided from the traffic light 6003, the information distributed from the traffic light can be changed through communication relay between traffic lights, with there being no need to newly connecting a signal line or a communication device to the traffic light. According to the method of this embodiment, the communication speed of visible light communication can be

significantly improved, so that the distribution information can be changed in a shorter time. This allows the distribution information to be changed several times a day, as an example. Besides, snow information, rain information, and the like can be distributed immediately.

[0459]

Furthermore, the lighting may distribute the current position information to provide the position information to the vehicle 6001 or the pedestrian 6002. In facilities with roofs such as a shopping arcade and a tunnel, it is often difficult to obtain position information using a GPS. However, the use of visible light communication has an advantageous effect that the position information can be obtained even in such a situation. In addition, since the communication speed can be increased according to this embodiment as compared with conventional techniques, for example it is possible to receive information while passing a specific spot such as a store or an intersection.

[0460]

Note that this embodiment provides speedups in visible light communication, and so is equally applicable to all other ITS systems using visible light communication.

[0461]

FIG. 112 is a schematic diagram of the case of applying the present invention to inter-vehicle communication where vehicles communicate with each other using visible light communication.

[0462]

The vehicle 6001 transmits information to a vehicle 6001a behind, through a brake lamp or other LED light. The vehicle 6001 may also transmit data to an oncoming vehicle 6001b, through a headlight or other front light.

[0463]

By communicating between vehicles using visible light in this way, the vehicles can share their information with each other. For instance, congestion information or warning information may be provided to the vehicle behind by relay transmission of information of

an accident at an intersection ahead.

[0464]

Likewise, information for helping driving may be provided to the oncoming vehicle by transmitting congestion information or sudden braking information obtained from sensor information of the brake.

[0465]

Since the communication speed of visible light communication is improved according to the present invention, there is an advantageous effect that information can be transmitted while passing the oncoming vehicle. Regarding the vehicle behind, too, information can be transmitted to many vehicles in a shorter time because the information transmission interval is shorter. The increase in communication speed also enables transmission of sound or image information. Hence, richer information can be shared among vehicles.

[0466]

(Position information reporting system and facility system)

FIG. 113 is a schematic diagram of a position information reporting system and a facility system using the visible light communication technique according to this embodiment. A system of delivering patient medical records, transported articles, drugs, and the like by a robot inside a hospital is described as a typical example.

[0467]

A robot 6101 has the visible light communication function. A lighting distributes position information. The robot 6101 obtains the position information of the lighting, with it being possible to deliver drugs or other items to a specific hospital room. This alleviates burdens on doctors. Since the light never leaks to an adjacent room, there is also an advantageous effect that the robot 6101 is kept from going to the wrong room.

[0468]

The system using visible light communication according to this embodiment is not limited to hospitals, and is adaptable to any

system that distributes position information using lighting equipment. Examples of this include: a mechanism of transmitting position and guidance information from a lighting of an information board in an indoor shopping mall; and an application to cart movement in an airport.

[0469]

Moreover, by providing a shop lighting with the visible light communication technique, it is possible to distribute coupon information or sale information. When the information is superimposed on visible light, the user intuitively understands that he or she is receiving the information from the light of the shop. This has an advantageous effect of enhancing user convenience.

[0470]

In the case of transmitting information in or outside a room, if position information is distributed using a wireless LAN, radio waves leak to an adjacent room or corridor, so that a function of blocking radio waves by the outer wall to prevent radio waves from leaking out of the room is needed. Such blocking radio waves by the outer wall causes a problem that any device communicating with the outside, such as a mobile phone, is unusable.

[0471]

When transmitting position information using visible light communication according to this embodiment, the communication can be confined within the reach of light. This has an advantageous effect that, for example, position information of a specific room can be easily transmitted to the user. There is also an advantageous effect that no special device is needed because normally light is blocked by the outer wall.

[0472]

In addition, since the positions of lightings are usually unchanged in buildings, large-scale facilities, and ordinary houses, the position information transmitted by each lighting does not change frequently. The frequency of updating a database of the position information of each lighting is low. This has an advantageous effect that the maintenance cost in position

information management is low.

[0473]

(Supermarket system)

FIG. 114 illustrates a supermarket system in which, in a store, a device capable of the communication method according to this embodiment is mounted on a shopping cart to obtain position information from a shelf lighting or an indoor lighting.

[0474]

A cart 6201 carries a visible light communication device that uses the communication method according to this embodiment. A lighting 6100 distributes position information and shelf information by visible light communication. The cart can receive product information distributed from the lighting. The cart can also receive the position information to thereby recognize at which shelf the cart is situated. For example, by storing shelf position information in the cart, the direction can be displayed on the cart when the user designates, to the cart, to which shelf he or she wants to go or which product he or she wants to buy.

[0475]

Visible light communication enables obtainment of such accurate position information that makes the shelf positions known, so that the movement information of the cart can be obtained and utilized. For example, a database of position information obtained by the cart from each lighting may be created.

[0476]

The information from the lighting, together with cart information, is transmitted using visible light communication, or transmitted to a server using a wireless LAN or the like. Alternatively, a memory is equipped in the cart, and data is collected after the store is closed to compile, in the server, which path each cart has taken.

[0477]

By collecting the cart movement information, it is possible to recognize which shelf is popular and which aisle is passed most. This has an advantageous effect of being applicable to marketing.

[0478]

(Communication between mobile phone terminal and camera)

FIG. 115 illustrates an example of application of using visible light communication according to this embodiment.

[0479]

A mobile phone terminal 6301 transmits data to a camera 6302 using a flash. The camera 6302 receives the data transmitted from the mobile phone terminal 6301, from light information received by an imaging unit.

[0480]

Camera imaging settings are stored in the mobile phone terminal 6301 beforehand, and setting information is transmitted to the camera 6302. Thus, the camera can be set using rich user interfaces of the mobile phone terminal.

[0481]

Moreover, the use of the image sensor of the camera enables the setting information to be transmitted from the mobile phone terminal to the camera upon communication between the camera and the mobile phone terminal, with there being no need to provide a new communication device such as a wireless LAN.

[0482]

(Underwater communication)

FIG. 116 is a schematic diagram of the case of adapting the communication method according to this embodiment to underwater communication. Since radio waves do not penetrate water, divers underwater or a ship on the sea and a ship in the sea cannot communicate with each other by radio. Visible light communication according to this embodiment, on the other hand, is available even underwater.

[0483]

In the visible light communication method according to this embodiment, data can be transmitted from an object or building emitting light. By pointing a light receiving unit to a building, it is possible to obtain guidance information or detailed information of the building. This allows useful information to be provided to tourists.

[0484]

The visible light communication method according to this embodiment is also applicable to communication from a lighthouse to a ship. More detailed information can be transferred because a larger amount of communication than in conventional techniques is possible.

[0485]

Since light is used in visible light communication according to this embodiment, communication control on a room basis such as communicating only in a specific room can be carried out. As an example, the communication method according to this embodiment may be applied to the case of accessing information available only in a specific room in a library. As another example, the communication method according to this embodiment may be used for exchange of key information, while communication such as a wireless LAN is used for actual communication.

[0486]

Note that the communication method according to this embodiment can be used for all imaging devices having MOS sensors and LED communication, and are applicable to digital cameras, smartphones, and so on.

[0487]

[Embodiment 5]

(Service provision example)

This embodiment describes an example of service provision to a user as an example of application of the present invention, with reference to FIG. 117. FIG. 117 is a diagram for describing an example of service provision to a user in Embodiment 5. A network server 4000a, transmitters 4000b, 4000d, and 4000e, receivers 4000c and 4000f, and a building 4000g are illustrated in FIG. 117.

[0488]

The receivers 4000c and 4000f receive signals from the plurality of transmitters 4000b, 4000d, and 4000e in or outside the house and process the received signals, and can thereby provide services to the user. Here, the transmitters and the receivers may

process the signals individually to provide the services to the user, or provide the services to the user while changing their behaviors or transmitted signals according to instructions from a network in cooperation with the network server 4000a forming the network.

[0489]

Note that the transmitters and the receivers may be equipped in mobile objects such as vehicles or persons, equipped in stationary objects, or later equipped in existing objects.

[0490]

FIG. 118 is a diagram for describing an example of service provision to a user in Embodiment 5. Transmitters 4001a and a receiver 4001b are illustrated in FIG. 118.

[0491]

As illustrated in FIG. 118, the receiver 4001b receives signals transmitted from the plurality of transmitters 4001a and processes information included in the signals, thereby providing services to the user. The information included in the signals are information relating to: devices IDs uniquely identifying devices; position information; maps; signs; tourist information; traffic information; regional services; coupons; advertisements; product description; characters; music; video; photos; sounds; menus; broadcasting; emergency guidance; time tables; guides; applications; news; bulletin boards; commands to devices; information identifying individuals; vouchers; credit cards; security; and URLs, for example.

[0492]

The user may perform a registration process or the like for using the information included in the signals on a network server beforehand so that the user can be provided with services by receiving the signals by the receiver 4001b at the place where the transmitters 4001a transmit the signals. Alternatively, the user may be provided with services without via the network server.

[0493]

FIG. 119 is a flowchart illustrating the case where the receiver simultaneously processes the plurality of signals received from the transmitters in this embodiment.

[0494]

First, the procedure starts in Step 4002a. Next, in Step 4002b, the receiver receives the signals from the plurality of light sources. Next, in Step 4002c, the receiver determines the area in which each light source is displayed from the reception result, and extracts the signal from each area.

[0495]

In Step 4002e, the receiver repeatedly performs a process based on information included in the signal for the number of obtained signals until the number of signals to be processed reaches 0 in Step 4002d. When the number of signals to be processed reaches 0, the procedure ends in Step 4002f.

[0496]

FIG. 120 is a diagram illustrating an example of the case of realizing inter-device communication by two-way communication in Embodiment 5. An example of the case of realizing inter-device communication by two-way communication between a plurality of transmitter-receivers 4003a, 4003b, and 4003c each including a transmitter and a receiver is illustrated in FIG. 118. Note that the transmitter-receivers may be capable of communication between the same devices as in FIG. 118, or communication between different devices.

[0497]

Moreover, in this embodiment, the user can be provided with services in such a manner that applications are distributed to a mobile phone, a smartphone, a personal computer, a game machine, or the like using the communication means in this embodiment or other networks or removable storages and already equipped devices (LED, photodiode, image sensor) are used from the applications. Here, the applications may be installed in the device beforehand.

[0498]

(Example of service using directivity)

A service using directivity characteristics in this embodiment is described below, as an example of application of the present invention. In detail, this is an example of the case of using the

present invention in public facilities such as a movie theater, a concert hall, a museum, a hospital, a community center, a school, a company, a shopping arcade, a department store, a government office, and a food shop. The present invention achieves lowering of directivity of a signal transmitted from a transmitter to a receiver as compared with conventional visible light communication, so that information can be simultaneously transmitted to many receivers present in a public facility.

[0499]

FIG. 121 is a diagram for describing a service using directivity characteristics in Embodiment 5. A screen 4004a, a receiver 4004b, and a lighting 4004c are illustrated in FIG. 121.

[0500]

As illustrated in FIG. 121, the application of this embodiment to the movie theater can suppress a situation where, during a movie, the user uses such a device (mobile phone, smartphone, personal computer, game machine, etc.) that interferes with the other users enjoying the movie. The transmitter uses, as a signal, video projected on the screen 4004a displaying the movie or light emitted from the lighting 4004c disposed in the facility, and includes a command for controlling the receiver 4004b in the signal. By the receiver 4004b receiving the command, it is possible to control the operation of the receiver 4004b to prevent any act that interferes with the other users watching the movie. The command for controlling the receiver 4004b relates to power or reception sound, communication function, LED display, vibration ON/OFF, level adjustment, and the like.

[0501]

Moreover, the strength of directivity can be controlled by the receiver filtering the signal from the transmitter through the use of the intensity of the light source and the like. In this embodiment, the command or information can be simultaneously transmitted to the receivers present in the facility, by setting low directivity.

[0502]

In the case of increasing the directivity, the constraint may be

imposed by the transmitter limiting the amount of light source or the receiver reducing the sensitivity of receiving the light source or performing signal processing on the received light source amount.

[0503]

In the case where this embodiment is applied to a store where the user's order is received and processed at the place, such as a food shop or a government office, a signal including the order transmitted from a transmitter held by the user is received by a receiver placed at such a position that can overlook the store, so that which menu is ordered by the user of which seat can be detected. The service provider processes the order on a time axis, with it being possible to provide the service of high fairness to the user.

[0504]

Here, a secret key or a public key preset between the transmitter and the receiver may be used to encrypt/decrypt the information included in the signal, to thereby restrict transmitters capable of signal transmission and receivers capable of signal reception. Moreover, a protocol such as SSL used in the Internet by default may be employed for a transmission path between the transmitter and the receiver, to prevent signal interception by other devices.

[0505]

(Service example by combination of real world and Internet world)

The following describes a service provided to a user by superimposing of information of the real world captured by a camera and the Internet world, as an example of application of the present invention.

[0506]

FIG. 122 is a diagram for describing another example of service provision to a user in Embodiment 5. In detail, FIG. 122 illustrates an example of a service in the case of applying this embodiment using a camera 4005a equipped in a receiver such as a mobile phone, a smartphone, or a game machine. The camera 4005a, light sources 4005b, and superimposition information 4005c are illustrated in FIG. 122.

[0507]

Signals 4005d transmitted from the plurality of light sources 4005b are extracted from the imaging result of the camera 4005a, and information included in the signals 4005d is superimposed on the camera 4005a and displayed. Examples of the superimposition information 4005c to be superimposed on the camera 4005a include character strings, images, video, characters, applications, and URLs. Note that the information included in the signals may be processed not only by superimposition on the camera but also by use of sounds, vibrations, or the like.

[0508]

FIG. 123 is a diagram illustrating a format example of a signal included in a light source emitted from a transmitter. Light source characteristics 4006a, a service type 4006b, and service-related information 4006c are illustrated in FIG. 123.

[0509]

The information 4006c related to the service of superimposing the signal received by the receiver on the camera is the result of filtering the information obtainable from the signal according to the information such as the service type 4006b included in the signal transmitted from the transmitter and the distance from the camera to the light source. The information to be filtered by the receiver may be determined according to settings made in the receiver beforehand or user preference set in the receiver by the user.

[0510]

The receiver can estimate the distance to the transmitter transmitting the signal, and display the distance to the light source. The receiver estimates the distance to the transmitter, by performing digital signal processing on the intensity of light emitted from the transmitter captured by the camera.

[0511]

However, since the intensity of light of each transmitter captured by the camera of the receiver is different depending on the position or strength of the light source, significant deviation may be caused if the distance is estimated only by the intensity of light of the

captured transmitter.

[0512]

To solve this, the light source characteristics 4006a indicating the intensity, color, type, and the like of the light source are included in the signal transmitted from the transmitter. By performing digital signal processing while taking into account the light source characteristics included in the signal, the receiver can estimate the distance with high accuracy. In the case where a plurality of light sources are captured by the receiver, if all light sources have the same intensity, the distance is estimated using the intensity of light of the light source. If there is a transmitter of different intensity out of the light sources captured by the receiver, the distance from the transmitter to the receiver is estimated by not only using the light source amount but also using other distance measurement means in combination.

[0513]

As the other distance measurement means, the distance may be estimated by using the parallax in image captured by a twin-lens camera, by using an infrared or millimeter wave radar, or by obtaining the moving amount of the receiver by a 9-axis sensor or an image sensor in the receiver and combining the moving distance with triangulation.

[0514]

Note that the receiver may not only filter and display the signal using the strength or distance of the signal transmitted from the transmitter, but also adjust the directivity of the signal received from the transmitter.

[0515]

[Embodiment 6]

The following is a description of the flow of processing of communication performed using a camera of a smartphone by transmitting information using a blink pattern of an LED included in a device.

[0516]

FIG. 124 is a diagram illustrating an example of the

environment in a house in the present embodiment. In the environment illustrated in FIG. 124, there are a television 1101, a microwave 1106, and an air cleaner 1107, in addition to a smartphone 1105, for instance, around a user.

[0517]

FIG. 125 is a diagram illustrating an example of communication between the smartphone and the home electric appliances according to the present embodiment. FIG. 125 illustrates an example of information communication, and is a diagram illustrating a configuration in which information output by devices such as the television 1101 and the microwave 1106 in FIG. 124 is obtained by a smartphone 1201 owned by a user, thereby obtaining information. As illustrated in FIG. 125, the devices transmit information using LED blink patterns, and the smartphone 1201 receives the information using an image pickup function of a camera, for instance.

[0518]

FIG. 126 is a diagram illustrating an example of a configuration of a transmitter device 1301 according to the present embodiment.

[0519]

The transmitter device 1301 transmits information using light blink patterns by pressing a button by a user, transmitting a transmission instruction using, for instance, near field communication (NFC), and detecting a change in a state such as failure inside the device. At this time, transmission is repeated for a certain period of time. A simplified identification (ID) may be used for transmitting information to a device which is registered previously. In addition, if a device has a wireless communication unit which uses a wireless LAN and specific power-saving wireless communication, authentication information necessary for connection thereof can also be transmitted using blink patterns.

[0520]

In addition, a transmission speed determination unit 1309 ascertains the performance of a clock generation device inside a

device, thereby performing processing of decreasing the transmission speed if the clock generation device is inexpensive and does not operate accurately and increasing the transmission speed if the clock generation device operates accurately. Alternatively, if a clock generation device exhibits poor performance, it is also possible to reduce an error due to the accumulation of differences of blink intervals because of a long-term communication, by dividing information to be transmitted itself into short pieces.

[0521]

FIG. 127 illustrates an example of a configuration of a receiver device 1401 according to the present embodiment.

[0522]

The receiver device 1401 determines an area where light blink is observed, from a frame image obtained by an image obtaining unit 1404. At this time, for the blink, it is also possible to take a method of tracking an area where an increase or a decrease in brightness by a certain amount is observed.

[0523]

A blink information obtaining unit 1406 obtains transmitted information from a blink pattern, and if the information includes information related to a device such as a device ID, an inquiry is made as to information on a related server on a cloud computing system using the information, or interpolation is performed using information stored previously in a device in a wireless-communication area or information stored in the receiver apparatus. This achieves advantageous effect of reducing a time for correcting error due to noise when capturing a light emission pattern or for a user to hold up a smartphone to the light-emitting part of the transmitter device to obtain information already acquired.

[0524]

The following is a description of FIG. 128.

[0525]

FIG. 128 is a diagram illustrating a flow of processing of transmitting information to a receiver device such as a smartphone by blinking an LED of a transmitter device according to the present

embodiment. Here, a state is assumed in which a transmitter device has a function of communicating with a smartphone by NFC, and information is transmitted with a light emission pattern of the LED embedded in part of a communication mark for NFC which the transmitter device has.

[0526]

First, in step 1001a, a user purchases a home electric appliance, and connects the appliance to power supply for the first time, thereby causing the appliance to be in an energized state.

[0527]

Next, in step 1001b, it is checked whether initial setting information has been written. In the case of Yes, the processing proceeds to C in FIG. 128. In the case of No, the processing proceeds to step 1001c, where the mark blinks at a blink speed (for example: 1 to 2/5) which the user can easily recognize.

[0528]

Next, in step 1001d, the user checks whether device information of the home electric appliance is obtained by bringing the smartphone to touch the mark via NFC communication. Here, in the case of Yes, the processing proceeds to step 1001e, where the smartphone receives device information to a server of the cloud computing system, and registers the device information at the cloud computing system. Next, in step 1001f, a simplified ID associated with an account of the user of the smartphone is received from the cloud computing system and transmitted to the home electric appliance, and the processing proceeds to step 1001g. It should be noted that in the case of No in step 1001d, the processing proceeds to step 1001g.

[0529]

Next, in step 1001g, it is checked whether there is registration via NFC. In the case of Yes, the processing proceeds to step 1001j, where two blue blinks are made, and thereafter the blinking stops in step 1001k.

[0530]

In the case of No in step 1001g, the processing proceeds to

step 1001h. Next, it is checked in step 1001h whether 30 seconds have elapsed. Here, in the case of Yes, the processing proceeds to step 1001i, where an LED portion outputs device information (a model number of the device, whether registration processing has been performed via NFC, an ID unique to the device) by blinking light, and the processing proceeds B in FIG. 129.

[0531]

It should be noted that in the case of No in step 1001h, the processing returns to step 1001d.

[0532]

Next, a description is given of, using FIGS. 129 to 132, a flow of processing of transmitting information to a receiver device by blinking an LED of a transmitter device according to the present embodiment. Here, FIGS. 129 to 132 are diagrams illustrating a flow of processing of transmitting information to a receiver device by blinking an LED of a transmitter apparatus.

[0533]

The following is a description of FIG. 129.

[0534]

First, the user activates an application for obtaining light blink information of the smartphone in step 1002a.

[0535]

Next, the image obtaining portion obtains blinks of light in step 1002b. Then, a blinking area determination unit determines a blinking area from a time series change of an image.

[0536]

Next, in step 1002c, a blink information obtaining unit determines a blink pattern of the blinking area, and waits for detection of a preamble.

[0537]

Next, in step 1002d, if a preamble is successfully detected, information on the blinking area is obtained.

[0538]

Next, in step 1002e, if information on a device ID is successfully obtained, also in a reception continuing state,

information is transmitted to a server of the cloud computing system, an information interpolation unit performs interpolation while comparing information acquired from the cloud computing system to information obtained by the blink information obtaining unit.

[0539]

Next, in step 1002f, when all the information including information as a result of the interpolation is obtained, the smartphone or the user is notified thereof. At this time, a GUI and a related site acquired from the cloud computing system are displayed, thereby allowing the notification to include more information and be readily understood, and the processing proceeds to D in FIG. 130

[0540]

The following is a description of FIG. 130.

[0541]

First, in step 1003a, an information transmission mode is started when a home electric appliance creates a message indicating failure, a usage count to be notified to the user, and a room temperature, for instance.

[0542]

Next, the mark is caused to blink per 1 to 2 seconds in step 1003b. Simultaneously, the LED also starts transmitting information.

[0543]

Next, in step 1003c, it is checked whether communication via NFC has been started. It should be noted that in the case of No, the processing proceeds to G in FIG. 132. In the case of Yes, the processing proceeds to step 1003d, where blinking the LED is stopped.

[0544]

Next, the smartphone accesses the server of the cloud computing system and displays related information in step 1003e.

[0545]

Next, in step 1003f, in the case of failure which needs to be handled at the actual location, a serviceman who gives support is

looked for by the server. Information on the home electric appliance, a setting position, and the location are utilized.

[0546]

Next, in step 1003g, the serviceman sets the mode of the device to a support mode by pressing buttons of the home electric appliance in the predetermined order.

[0547]

Next, in step 1003h, if blinks of a marker for an LED of a home electric appliance other than the home electric appliance of interest can be seen from the smartphone, some of or all such LEDs observed simultaneously blink so as to interpolate information, and the processing proceeds to E in FIG. 131.

[0548]

The following is a description of FIG. 131.

[0549]

First, in step 1004a, the serviceman presses a setting button of his/her receiving terminal if the performance of the terminal allows detection of blinking at a high speed (for example, 1000 times/second).

[0550]

Next, in step 1004b, the LED of the home electric appliance blinks in a high speed mode, and the processing proceeds to F.

[0551]

The following is a description of FIG. 132.

[0552]

First, the blinking is continued in step 1005a.

[0553]

Next, in step 1005b, the user obtains, using the smartphone, blink information of the LED.

[0554]

Next, the user activates an application for obtaining light blinking information of the smartphone in step 1005c.

[0555]

Next, the image obtaining portion obtains the blinking of light in step 1005d. Then, the blinking area determination unit

determines a blinking area, from a time series change in an image.

[0556]

Next, in step 1005e, the blink information obtaining unit determines a blink pattern of the blinking area, and waits for detection of a preamble.

[0557]

Next, in step 1005f, if a preamble is successfully detected, information on the blinking area is obtained.

[0558]

Next, in step 1005g, if information on a device ID is successfully obtained, also in a reception continuing state, information is transmitted to the server of the cloud computing system, and the information interpolation unit performs interpolation while comparing information acquired from the cloud computing system with information obtained by the blink information obtaining unit.

[0559]

Next, in step 1005h, if all the information pieces including information as a result of the interpolation are obtained, the smartphone or the user is notified thereof. At this time, a GUI and a related site acquired from the cloud computing system are displayed, thereby allowing the notification to be include more information and easier to understand.

[0560]

Then, the processing proceeds to step 1003f in FIG. 130.

[0561]

In this manner, a transmission device such as a home electric appliance can transmit information to a smartphone by blinking an LED. Even a device which does not have means of communication such as wireless communication function or NFC can transmit information, and provide a user with information having a lot of details which is in the server of the cloud computing system via a smartphone.

[0562]

Moreover, as described in this embodiment, consider a

situation where two devices including at least one mobile device are capable of transmitting and receiving data by both communication methods of bidirectional communication (e.g. communication by NFC) and unidirectional communication (e.g. communication by LED luminance change). In the case where data transmission and reception by bidirectional communication are established when data is being transmitted from one device to the other device by unidirectional communication, unidirectional communication can be stopped. This benefits efficiency because power consumption necessary for unidirectional communication is saved.

[0563]

As described above, according to Embodiment 6, an information communication device can be achieved which allows communication between various devices including a device which exhibits low computational performance.

[0564]

Specifically, an information communication device according to the present embodiment includes: an information management unit configured to manage device information which includes an ID unique to the information communication device and state information of a device; a light emitting element; and a light transmission unit configured to transmit information using a blink pattern of the light emitting element, wherein when an internal state of the device has changed, the light transmission unit is configured to convert the device information into the blink pattern of the light emitting element, and transmit the converted device information.

[0565]

Here, for example, the device may further include an activation history management unit configured to store information sensed in the device including an activation state of the device and a user usage history, wherein the light transmission unit is configured to obtain previously registered performance information of a clock generation device to be utilized, and change a transmission speed.

[0566]

In addition, for example, the light transmission unit may

include a second light emitting element disposed in vicinity of a first light emitting element for transmitting information by blinking, and when information transmission is repeatedly performed a certain number of times by the first light emitting element blinking, the second light emitting element may emit light during an interval between an end of the information transmission and a start of the information transmission.

[0567]

It should be noted that these general and specific embodiments may be implemented using a system, a method, an integrated circuit, a computer program, or a recording medium, or any combination of systems, methods, integrated circuits, computer programs, or recording media.

[0568]

[Embodiment 7]

In the present embodiment, a description is given, using a cleaner as an example, of the procedure of communication between a device and a user using visible light communication, initial settings to a repair service at the time of failure using visible light communication, and service cooperation using the cleaner.

[0569]

FIGS. 133 and 134 are diagrams for describing the procedure of performing communication between a user and a device using visible light according to the present embodiment.

[0570]

The following is a description of FIG. 133.

[0571]

First, the processing starts from A.

[0572]

Next, the user turns on a device in step 2001a.

[0573]

Next, in step 2001b, as start processing, it is checked whether initial settings such as installation setting and network (NW) setting have been made.

[0574]

Here, if initial settings have been made, the processing proceeds to step 2001f, where normal operation starts, and the processing ends as illustrated by C.

[0575]

If initial settings have not been made, the processing proceeds to step 2001c, where "LED normal light emission" and an "audible tone" notify the user that initial settings need to be made.

[0576]

Next, in step 2001d, device information (product number and serial number) is collected, and visible light communication is prepared.

[0577]

Next, in step 2001e, "LED communication light emission", "icon display on the display", "audible tone", and "light emission by plural LEDs" notify the user that device information (product number and serial number) can be transmitted by visible light communication.

[0578]

Then, the processing ends as illustrated by B.

[0579]

Next is a description of FIG. 134.

[0580]

First, the processing starts as illustrated by B.

[0581]

Next, in step 2002a, the approach of a visible light receiving terminal is perceived by a "proximity sensor", an "illuminance sensor", and a "human sensing sensor".

[0582]

Next, in step 2002b, visible light communication is started by the perception thereof which is a trigger.

[0583]

Next, in step 2002c, the user obtains device information using the visible light receiving terminal.

[0584]

Next, the processing ends as illustrated by D. Alternatively, the processing proceeds to one of steps 2002f to 2002i.

[0585]

If the processing proceeds to step 2002f, it is perceived, by a "sensitivity sensor" and "cooperation with a light control device," that the light of a room is switched off, and light emission for device information is stopped. The processing ends as illustrated by E. If the processing proceeds to step 2002g, the visible light receiving terminal notifies, by "NFC communication" and "NW communication", that device information has been perceived and obtained, and the processing ends. If the processing proceeds to step 2002h, it is perceived that the visible light receiving terminal has moved away, light emission for device information is stopped, and the processing ends. If the processing proceeds to step 2002i, after a certain time period elapses, light emission for device information is stopped, and the processing ends.

[0586]

It should be noted that if the approach is not perceived in step 2002a, the processing proceeds to step 2002d, where after a certain period of time elapses, the level of notification indicating that visible light communication is possible is increased by "brightening", "increasing sound volume", and "moving an icon", for instance. Here, the processing returns to step 2002d. Alternatively, the processing proceeds to step 2002e, and proceeds to step 2002i after another certain period of time elapses.

[0587]

FIG. 135 is a diagram for describing a procedure from when the user purchases a device until when the user makes initial settings of the device according to the present embodiment.

[0588]

In FIG. 135, first, the processing starts as illustrated by D.

[0589]

Next, in step 2003a, position information of a smartphone which has received device information is obtained using the global positioning system (GPS).

[0590]

Next, in step 2003b, if the smartphone has user information

such as a user name, a telephone number, and an e-mail address, such user information is collected in the terminal. Alternatively, in step 2003c, if the smartphone does not have user information, user information is collected from a device in the vicinity via NW.

[0591]

Next, in step 2003d, device information, user information, and position information are transmitted to the cloud server.

[0592]

Next, in step 2003e, using the device information and the position information, information necessary for initial settings and activation information are collected.

[0593]

Next, in step 2003f, cooperation information such as an Internet protocol (IP), an authentication method, and available service necessary for setting cooperation with a device whose user has been registered is collected. Alternatively, in step 2003g, device information and setting information are transmitted to a device whose user has been registered via NW to make cooperation setting with devices in the vicinity thereof.

[0594]

Next, user setting is made in step 2003h using device information and user information.

[0595]

Next, initial setting information, activity information, and cooperation setting information are transmitted to the smartphone in step 2003i.

[0596]

Next, the initial setting information, the activation information, and the cooperation setting information are transmitted to home electric appliance by NFC in step 2003j.

[0597]

Next, device setting is made using the initial setting information, the activation information, and the cooperation setting information in step 2003k.

[0598]

Then, the processing ends as illustrated by F.

[0599]

FIG. 136 is a diagram for describing service exclusively performed by a serviceman when a device fails according to the present embodiment.

[0600]

In FIG. 136, first, the processing starts as illustrated by C.

[0601]

Next, in step 2004a, history information such as operation log and user operation log generated during a normal operation of the device is stored into a local storage medium.

[0602]

Next, in step 2004b, at the same time with the occurrence of a failure, error information such as an error code and details of the error is recorded, and LED abnormal light emission notifies that visible light communication is possible.

[0603]

Next, in step 2004c, the mode is changed to a high-speed LED light emission mode by the serviceman executing a special command, thereby starting high-speed visible light communication.

[0604]

Next, in step 2004d, it is identified whether a terminal which has approached is an ordinary smartphone or a receiving terminal exclusively used by the serviceman. Here, if the processing proceeds to step 2004e, error information is obtained in the case of a smartphone, and the processing ends.

[0605]

On the other hand, if the processing proceeds to step 2004f, the receiving terminal for exclusive use obtains error information and history information in the case of a serviceman.

[0606]

Next, in step 2004g, device information, error information, and history information are transmitted to the cloud computing system, and a repair method is obtained. Here, if the processing proceeds to step 2004h, the high-speed LED light emission mode is

canceled by the serviceman executing a special command, and the processing ends.

[0607]

On the other hand, if the processing proceeds to step 2004i, product information on products related and similar to the product in the device information, selling prices at nearby stores, and new product information are obtained from the cloud server.

[0608]

Next, in step 2004j, user information is obtained via visible light communication between the user's smartphone and the terminal exclusively used by the serviceman, and an order for a product is made to a nearby store via the cloud server.

[0609]

Then, the processing ends as illustrated by I.

[0610]

FIG. 137 is a diagram for describing service for checking a cleaning state using a cleaner and visible light communication according to the present embodiment.

[0611]

First, the processing starts as illustrated by C.

[0612]

Next, cleaning information of a device performing normal operation is recorded in step 2005a.

[0613]

Next, in step 2005b, dirt information is created in combination with room arrangement information, and encrypted and compressed.

[0614]

Here, if the processing proceeds to step 2005c, the dirt information is stored in a local storage medium, which is triggered by compression of the dirt information. Alternatively, if the processing proceeds to step 2005d, dirt information is transmitted to a lighting device by visible light communication, which is triggered by a temporary stop of cleaning (stoppage of suction processing). Alternatively, if the processing proceeds to step 2005e, the dirt information is transmitted to a domestic local server and the cloud

server via NW, which is triggered by recording dirt information.

[0615]

Next, in step 2005f, device information, a storage location, and a decryption key are transmitted to the smartphone by visible light communication, which is triggered by the transmission and storage of the dirt information.

[0616]

Next, in step 2005g, the dirt information is obtained via NW and NFC, and decoded.

[0617]

Then, the processing ends as illustrated by J.

[0618]

As described above, according to Embodiment 7, a visible light communication system can be achieved which includes an information communication device allowing communication between various devices including a device which exhibits low computational performance.

[0619]

Specifically, the visible light communication system (FIG. 133) including the information communication device according to the present embodiment includes a visible light transmission permissibility determination unit for determining whether preparation for visible light transmission is completed, and a visible light transmission notification unit which notifies a user that visible light transmission is being performed, wherein when visible light communication is possible, the user is notified visually and auditorily. Accordingly, the user is notified of a state where visible light reception is possible by an LED light emission mode, such as "emitted light color", "sound", "icon display", or "light emission by a plurality of LEDs", thereby improving user's convenience.

[0620]

Preferably, the visible light communication system may include, as described using FIG. 134, a terminal approach sensing unit which senses the approach of a visible light receiving terminal, and a visible light transmission determination unit which determines

whether visible light transmission is started or stopped, based on the position of a visible light receiving terminal, and may start visible light transmission, which is triggered by the terminal approaching sensing unit sensing the approach of the visible light receiving terminal.

[0621]

Here, as described using FIG. 134, for example, the visible light communication system may stop visible light transmission, which is triggered by the terminal approaching sensing unit sensing that the visible light receiving terminal has moved away. In addition, as described using FIG. 134, for example, the visible light communication system may include a surrounding illuminance sensing unit which senses that a light of a room is turned off, and may stop visible light transmission, which is triggered by the surrounding illuminance sensing unit sensing that the light of the room is turned off. By sensing that a visible light receiving terminal approaches and moves away and a light of a room is turned off, visible light communication is started only in a state in which visible light communication is possible. Thus, unnecessary visible light communication is not performed, thereby saving energy.

[0622]

Furthermore, as described using FIG. 134, for example, the visible light communication system may include: a visible light communication time monitoring unit which measures a time period during which visible light transmission is performed; and a visible light transmission notification unit which notifies a user that visible light transmission is being performed, and may further increase the level of visual and auditory notification to a user, which is triggered by no visible light receiving terminal approaching even though visible light communication is performed more than a certain time period. In addition, as described using FIG. 134, for example, the visible light communication system may stop visible light transmission, which is triggered by no visible light receiving terminal approaching even though visible light communication is performed more than a certain time period after the visible light transmission notification

unit increases the level of notification.

[0623]

Accordingly, if reception by a user is not performed after a visible light transmission time elapses which is greater than or equal to a certain time period, a request to a user to perform visible light reception and to stop visible light transmission is made to avoid not performing visible light reception and not stopping visible light transmission, thereby improving a user's convenience.

[0624]

The visible light communication system (FIG. 135) including the information communication device according to the present embodiment may include: a visible light reception determination unit which determines that visible light communication has been received; a receiving terminal position obtaining unit for obtaining a position of a terminal; and a device-setting-information collecting unit which obtains device information and position information to collect device setting information, and may obtain a position of a receiving terminal, which is triggered by the reception of visible light, and collect information necessary for device setting. Accordingly, position information and user information necessary for device setting and user registration are automatically collected and set, which is triggered by device information being obtained via visible light communication, thereby improving convenience by skipping the input and registration procedure by a user.

[0625]

Here, as described using FIG. 137, the visible light communication system may further include: a device information management unit which manages device information; a device relationship management unit which manages the similarity between devices; a store information management unit which manages information on a store which sells a device; and a nearby store search unit which searches for a nearby store, based on position information, and may search for a nearby store which sells a similar device and obtain a price thereof, which is triggered by receiving device information and position information. This saves time and

effort for collecting information on a selling state of a related device and stores selling such a device according to device information, and searching for a device, thereby improving user convenience.

[0626]

In addition, the visible light communication system (FIG. 135) which includes the information communication device according to the present embodiment may include: a user information monitoring unit which monitors user information being stored in a terminal; a user information collecting unit which collects user information from devices in the vicinity through NW; and a user registration processing unit which obtains user information and device information to register a user, and may collect user information from accessible devices in the vicinity, which is triggered by no user information being obtained, and register a user together with device information. Accordingly, position information and user information necessary for device setting and user registration are automatically collected and set, which is triggered by device information being obtained by visible light communication, thereby improving convenience by skipping the input and a registration procedure by a user.

[0627]

In addition, the visible light communication system (FIG. 136) including the information communication device according to the present embodiment may include: a command determination unit which accepts a special command; and a visible light communication speed adjustment unit which controls the frequency of visible light communication and cooperation of a plurality of LEDs, and may adjust the frequency of visible light communication and the number of transmission LEDs by accepting a special command, thereby accelerating visible light communication. Here, for example, as described using FIG. 137, the visible light communication system may include: a terminal type determination unit which identifies the type of an approaching terminal by NFC communication; and a transmission information type determination unit which distinguishes information to be transmitted according to a terminal

type, and may change the amount of information to be transmitted and the visible light communication speed according to the terminal which approaches. Thus, according to a receiving terminal, the frequency of visible light communication and the number of transmission LEDs are adjusted to change the speed of the visible light communication and information to be transmitted, thereby allowing high speed communication and improving user's convenience.

[0628]

In addition, the visible light communication system (FIG. 137) which includes the information communication device according to the present embodiment may include: a cleaning information recording unit which records cleaning information; a room arrangement information recording unit which records room arrangement information; an information combining unit which creates dirty portion information by superimposing the room arrangement information and the cleaning information; and an operation monitoring unit which monitors the stop of normal operation, and may transmit the dirty portion information, using visible light, which is triggered by the perception of the stop of a device.

[0629]

It should be noted that these general and specific embodiments may be implemented using a system, a method, an integrated circuit, a computer program, or a recording medium, or any combination of systems, methods, integrated circuits, computer programs, or recording media.

[0630]

[Embodiment 8]

In the present embodiment, cooperation of devices and Web information using optical communication are described, using a home delivery service as an example.

[0631]

The outline of the present embodiment is illustrated in FIG. 138. Specifically, FIG. 138 is a schematic diagram of home delivery

service support using optical communication according to the present embodiment.

[0632]

Specifically, an orderer orders a product from a product purchase site using a mobile terminal 3001a. When the order is completed, an order number is issued from the product purchase site. The mobile terminal 3001a which has received the order number transmits the order number to an intercom indoor unit 3001b, using NFC communication.

[0633]

The intercom indoor unit 3001b, for example, displays the order number received from the mobile terminal 3001a on the monitor of the unit itself, thereby showing to the user that the transmission has been completed.

[0634]

The intercom indoor unit 3001b transmits, to an intercom outdoor unit 3001c, blink instructions and blink patterns for an LED included in the intercom outdoor unit 3001c. The blink patterns are created by the intercom indoor unit 3001b according to the order number received from the mobile terminal 3001a.

[0635]

The intercom outdoor unit 3001c blinks the LED according to the blink patterns designated by the intercom indoor unit 3001b.

[0636]

Instead of a mobile terminal, an environment may be used which is accessible to a product purchase site in WWW 3001d, such as a personal computer (PC).

[0637]

A home network may be used as means for transmission from the mobile terminal 3001a to the intercom indoor unit 3001b, in addition to NFC communication.

[0638]

The mobile terminal 3001a may transmit the order number to the intercom outdoor unit 3001c directly, not via the intercom indoor unit 3001b.

[0639]

If there is an order from an orderer, an order number is transmitted from a delivery order receiving server 3001e to a deliverer mobile terminal 3001f. When the deliverer arrives at a delivery place, the deliverer mobile terminal 3001f and the intercom outdoor unit 3001c bidirectionally perform optical communication using the LED blink patterns created based on the order number.

[0640]

Next, a description is given using FIGS. 139 to 144. FIGS. 139 to 144 are flowcharts for describing home delivery service support using optical communication according to Embodiment 3 of the present invention.

[0641]

FIG. 139 illustrates a flow from when an orderer places an order until when an order number is issued. The following is a description of FIG. 139.

[0642]

In step 3002a, the orderer mobile terminal 3001a reserves delivery using the web browser or an application of the smartphone. Then, the processing proceeds to A in FIG. 140.

[0643]

In step 3002b subsequent to B in FIG. 140, the orderer mobile terminal 3001a waits for the order number to be transmitted. Next, in step 3002c, the orderer mobile terminal 3001a checks whether the terminal has been brought to touch an order number transmission destination device. In the case of Yes, the processing proceeds to step 3002d, where the order number is transmitted by touching the intercom indoor unit via NFC (if the intercom and the smartphone are in the same network, a method for transmitting the number via the network may also be used). On the other hand, in the case of No, the processing returns to step 3002b.

[0644]

First, the intercom indoor unit 3001b waits for an LED blink request from another terminal in step 3002e. Next, the order number is received from the smartphone in step 3002f. Next, the

intercom indoor unit 3001b gives an instruction to blink an LED of the intercom outdoor unit according to the received order number, in step 3002g. Then, the processing proceeds to C in FIG. 142.

[0645]

First, the intercom outdoor unit 3001c waits for the LED blink instruction from the intercom indoor unit in step 3002h. Then, the processing proceeds to G in FIG. 142.

[0646]

In step 3002i, the deliverer mobile terminal 3001f waits for an order notification. Next, the deliverer mobile terminal 3001f checks whether the order notification has been given from the delivery order server. Here, in the case of No, the processing returns to step 3002i. In the case of Yes, the processing proceeds to step 3002k, where the deliverer mobile terminal 3001f receives information on an order number, a delivery address, and the like. Next, in step 3002n, the deliverer mobile terminal 3001f waits until its camera is activated to recognize an LED light emission instruction for the order number received by the user and LED light emission from another device. Then, the processing proceeds to E in FIG. 141.

[0647]

FIG. 140 illustrates the flow until an orderer makes a delivery order using the orderer mobile terminal 3001a. The following is a description of FIG. 140.

[0648]

First, a delivery order server 3001e waits for an order number in step 3003a. Next, in step 3003b, the delivery order server 3001e checks whether a delivery order has been received. Here, in the case of No, the processing returns to step 3003a. In the case of Yes, the processing proceeds to step 3003c, where an order number is issued to the received delivery order. Next, in step 3003d, the delivery order server 3001e notifies a deliverer that the delivery order has been received, and the processing ends.

[0649]

In step 3003e subsequent to A in FIG. 139, the orderer mobile terminal 3001a selects what to order from the menu presented by the

delivery order server. Next, in step 3003f, the orderer mobile terminal 3001a sets the order, and transmits the order to the delivery server. Next, the orderer mobile terminal 3001a checks in step 3003g whether the order number has been received. Here, in the case of No, the processing returns to step 3003f. In the case of Yes, the processing proceeds to step 3003h, where the orderer mobile terminal 3001a displays the received order number, and prompts the user to touch the intercom indoor unit. Then, the processing proceeds to B in FIG. 139.

[0650]

FIG. 141 illustrates the flow of the deliverer performing optical communication with the intercom outdoor unit 3001c at a delivery destination, using the deliverer mobile terminal 3001f. The following is a description of FIG. 141.

[0651]

In step 3004a subsequent to E in FIG. 139, the deliverer mobile terminal 3001f checks whether to activate a camera in order to recognize an LED of the intercom outdoor unit 3001c at the delivery destination. Here, in the case of No, the processing returns E in FIG. 139.

[0652]

On the other hand, in the case of Yes, the processing proceeds to step 3004b, where the blinks of the LED of the intercom outdoor unit at the delivery destination are identified using the camera of the deliverer mobile terminal.

[0653]

Next, in step 3004c, the deliverer mobile terminal 3001f recognizes light emission of the LED of the intercom outdoor unit, and checks it against the order number.

[0654]

Next, in step 3004d, the deliverer mobile terminal 3001f checks whether the blinks of the LED of the intercom outdoor unit correspond to the order number. Here, in the case of Yes, the processing proceeds to F in FIG. 143.

[0655]

It should be noted that in the case of No, the deliverer mobile terminal 3001f checks whether the blinks of another LED can be identified using the camera. In the case of Yes, the processing returns to step 3004c, whereas the processing ends in the case of No.

[0656]

FIG. 142 illustrates the flow of order number checking between the intercom indoor unit 3001b and the intercom outdoor unit 3001c. The following is a description of FIG. 142.

[0657]

In step 3005a subsequent to G in FIG. 139, the intercom outdoor unit 3001c checks whether the intercom indoor unit has given an LED blink instruction. In the case of No, the processing returns to G in FIG. 139. In the case of Yes, the processing proceeds to step 3005b, where the intercom outdoor unit 3001 blinks the LED in accordance with the LED blink instruction from the intercom indoor unit. Then, the processing proceeds to H in FIG. 143.

[0658]

In step 3005c subsequent to I in FIG. 143, the intercom outdoor unit 3001c notifies the intercom indoor unit of the blinks of the LED recognized using the camera of the intercom outdoor unit. Then, the processing proceeds to J in FIG. 144.

[0659]

In step 3005d subsequent to C in FIG. 139, the intercom indoor unit 3001c gives an instruction to the intercom outdoor unit to blink the LED according to the order number. Next, in step 3005e, the intercom indoor unit 3001b waits until the camera of the intercom outdoor unit recognizes the blinks of the LED of the deliverer mobile terminal. Next, in step 3005f, the intercom indoor unit 3001b checks whether the intercom outdoor unit has notified that the blinks of the LED are recognized. Here, in the case of No, the processing returns to step 3005e. In the case of Yes, the intercom indoor unit 3001b checks the blinks of the LED of the intercom outdoor unit against the order number in step 3005g. Next, in step 3005h, the intercom indoor unit 3001b checks whether the blinks of the LED of the intercom outdoor unit correspond to the order

number. In the case of Yes, the processing proceeds to K in FIG. 144. On the other hand, in the case of No, the intercom indoor unit 3001b gives an instruction to the intercom outdoor unit to stop blinking the LED in step 3005i, and the processing ends.

[0660]

FIG. 143 illustrates the flow between the intercom outdoor unit 3001c and the deliverer mobile terminal 3001f after checking against the order number. The following is a description of FIG. 143.

[0661]

In step 3006a subsequent to F in FIG. 141, the deliverer mobile terminal 3001f starts blinking the LED according to the order number held by the deliverer mobile terminal.

[0662]

Next, in step 3006b, an LED blinking portion is put in the range from the intercom outdoor unit where the camera can capture an image.

[0663]

Next, in step 3006c, the deliverer mobile terminal 3001f checks whether the blinks of the LED of the intercom outdoor unit indicate that the blinks of the LED of the deliverer mobile terminal shot by the camera of the intercom outdoor unit correspond to the order number held by the intercom indoor unit.

[0664]

Here, in the case of No, the processing returns to step 3006b. On the other hand, the processing proceeds to step 3006e in the case of Yes, where the deliverer mobile terminal displays whether the blinks correspond to the order number, and the processing ends.

[0665]

Furthermore, as illustrated in FIG. 143, the intercom outdoor unit 3001c checks whether the blinks of the LED of the deliverer mobile terminal have been recognized using the camera of the intercom outdoor unit, in step 3006f subsequent to H in FIG. 142. Here, in the case of Yes, the processing proceeds to I in FIG. 142. In the case of No, the processing returns to H in FIG. 142.

[0666]

FIG. 144 illustrates the flow between the intercom outdoor unit 3001c and the deliverer mobile terminals 3001f after checking against the order number. The following is a description of FIG. 144.

[0667]

In step 3007a subsequent to K in FIG. 142, the intercom outdoor unit 3001c checks whether a notification has been given regarding whether the blinks of the LED notified from the intercom indoor unit correspond to the order number. Here, in the case of No, the processing returns to K in FIG. 142. On the other hand, in the case of Yes, the processing proceeds to step 3007b, where the intercom outdoor unit blinks the LED to show whether the blinks correspond to the order number, and the processing ends.

[0668]

Furthermore, as illustrated in FIG. 144, in step 3007c subsequent to J in FIG. 142, the intercom indoor unit 3001b notifies the orderer by the display of the intercom indoor unit showing that the deliverer has arrived, with ring tone output. Next, in step 3007d, the intercom indoor unit gives, to the intercom outdoor unit, an instruction to stop blinking the LED and an instruction to blink the LED to show that the blinks correspond to the order number. Then, the processing ends.

[0669]

It should be noted that a delivery box for keeping a delivered product is often placed at the entrance, for instance, in the case where an orderer is not at home in an apartment, which is the delivery destination. A deliverer puts a delivery product in the delivery box if the orderer is not at home when the deliverer delivers the product. Using the LED of the deliverer mobile terminal 3001f, optical communication is performed with the camera of the intercom outdoor unit 3001c to transmit the size of the delivery product, whereby the intercom outdoor unit 3001c automatically allows only a delivery box to be used which has a size corresponding to the delivery product.

[0670]

As described above, according to Embodiment 8, cooperation

between a device and web information can be achieved using optical communication.

[0671]

[Embodiment 9]

The following is a description of Embodiment 9.

[0672]

(Registration of user and mobile phone in use to server)

FIG. 145 is a diagram for describing processing of registering a user and a mobile phone in use to a server according to the present embodiment. The following is a description of FIG. 145.

[0673]

First, a user activates an application in step 4001b.

[0674]

Next, in step 4001c, an inquiry as to information on this user and his/her mobile phone is made to a server.

[0675]

Next, it is checked in step 4001d whether user information and information on a mobile phone in use are registered in a database (DB) of the server.

[0676]

In the case of Yes, the processing proceeds to step 4001f, where the analysis of a user voice characteristic (processing a) is started as parallel processing, and the processing proceeds to B in FIG. 147.

[0677]

On the other hand, in the case of No, the processing proceeds to step 4001e, where a mobile phone ID and a user ID are registered into a mobile phone table of the DB, and the processing proceeds to B in FIG. 147.

[0678]

(Processing a: Analyzing user voice characteristics)

FIG. 146 is a diagram for describing processing of analyzing user voice characteristics according to the present embodiment. The following is a description of FIG. 146.

[0679]

First, in step 4002a, sound is collected from a microphone.

[0680]

Next, in step 4002b, it is checked whether the collected sound is estimated to be the user voice, as a result of sound recognition. Here, in the case of No, the processing returns to step 4002a.

[0681]

In the case of Yes, the processing proceeds to step 4002c, where it is checked whether what is said is a keyword (such as "next" and "return") used for this application. In the case of Yes, the processing proceeds to step 4002f, where voice data is registered into a user keyword voice table of the server, and the processing proceeds to step 4002d. On the other hand, in the case of No, the processing proceeds to step 4002d.

[0682]

Next, in step 4002d, voice characteristics (frequency, sound pressure, rate of speech) are analyzed.

[0683]

Next, in step 4002e, the analysis result is registered into the mobile phone and a user voice characteristic table of the server.

[0684]

(Preparation for sound recognition processing)

FIG. 147 is a diagram for describing processing of preparing sound recognition processing according to the present embodiment. The following is a description of FIG. 147.

[0685]

First, in step 4003a subsequent to B in the diagram, operation for displaying a cooking menu list is performed (user operation).

[0686]

Next, in step 4003b, the cooking menu list is obtained from the server.

[0687]

Next, in step 4003c, the cooking menu list is displayed on a screen of the mobile phone.

[0688]

Next, in step 4004d, collecting sound is started using the

microphone connected to the mobile phone.

[0689]

Next, in step 4003e, collecting sound by a sound collecting device in the vicinity thereof is started (processing b) as parallel processing.

[0690]

Next, in step 4003f, the analysis of environmental sound characteristics is started as parallel processing (processing c).

[0691]

Next, in step 4003g, cancellation of the sound output from a sound output device which is present in the vicinity is started (processing d) as parallel processing.

[0692]

Next, in step 4003h, user voice characteristics are obtained from the DB of the server.

[0693]

Finally, in step 4003i, recognition of user voice is started, and the processing proceeds to C in FIG. 151.

[0694]

(Processing b: Collecting sound by sound collecting device in vicinity)

FIG. 148 is a diagram for describing processing of collecting sound by a sound collecting device in the vicinity according to the present embodiment. The following is a description of FIG. 148.

[0695]

First, in step 4004a, a device which can communicate with a mobile phone and collect sound (a sound collecting device) is searched for.

[0696]

Next, in step 4004b, it is checked whether a sound collecting device has been detected.

[0697]

Here, in the case of No, the processing ends. In the case of Yes, the processing proceeds to step 4004c, where position information and microphone characteristic information of the sound

collecting device are obtained from the server.

[0698]

Next, in step 4004d, it is checked whether the server has such information.

[0699]

In the case of Yes, the processing proceeds to step 4004e, where it is checked whether the location of the sound collecting device is sufficiently close to the position of the mobile phone, so that the user voice can be collected. It should be noted that in the case of No in step 4004e, the processing returns to step 4004a. On the other hand, in the case of Yes in step 4004e, the processing proceeds to step 4004f, where the sound collecting device is caused to start collecting sound. Next, in step 4004g, the sound collected by the sound collecting device is transmitted to the mobile phone until an instruction to terminate sound collecting processing is given. It should be noted that rather than transmitting the collected sound to the mobile phone as it is, the result obtained by sound recognition may be transmitted to the mobile phone. Further, the sound transmitted to the mobile phone is processed similarly to the sound collected from the microphone connected to the mobile phone, and the processing returns to step 4004a.

[0700]

It should be noted that in the case of No in step 4004d, the processing proceeds to step 4004h, where the sound collecting device is caused to start collecting sound. Next, in step 4004i, a tone is output from the mobile phone. Next, in step 4004j, the voice collected by the sound collecting device is transmitted to the mobile phone. Next, in step 4004k, it is checked whether a tone has been recognized based on the sound transmitted from the sound collecting device. Here, in the case of Yes, the processing proceeds to step 4004g, whereas the processing returns to step 4004a in the case of No.

[0701]

(Processing c: Analyzing environmental sound characteristics)

FIG. 149 is a diagram for describing processing of analyzing

environmental sound characteristics according to the present embodiment. The following is a description of FIG. 149.

[0702]

First, in step 4005f, the list of devices is obtained which excludes any device whose position is sufficiently far from the position of a microwave, among the devices which this user owns. Data of sounds output by these devices is obtained from the DB.

[0703]

Next, in step 4005g, the characteristics (frequency, sound pressure, and the like) of the obtained sound data are analyzed, and stored as environmental sound characteristics. It should be noted that particularly the sound output by, for instance, a rice cooker near the microwave tends to be incorrectly recognized, and thus characteristics thereof are stored with high importance being set

[0704]

Next, sound is collected by a microphone in step 4005a.

[0705]

Next, it is checked in step 4005b whether the collected sound is user voice, and in the case of Yes, the processing returns to step 4005a. In the case of No, the processing proceeds to step 4005c, where characteristics (frequency, sound pressure) of the collected sound are analyzed.

[0706]

Next, in step 4005d, environmental sound characteristics are updated based on the analysis result.

[0707]

Next, in step 4005e, it is checked whether an ending flag is on, and the processing ends in the case of Yes, whereas the processing returns to step 4005a in the case of No.

[0708]

(Processing d: Cancelling sound from sound output device present in vicinity)

FIG. 150 is a diagram for describing processing of canceling sound from a sound output device which is present in the vicinity according to the present embodiment. The following is a description

of FIG. 150.

[0709]

First, in step 4006a, a device which can communicate and output sound (sound output device) is searched for.

[0710]

Next, in step 4006b, it is checked whether a sound output device has been detected, and the processing ends in the case of No. In the case of Yes, the processing proceeds to step 4006c, where the sound output device is caused to output tones including various frequencies.

[0711]

Next, in step 4006d, the mobile phone and the sound collecting device in FIG. 148 (sound collecting devices) collect the sound, thereby collecting the tones output from the sound output device.

[0712]

Next, it is checked in step 4006e whether a tone has been collected and recognized. The processing ends in the case of No. In the case of Yes, the processing proceeds to step 4006f, where transmission characteristics from the sound output device to each sound collecting device are analyzed (a relationship for each frequency between the output sound volume and the volume of collected sound and the delay time between the output of a tone and collection of the sound).

[0713]

Next, it is checked in step 4006g whether sound data output from the sound output device is accessible from the mobile phone.

[0714]

Here, in the case of Yes, the processing proceeds to step 4006h, where until an instruction is given to terminate cancellation processing, an output sound source, an output portion, and the volume are obtained from the sound output device, and the sound output by the sound output device is canceled from the sound collected by the sound collecting devices in consideration of the transmission characteristics. The processing returns to step 4006a.

On the other hand, in the case of No, the processing proceeds to step 4006i, where until an instruction is given to terminate cancellation processing, the output sound from the sound output device is obtained, and the sound output by the sound output device is canceled from the sound collected by the sound collecting devices in consideration of the transmission characteristics. The processing returns to step 4006a.

[0715]

(Selection of what to cook, and setting detailed operation in microwave)

FIG. 151 is a diagram for describing processing of selecting what to cook and setting detailed operation of a microwave according to the present embodiment. The following is a description of FIG. 151.

[0716]

First, in step 4007a subsequent to C in the diagram, what to cook is selected (user operation).

[0717]

Next, in step 4007b, recipe parameters (the quantity to cook, how strong the taste is to be, a baking degree, and the like) are set (user operation).

[0718]

Next, in step 4007c, recipe data and a detailed microwave operation setting command are obtained from the server in accordance with the recipe parameters.

[0719]

Next, in step 4007d, the user is prompted to bring the mobile phone to touch a noncontact integrated circuit (IC) tag embedded in the microwave.

[0720]

Next, in step 4007e, it is checked whether the microwave being touched is detected.

[0721]

Here, in the case of No, the processing returns to step 4007e. In the case of Yes, the processing proceeds to step 4007f, where the

microwave setting command obtained from the server is transmitted to the microwave. Accordingly, all the settings for the microwave necessary for this recipe are made, and the user can cook by only pressing an operation start button of the microwave.

[0722]

Next, in step 4007g, notification sound for the microwave is obtained from the DB of the server, for instance, and set in the microwave (processing e).

[0723]

Next, in step 4007h, the notification sound of the microwave is adjusted (processing f), and the processing proceeds to D in FIG. 155.

[0724]

(Processing e: Obtaining notification sound for microwave from DB of server, for instance, and set in microwave)

FIG. 152 is a diagram for describing processing of obtaining notification sound for a microwave from a DB of a server, for instance, and setting the sound in the microwave according to the present embodiment. The following is a description of FIG. 152.

[0725]

First, in step 4008a, the user brings the mobile phone close to (= to touch) the noncontact IC tag embedded in the microwave.

[0726]

Next, in step 4008b, an inquiry is made as to whether notification sound data for the mobile phone (data of sound output when the microwave is operating and ends operation) is registered in the microwave.

[0727]

Next, it is checked in step 4008c whether the notification sound data for the mobile phone is registered in the microwave.

[0728]

Here, in the case of Yes, the processing ends. In the case of No, the processing proceeds to step 4008d, where it is checked whether the notification sound data for the mobile phone is registered in the mobile phone. In the case of Yes, the processing proceeds to step 4008h, where the notification sound data registered

in the mobile phone is registered in the microwave, and the processing ends. In the case of No, the processing proceeds to step 4008e, where the DB of the server, the mobile phone, or the microwave is referred to.

[0729]

Next, in step 4008f, if notification sound data for the mobile phone (data of notification sound which this mobile phone can easily recognize) is in the DB, that data is obtained from the DB, whereas if such data is not in the DB, notification sound data for typical mobile phones (data of typical notification sound which mobile phones can easily recognize) is obtained from the DB.

[0730]

Next, in step 4008g, the obtained notification sound data is registered in the mobile phone.

[0731]

Next, in step 4008h, the notification sound data registered in the mobile phone is registered in the microwave, and the processing ends.

[0732]

(Processing f: Adjusting notification sound of microwave)

FIG. 153 is a diagram for describing processing of adjusting notification sound of a microwave according to the present embodiment. The following is a description of FIG. 153.

[0733]

First, in step 4009a, notification sound data of the microwave registered in the mobile phone is obtained.

[0734]

Next, in step 4009b, it is checked whether a frequency of the notification sound for the terminal and a frequency of environmental sound overlap a certain amount or more.

[0735]

Here, in the case of No, the processing ends.

[0736]

However, in the case of Yes, the processing proceeds to step 4009c, where the volume of notification sound is set so as to be

sufficiently larger than the environmental sound. Alternatively, the frequency of the notification sound is changed.

[0737]

Here, as an example of a method for generating notification sound having a changed frequency, if the microwave can output the sound in (c) of FIG. 154, notification sound is generated in the pattern in (c), and the processing ends. If the microwave cannot output sound in (c), but can output the sound in (b), notification sound is generated in the pattern in (b), and the processing ends. If the microwave can output only the sound in (a), notification sound is generated in the pattern in (a), and the processing ends.

[0738]

FIG. 154 is a diagram illustrating examples of waveforms of notification sounds set in a microwave according to the present embodiment.

[0739]

The waveform illustrated in (a) of FIG. 154 includes simple square waves, and almost all sound output devices can output sound in the waveform. Since the sound in the waveform is easily mixed up with sound other than notification sound, the sound is output several times, and if the sound can be recognized some of the several times, it is to be determined that the output of the notification sound is recognized, which is an example of handling such case.

[0740]

The waveform illustrated in (b) of FIG. 154 is a waveform obtained by sectioning the waveform in (a) finely at short square waves, and such sound in the waveform can be output if the operation clock frequency of a sound output device is high enough. Although people hear this sound as similar sound to the sound in (a), a feature of the sound is that the sound has a greater amount of information than (a), and tends not to be mixed up with sound other than notification sound in machine recognition.

[0741]

The waveform illustrated in (c) of FIG. 154 is obtained by changing the temporal lengths of sound output portions, and is

referred to as a pulse-width modulation (PWM) waveform. Although it is more difficult to output such sound in the PWM waveform than the sound in (b), the sound in the PWM waveform has a greater amount of information than the sound in (b), thus improving a recognition rate and also allowing information to be transmitted from the microwave to the mobile phone simultaneously.

[0742]

It should be noted that although the sounds in the waveforms in (b) and (c) of FIG. 154 are less likely to be incorrectly recognized than the sound illustrated in (a) of FIG. 154, the recognition rate of the sounds can be further improved by repeating the sounds in the same waveform several times, as with the sound in (a) of FIG. 154.

[0743]

(Display of details of cooking)

FIG. 155 is a diagram illustrating examples of waveforms of notification sounds set in a microwave according to the present embodiment. The following is a description of FIG. 155.

[0744]

First, the details of cooking are displayed in step 4011a subsequent to D in the diagram.

[0745]

Next, it is checked in step 4011b whether the cooking in detail is to be done by the operation of the microwave.

[0746]

Here, in the case of Yes, the processing proceeds to step 4011c, where the user is notified that food is to be put in the microwave, and the operation start button is to be pressed. The processing proceeds to E in FIG. 156.

[0747]

On the other hand, in the case of No, the processing proceeds to step 4011d, where the details of cooking are displayed, and the processing proceeds to F in the diagram or proceeds to step 4011e.

[0748]

In step 4011e, it is checked whether the operation is performed by the user. If the application has ended, the processing

ends.

[0749]

On the other hand, in the case of operation of changing display content, manual input (pressing a button, for instance), or voice input (such as "next", "previous"), the processing proceeds to step 4011f, where it is checked whether cooking ends as a result of changing the display content. Here, in the case of Yes, the processing proceeds to step 4011g, where the user is notified of the end of cooking, and the processing ends. In the case of No, the processing proceeds to step 4011a.

[0750]

(Recognition of notification sound of microwave)

FIG. 156 is a diagram for describing processing of recognizing notification sound of a microwave according to the present embodiment. The following is a description of FIG. 156.

[0751]

First, in step 4012a subsequent to E in the diagram, collecting sound by a sound collecting device in the vicinity and recognition of notification sound of the microwave are started (processing g) as parallel processing.

[0752]

Next, in step 4012f, checking of the operation state of the mobile phone is started (processing i) as parallel processing.

[0753]

Next, in step 4012g, tracking a user position is started (processing j) as parallel processing.

[0754]

Next, the details of recognition are checked in step 4012b.

[0755]

Here, if notification sound indicating a button being pressed has been recognized, the processing proceeds to step 4012c, where the change of the setting is registered, and the processing returns to step 4012b. If operation by the user is recognized, the processing proceeds to F in FIG. 155. If notification sound indicating the end of operation or the sound of opening the door of the microwave is

recognized after an operation time elapses since the display is presented to prompt the user to put food into the microwave and press the operation start button, the user is notified of the end of operation of the microwave (processing h) in step 4012e, and the processing proceeds to G in FIG. 155. If the notification sound indicating the start of the operation is recognized, the processing proceeds to step 4012d, where the elapse of the operation time is waited for, and the processing proceeds to step 4012e, where the user is notified of the end of operation of the microwave (processing h). Then, the processing proceeds to G in FIG. 155.

[0756]

(Processing g: Collecting sound by sound collecting device in vicinity and recognizing notification sound of microwave)

FIG. 157 is a diagram for describing processing of collecting sound by a sound collecting device in the vicinity and recognizing notification sound of a microwave according to the present embodiment. The following is a description of FIG. 157.

[0757]

First, in step 4013a, a device (sound collecting device) is searched for which can communicate with a mobile phone and collect sound.

[0758]

Next, it is checked in step 4013b whether a sound collecting device has been detected.

[0759]

Here, in the case of No, the processing ends. On the other hand, in the case of Yes, the processing proceeds to step 4013c, where the position information of the sound collecting device and microphone characteristics information are obtained from the server.

[0760]

Next, in step 4013d, it is checked whether the server has that information.

[0761]

In the case of Yes, the processing proceeds to step 4013r, where it is checked whether the location of the sound collecting

device is close enough to the microwave so that notification sound can be collected.

[0762]

Here, in the case of No in step 4013r, the processing returns to step 4013a. In the case of Yes, the processing proceeds to step 4013s, where it is checked whether an arithmetic unit of the sound collecting device can perform sound recognition. In the case of Yes in step 4013s, information for recognizing notification sound of the microwave is transmitted to the sound collecting device in step 4013u. Next, in step 4013v, the sound collecting device is caused to start collecting and recognizing sound, and transmit the recognition results to the mobile phone. Next, in step 4013q, processing of recognizing notification sound of the microwave is performed until the cooking procedure proceeds to the next cooking step, and the recognition results are transmitted to the mobile phone. On the other hand, in the case of No in step 4013s, the processing proceeds to step 4013t, where the sound collecting device is caused to start collecting sound, and transmit collected sound to the mobile phone. Next, in step 4013j, the sound collecting device is caused to transmit the collected sound to the mobile phone until the cooking procedure proceeds to the next cooking step, and the mobile phone identifies notification sound of the microwave.

[0763]

It should be noted that in the case of No in step 4013d, the processing proceeds to step 4013e, where it is checked whether the arithmetic unit of the sound collecting device can perform sound recognition.

[0764]

In the case of Yes, the processing proceeds to step 4013k, where information for recognizing notification sound of the microwave is transmitted to the sound collecting device. Next, in step 4013m, the sound collecting device is caused to start collecting sound and recognizing sound, and transmit the recognition results to the mobile phone. Next, in step 4013n, notification sound of the microwave is output. Next, in step 4013p, it is checked whether the

sound collecting device has successfully recognized the notification sound. In the case of Yes in step 4013p, the processing proceeds to 4013q, where the sound collecting device is caused to perform processing of recognizing the notification sound of the microwave until the cooking procedure proceeds to the next cooking step, and transmit the recognition results to the mobile phone, and then the processing returns to step 4013a. In the case of No in step 4013p, the processing returns to step 4013a.

[0765]

Further, in the case of No in step 4013e, the processing proceeds to step 4013f, where the sound collecting device is caused to start collecting sound, and transmit the collected sound to the mobile phone. Next, in step 4013g, the notification sound of the microwave is output. Next, in step 4013h, recognition processing is performed on the sound transmitted from the sound collecting device. Next, in step 4013i, it is checked whether the notification sound has been successfully recognized. Here, in the case of Yes, the processing proceeds to 4013j, where the sound collecting device is caused to transmit the collected sound to the mobile phone until the cooking procedure proceeds to the next cooking step, and the mobile phone recognizes the notification sound of the microwave, and then the processing returns to step 4013a. In the case of No, the processing returns to step 4013a.

[0766]

(Processing h: Notifying user of end of operation of microwave)

FIG. 158 is a diagram for describing processing of notifying a user of the end of operation of the microwave according to the present embodiment. The following is a description of FIG. 158.

[0767]

First, in step 4013a, it is checked whether it can be determined that the mobile phone is currently being used or carried using sensor data. It should be noted that in the case of Yes, the processing proceeds to step 4014m, where the user is notified of the end of operation of the microwave using screen display, sound, and vibration of the mobile phone, for instance, and the processing ends.

[0768]

On the other hand, in the case of No in step 4013a, the processing proceeds to step 4014b, where a device which is being operated (a device under user operation) is searched for from among devices such as a personal computer (PC) which the user has logged in.

[0769]

Next, it is checked in step 4014c whether the device under user operation has been detected. It should be noted that in the case of Yes, the user is notified of the end of operation of the microwave using, for instance, the screen display of the device under user operation, and the processing ends.

[0770]

In the case of No in step 4014c, the processing proceeds to step 4014e, where a device (imaging device) is searched for which can communicate with the mobile phone and obtain images.

[0771]

Next, it is checked in step 4014f whether an imaging device has been detected.

[0772]

Here, in the case of Yes, the processing proceeds to step 4014p, where the imaging device is caused to capture an image, transmit data of a user face to the imaging device itself, and then recognize the user face. Alternatively, the imaging device is caused to transmit the captured image to the mobile phone or the server, and the user face is recognized at the destination to which the image is transmitted.

[0773]

Next, it is checked in step 4014q whether the user face has been recognized. In the case of No, the processing returns to step 4014e. In the case of Yes, the processing proceeds to step 4014r, where it is checked whether a device (detection device) which has detected the user includes a display unit and a sound output unit. In the case of Yes in step 4014r, the processing proceeds to step 4014s, where the user is notified of the end of operation of the microwave

using the unit included in the device, and the processing ends.

[0774]

In the case of No in step 4014f, the processing proceeds to step 4014g, where a device (sound collecting device) is searched for which can communicate with the mobile phone and collect sound.

[0775]

In the case of No in step 4014h, the processing proceeds to step 4014i, where another device is detected which can determine a position of the user by operation of the device, by means of walk vibration, and the like. Next, the processing proceeds to step 4014m, where the user is notified of the end of operation of the microwave using, for instance, screen display, sound, and vibration of the mobile phone, and the processing ends.

[0776]

It should be noted that in the case of Yes in step 4014i, the processing proceeds to step 4014r, where it is checked whether a device (detection device) which has detected the user includes a display unit and a sound output unit. Here, in the case of No, the position information of a detection device is obtained from the server.

[0777]

Next, in step 4014u, a device (notification device) which is near the detection device, and includes a display unit and a sound output unit is searched for. Next, in step 4014v, the user is notified of the end of operation of the microwave by a screen display or sound of sufficient volume in consideration of the distance from the notification device to the user, and the processing ends.

[0778]

(Processing i: Checking operation state of mobile phone)

FIG. 159 is a diagram for describing processing of checking an operation state of a mobile phone according to the present embodiment. The following is a description of FIG. 159.

[0779]

First, it is checked in step 4015a whether the mobile phone is being operated, the mobile phone is being carried, an input/output device connected to the mobile phone has received input and output,

video and music are being played back, a device located near the mobile phone is being operated, or the user is recognized by a camera or various sensors of a device located near the mobile phone.

[0780]

Here, in the case of Yes, the processing proceeds to step 4015b, where it is acknowledged that there is a high probability that the position of the user is close to this mobile phone. Then, the processing returns to step 4015a.

[0781]

On the other hand, in the case of No, the processing proceeds to step 4015c, where it is checked whether a device located far from the mobile phone is being operated, the user is recognized by a camera or various sensors of the device located far from the mobile phone, or the mobile phone is being charged.

[0782]

In the case of Yes in step 4015c, the processing proceeds to step 4015d, where it is acknowledged that there is a high probability that the position of the user is far from this mobile phone, and the processing returns to step 4015a. In the case of No in step 4015c, the processing returns to step 4015a.

[0783]

(Processing j: Tracking user position)

FIG. 160 is a diagram for describing processing of tracking a user position according to the present embodiment. The following is a description of FIG. 160.

[0784]

First, in step 4016a, it is checked whether or not the mobile phone is determined as being carried, using a bearing sensor, a position sensor, or a 9-axis sensor. The 9-axis sensor is a sensor including at least one of an accelerometer, an angular velocity sensor, and a geomagnetic sensor.

[0785]

In the case of Yes in step 4016a, the processing proceeds to step 4016b, where the positions of the mobile phone and the user are registered into the DB, and the processing returns to step 4016a.

[0786]

On the other hand, in the case of No in step 4016a, the processing proceeds to step 4016c, where a device (user detection device) is searched for which can communicate with the mobile phone, and detect a user position and the presence of the user, such as a camera, a microphone, or a human sensing sensor.

[0787]

Next, it is checked in step 4016d whether a sound collecting device is detected. In the case of No in step 4016d, the processing returns to step 4016a.

[0788]

In the case of Yes in step 4016d, the processing proceeds to step 4016e, where it is checked whether the user detection device detects the user. In the case of No in step 4016e, the processing returns to step 4016a.

[0789]

In the case of Yes in step 4016e, the processing proceeds to step 4016f, where the detection of the user is transmitted to the mobile phone.

[0790]

Next, in step 4016g, the user being present near the user detection device is registered into the DB.

[0791]

Next, in step 4016h, if the DB has position information of the user detection device, the information is obtained, thereby determining the position of the user, and the processing returns to step 4016a.

[0792]

FIG. 161 is a diagram illustrating that while canceling sound from a sound output device, notification sound of a home electric appliance is recognized, an electronic device which can communicate is caused to recognize a current position of a user (operator), and based on the recognition result of the user position, a device located near the user position is caused to give a notification to the user. Further, FIG. 162 is a diagram illustrating content of a database held

in a server, a mobile phone, or a microwave according to the present embodiment.

[0793]

As illustrated in FIG. 162, on a microwave table 4040a, the model of a microwave, data for identifying sound which can be output (speaker characteristics, a modulation method, and the like), for each of various mobile phone models, data of notification sound having characteristics easily recognized by the mobile phone, and data of notification sound easily recognized by a typical mobile phone on the average are held in association with one another.

[0794]

A mobile phone table 4040b holds mobile phones, and for each of the mobile phones, the model of the mobile phone, a user who uses the mobile phone, and data indicating the position of the mobile phone in association with one another.

[0795]

A mobile phone model table 4040c holds the model of a mobile phone, sound-collecting characteristics of a microphone which is an accessory of the mobile phone of the model in association with each other.

[0796]

A user voice characteristic table 4040d holds a user and an acoustic feature of the user voice in association with each other.

[0797]

A user keyword voice table 4040e holds a user and voice waveform data obtained when the user says keywords such as "next" and "return" to be recognized by a mobile phone in association with each other. It should be noted that this data may be obtained by analyzing and changing in the form with which the data is easily handled, rather than the voice waveform data as is.

[0798]

A user owned device position table 4040f holds a user, a device that the user owns, and position data of the device in association with one another.

[0799]

A user owned device position table 4040g holds a user, a device that the user owns, and data of sound such as notification sound and operation sound output by the device in association with one another.

[0800]

A user position table 4040h holds a user and data of a position of the user in association with each other.

[0801]

FIG. 163 is a diagram illustrating that a user cooks based on cooking processes displayed on a mobile phone, and further operates the display content of the mobile phone by saying "next", "return", and others according to the present embodiment. FIG. 164 is a diagram illustrating that the user has moved to another place while he/she is waiting until the operation of a microwave ends after starting the operation or while he/she is stewing food according to the present embodiment. FIG. 165 is a diagram illustrating that a mobile phone transmits an instruction to detect the user to a device which is connected to the mobile phone via a network, and can recognize a position of the user and the presence of the user, such as a camera, a microphone, or a human sensing sensor. FIG. 166 illustrates that as an example of user detection, a user face is recognized using a camera included in a television, and further the movement and presence of the user are recognized using a human sensing sensor of an air-conditioner. It should be noted that a television and an air-conditioner may perform this recognition processing, or image data or the like may be transmitted to a mobile phone or a server, and recognition processing may be performed at the transmission destination. From a viewpoint of privacy protection, it is better not to transmit data of the user to an external server.

[0802]

FIG. 167 illustrates that devices which have detected the user transmit to the mobile phone the detection of the user and a relative position of the user to the devices which have detected the user.

[0803]

As described above, it is possible to determine a user position if the DB has position information of a device which has detected the user.

[0804]

FIG. 168 is a diagram illustrating that the mobile phone recognizes microwave operation end sound according to the present embodiment. FIG. 169 illustrates that the mobile phone which has recognized the end of the operation of the microwave transmits an instruction to, among the devices which have detected the user, a device having a screen-display function or a sound output function (the television in front of the user in this drawing) to notify the user of the end of the microwave operation.

[0805]

FIG. 170 illustrates that the device which has received the instruction notifies the user of the details of the notification (in the drawing, the television displays the end of operation of the microwave on the screen thereof). FIG. 171 is a diagram illustrating that a device which is present near the microwave is connected to the mobile phone via a network, and includes a microphone recognizes the microwave operation end sound. FIG. 172 is a diagram illustrating that the device which has recognized the end of operation of the microwave notifies the mobile phone thereof. FIG. 173 illustrates that if the mobile phone is near the user when the mobile phone receives the notification indicating the end of the operation of the microwave, the user is notified of the end of the operation of the microwave, using screen display, sound output, and the like by the mobile phone.

[0806]

FIG. 174 is a diagram illustrating that the user is notified of the end of the operation of the microwave. Specifically, FIG. 174 illustrates that if the mobile phone is not near the user when the mobile phone receives the notification indicating the end of the operation of the microwave, an instruction is transmitted to, among the devices which have detected the user, a device having a screen display function or a sound output function (the television in front of

the user in this drawing) to notify the user of the end of the operation of the microwave, and the device which has received the instruction notifies the user of the end of the operation of the microwave. This drawing illustrates that there are often cases where the mobile phone is not present near the microwave nor the user when the mobile phone is connected to a charger, and thus the illustrated situation tends to occur.

[0807]

FIG. 175 is a diagram illustrating that the user who has received the notification indicating the end of the operation of the microwave moves to a kitchen. It should be noted that the mobile phone shows what to do next for the cooking at this time. Further, the mobile phone may recognize that the user has moved to the kitchen by sound, for instance, and start giving explanation of the next process of the cooking in a timely manner.

[0808]

FIG. 176 illustrates that the microwave transmits information such as the end of operation to the mobile phone by wireless communication, the mobile phone gives a notification instruction to the television which the user is watching, and the user is notified by a screen display or sound of the television.

[0809]

It should be noted that a home LAN, direct wireless communication, especially the wireless communication of 700 MHz to 900 MHz, for instance, can be utilized for communication between an information source device (the microwave in this drawing) and the mobile phone and communication between the mobile phone and a device which gives a notification to the user (the television in this drawing). Further, although the mobile phone is utilized as a hub here, another device having communication capability may be utilized instead of the mobile phone.

[0810]

FIG. 177 illustrates that the microwave transmits information such as the end of operation to the television which the user is watching by wireless communication, and the user is notified thereof

using the screen display or sound of the television. This illustrates the operation performed when communication is performed not via the mobile phone serving as a hub in FIG. 176.

[0811]

FIG. 178 illustrates that if an air-conditioner on the first floor notifies the user of certain information, the air-conditioner on the first floor transmits information to an air-conditioner on the second floor, the air-conditioner on the second floor transmits the information to the mobile phone, the mobile phone gives a notification instruction to the television which the user is watching, and the user is notified thereof by the screen display or sound of the television. This shows that an information source device (the air-conditioner on the first floor in this drawing) cannot directly communicate with the mobile phone serving as a hub, the information source device transmits information to another device which can communicate therewith, and establishes communication with the mobile phone.

[0812]

FIG. 179 is a diagram illustrating that a user who is at a remote place is notified of information. Specifically, FIG. 179 illustrates that the mobile phone which has received a notification from the microwave by sound, optically, or via wireless communication, for instance, notifies the user at a remote place of information via the Internet or carrier communication. FIG. 180 illustrates that if the microwave cannot directly communicate with the mobile phone serving as a hub, the microwave transmits information to the mobile phone via a personal computer, for instance. FIG. 181 illustrates that the mobile phone which has received communication in FIG. 180 transmits information such as an operation instruction to the microwave, following the information-and-communication path in an opposite direction.

[0813]

It should be noted that the mobile phone may automatically transmit information in response to the information in FIG. 180, notify the user of the information, and transmit information on the

operation performed by the user in response to the notification.

[0814]

FIG. 182 illustrates that in the case where the air-conditioner which is an information source device cannot directly communicate with the mobile phone serving as a hub, the air-conditioner notifies the user of information. Specifically, FIG. 182 illustrates that in the case where the air-conditioner which is an information source device cannot directly communicate with the mobile phone serving as a hub, first, information is transmitted to a device such as a personal computer which establishes one step of communication with the mobile phone as shown by A, the information is transmitted to the mobile phone from the personal computer via the Internet or a carrier communication network as shown by B and C, and the mobile phone processes the information automatically, or the user operates the mobile phone, thereby transmitting the information to the personal computer via the Internet or the carrier communication network as shown by D and E, the personal computer transmits a notification instruction to a device (the television in this drawing) which can notify the user who the computer wants to notify the information as shown by F, and the user is notified of the information using the screen display or sound of the television as shown by G.

[0815]

Such a situation tends to occur if the user to receive notification information from the air-conditioner is different from the user who is using the mobile phone.

[0816]

It should be noted that although communication between the personal computer and the mobile phone is established via the Internet or the carrier communication network in this drawing, communication may be established via a home LAN, direct communication, or the like.

[0817]

FIG. 183 is a diagram for describing a system utilizing a communication device which uses a 700 to 900 MHz radio wave. Specifically, with the configuration in FIG. 183, a system is described

which utilizes a communication unit (referred to as a G unit in the following) which uses a 700 to 900 MHz radio wave (referred to as a G radio wave in the following). FIG. 183 illustrates that the microwave having a G unit transmits information, using a G radio wave, to a mobile phone on the third floor having a G unit, the mobile phone on the third floor having the G unit transmits, utilizing a home network, the information to a mobile phone on the second floor which does not have a G unit, and the user is notified of the information from the mobile phone on the second floor.

[0818]

It should be noted that for registration and authentication of communication between devices each having a G unit, a method using the NFC function of both the devices can be considered. In addition, if one of the devices does not have the NFC function, the output of a G radio wave is lowered so that communication is possible only in a range of about 10 to 20 cm, and both the devices are brought close to each other. If communication is successfully established, communication between the G units is registered and authenticated, which is a conceivable method as a registration mode.

[0819]

In addition, an information source device (the microwave in this drawing) may be a device other than a microwave, as long as the device has a G unit.

[0820]

In addition, a device (the mobile phone on the third floor in this drawing) which relays communication between the information source device and the information notification device (the mobile phone on the second floor in this drawing) may be a device such as a personal computer, an air-conditioner, or a smart meter rather than a mobile phone, as long as the device can access a G radio wave and a home network.

[0821]

In addition, an information notification device may be a device such as a personal computer or a television rather than a mobile phone, as long as the device can access a home network, and give a

notification to a user by using screen display, audio output, or the like.

[0822]

FIG. 184 is a diagram illustrating that a mobile phone at a remote place notifies a user of information. Specifically, FIG. 184 illustrates that an air-conditioner having a G unit transmits information to a mobile phone having a G unit in a house, the mobile phone in the house transmits the information to the mobile phone at the remote place via the Internet or a carrier communication network, and the mobile phone at the remote place notifies the user of the information.

[0823]

It should be noted that the information source device (the air-conditioner in this drawing) may be a device other than a microwave, as long as the device has a G unit.

[0824]

In addition, a device (the mobile phone in the house in this drawing) which relays communication between the information source device and the information notification device (the mobile phone at a remote place in this drawing) may be a device such as a personal computer, an air-conditioner, or a smart meter rather than a mobile phone, as long as the device can access a G radio wave, the Internet, or a carrier communication network.

[0825]

It should be noted that the information notification device may be a device such as a personal computer or a television rather than a mobile phone, as long as the device can access the Internet or a carrier communication network, and give a notification to a user by using screen display, audio output, or the like.

[0826]

FIG. 185 is a diagram illustrating that the mobile phone at a remote place notifies the user of information. Specifically, FIG. 185 illustrates that a television having a G unit recognizes notification sound of the microwave which does not have a G unit and transmits information to the mobile phone having a G unit in the house via a G

radio wave, the mobile phone in the house transmits the information to the mobile phone at a remote place via the Internet or a carrier communication network, and the mobile phone at the remote place notifies the user of the information.

[0827]

It should be noted that another device may perform a similar operation to that of an information source device (the microwave in this drawing), and a method for a notification recognition device (the television in this drawing) to recognize notification from the information source device may be performed using, for instance, a light emission state rather than sound, which also achieves similar effects.

[0828]

In addition, another device having a G unit may perform a similar operation to that of the notification recognition device. Further, a device (the mobile phone in the house in this drawing) which relays communication between the notification recognition device and the information notification device (the mobile phone at a remote place in this drawing) may be a device such as a personal computer, an air-conditioner, or a smart meter rather than a mobile phone, as long as the device can access a G radio wave, the Internet, or a carrier communication network.

[0829]

It should be noted that the information notification device may be a device such as a personal computer or a television rather than a mobile phone, as long as the device can access the Internet or a carrier communication network and give a notification to a user using screen display and audio output, for instance.

[0830]

In addition, FIG. 186 is a diagram illustrating that in a similar case to that of FIG. 185, a television on the second floor serves as a relay device instead of a device (a mobile phone in the house in FIG. 185) which relays communication between a notification recognition device (the television on the second floor in this drawing) and an information notification device (the mobile phone at a remote place

in this drawing).

[0831]

As described above, the device according to the present embodiment achieves the following functions.

- a function of learning user voice characteristics through the use of an application

- a function of detecting a sound collecting device which can collect sound output from a mobile phone, from among devices which can communicate with the mobile phone and have a sound-collecting function

- a function of detecting a sound collecting device which can collect sound output from an electronic device, from among devices which can communicate with a mobile phone and have a sound-collecting function

- a function of causing a sound collecting device to transmit to a mobile phone as-is sound collected by the sound collecting device or a sound recognition result

- a function of analyzing characteristics of environmental sound and improving accuracy of sound recognition

- a function of obtaining, from a DB, sound which may be output from a device that a user owns and improving accuracy of sound recognition

- a function of detecting a sound output device sound output from which can be collected by a mobile phone or a sound collecting device, from among devices which can communicate with the mobile phone and have a sound output function

- a function of cancelling unnecessary sound from collected sound by obtaining audio data output from a sound output device, and subtracting the data from collected sound in consideration of transmission characteristics

- a function of obtaining processes of cooking for giving instructions to a user, in response to the reception of input of parameters of a cooking recipe, and obtaining control data for controlling a cooking device from a server

- a function of making settings so that a mobile phone and a

sound collecting device easily recognize notification sound output from a device, based on data of sound which can be output by the device

- a function of improving accuracy of recognizing user voice by adjusting a recognition function, based on user voice characteristics

- a function of recognizing user voice using plural sound collecting devices

- a function of recognizing notification sound of an electronic device using plural sound collecting devices

- a function of obtaining necessary information from an electronic device and making settings in a microwave via, for instance, a mobile phone and a noncontact IC card of an electronic device in order to perform a series of operations only by one operation

- a function of searching for a user using a device such as a camera, a microphone, or a human sensing sensor which can communicate with a mobile phone, and causing the device to transmit a current position of the user to the mobile phone or store the position into a DB

- a function of notifying a user from a device located near the user using a position of the user stored in a DB

- a function of estimating whether a user is present near a mobile phone, based on states (an operating condition, a sensor value, a charging state, a data link state, and the like) of the mobile phone

[0832]

It should be noted that in the processing in FIGS. 145 to 175, similar functionality can be achieved even by changing sound data to light emission data (frequency, brightness, and the like), sound output to light emission, and sound collection to light reception, respectively.

[0833]

In addition, although a microwave is used as an example in the present embodiment, an electronic device which outputs notification sound to be recognized may not be a microwave, but changed to a

washing machine, a rice cooker, a cleaner, a refrigerator, an air cleaner, an electric water boiler, an automatic dishwasher, an air-conditioner, a personal computer, a mobile phone, a television, a car, a telephone, a mail receiving device, or the like, which also achieves similar effects.

[0834]

In addition, although a microwave, a mobile phone, and a device such as a television which gives notification to a user establish direct communication to one another in the present embodiment, the devices may communicate with one another indirectly via another device if there is a problem with direct communication.

[0835]

In addition, although communication established mainly utilizing a home LAN is assumed in the present embodiment, even direct wireless communication between devices and communication via the Internet or a carrier communication network can achieve similar functionality.

[0836]

The present embodiment achieves effects of preventing leakage of personal information since a mobile phone makes simultaneous inquiry about the position of a user, to cause a camera of a TV, for instance, to perform person identification, and a coded result is transmitted to the mobile phone of that user. Even if there are two or more people in a house, data obtained by a human sensing sensor of an air-conditioner, an air cleaner, and a refrigerator is transmitted to a position control database of a mobile phone or the like, whereby the movement of an operator recognized once is tracked by the sensor. This allows the position of the operator to be estimated.

[0837]

It should be noted that if a user owns a mobile phone having a gyroscope or an azimuth meter, data of identified position may be registered into a user position database.

[0838]

In addition, when an operator places a mobile phone, the

operation of a physical sensor firstly stops for a certain period of time, and thus this can be detected. Next, button operation and human sensing sensors of a home electric appliance and a light, a camera of a TV or the like, a microphone of the mobile phone, and the like are used to detect that the operator has left there. Then, the position of the operator is registered into a mobile phone or the user position database of a server in the house.

[0839]

As described above, according to Embodiment 9, an information communication device (recognition device) which enables communication between devices can be achieved.

[0840]

Specifically, the information communication device according to the present embodiment may include a recognition device which searches for an electronic device (sound collecting device) having sound-collecting functionality from among electronic devices which can communicate with an operation terminal, and recognizes, utilizing the sound-collecting functionality of the sound collecting device, notification sound of another electronic device.

[0841]

Here, this recognition device may be a recognition device utilizing the sound-collecting functionality of only a sound collecting device which can collect tones output from the operation terminal.

[0842]

In addition, the information communication device according to the present embodiment may include a sound collecting device which searches for an electronic device (sound output device) having sound output functionality from among electronic devices which can communicate with the operation terminal, analyzes sound transmission characteristics between the sound output device and the sound collecting device, obtains output sound data from the sound output device, and cancels, from the collected sound, sound output from the sound output device, based on the sound transmission characteristics and the output sound data.

[0843]

In addition, the information communication device according to the present embodiment may include a recognition device which adjusts notification sound of electronic device whose notification sound is to be recognized so that the sound is prevented from being lost in environmental sound.

[0844]

In addition, the information communication device according to the present embodiment may include a recognition device which stores, in a database, an electronic device owned by a user (owned electronic device), data of sound output by the owned electronic device, and position data of the owned electronic device, and adjusts notification sound of the electronic device to be recognized so that the sound output by the owned electronic device and the notification sound of the electronic device to be recognized are easily distinguished.

[0845]

Here, this recognition device may further adjust sound recognition processing so that it is easy to distinguish between the sound output by an owned electronic device and the notification sound of the electronic device to be recognized.

[0846]

In addition, the information communication device according to the present embodiment may include a recognition device which recognizes whether the positions of the operation terminal and an operator are close to each other, utilizing an operating condition of an operation terminal, a sensor value of a physical sensor, a data link state, and a charging state.

[0847]

Here, this recognition device may further recognize a position of the user, utilizing an operating state of an electronic device which can communicate with an operation terminal, a camera, a microphone, a human sensing sensor, and position data of the electronic device stored in the database.

[0848]

In addition, this recognition device may further be included in

an information notifying device which notifies a user of information using the notification device which can give notification to the user, utilizing a recognition result of the user position, and position data, stored in the database, of an electronic device (notification device) which has a function of giving notification to the user by means of screen display, voice output, and the like.

[0849]

It should be noted that these general and specific embodiments may be implemented using a system, a method, an integrated circuit, a computer program, or a recording medium, or any combination of systems, methods, integrated circuits, computer programs, or recording media.

[0850]

[Embodiment 10]

Currently, various simple authentication methods have been considered in wireless communication. For example, a push button method, a personal identification number (PIN) input method, an NFC method, and the like are specified in the Wi-Fi protected setup (WPS) of wireless LAN, which is set by the Wi-Fi alliance. With various simple authentication methods in wireless communication, whether a user using a device is to be authenticated is determined by limiting a time period or determining that the user is in a range where he/she can touch both devices, thereby authenticating the user.

[0851]

However, it cannot be said that the method of limiting a time period is secured if a user with evil intention is at some short distance. In addition, there are cases where the user has difficulty or troublesome in directly touching an installed device such as a home electric appliance.

[0852]

In view of this, in the present embodiment, a method of determining that a user who is to be authenticated is certainly in a room, and performing wireless authentication of a home electric appliance with ease and in a secured manner, by using communication using visible light for wireless authentication.

[0853]

FIG. 187 is a diagram illustrating an example of an environment in a house in the present embodiment. FIG. 188 is a diagram illustrating an example of communication between a smartphone and home electric appliances according to the present embodiment. FIG. 189 is a diagram illustrating a configuration of a transmitter device according to the present embodiment. FIG. 190 is a diagram illustrating a configuration of a receiver device according to the present embodiment. FIGS. 187 to 190 are similar to FIGS. 124 to 127, and thus a detailed description thereof is omitted.

[0854]

Home environment is assumed to be an environment where a tablet terminal which the user has in the kitchen and a TV placed in a living room are authenticated as illustrated in FIG. 187. Assume that both the devices are terminals which can be connected to a wireless LAN, and each include a WPS module.

[0855]

FIG. 191 is a sequence diagram for when a transmitter terminal (TV) performs wireless LAN authentication with a receiver terminal (tablet terminal), using optical communication in FIG. 187. The following is a description of FIG. 191.

[0856]

First, for example, a transmitter terminal as illustrated in FIG. 189 creates a random number (step 5001a). Next, the random number is registered in a registrar of WPS (step 5001b). Furthermore, a light emitting element is caused to emit light as indicated by a pattern of the random number registered in the registrar (step 5001c).

[0857]

On the other hand, while the light emitting element of the transmitter device is emitting light, a receiver device as illustrated in, for example, FIG. 190 activates a camera thereof in an optical authentication mode. Here, the optical authentication mode is a mode in which it can be recognized that the light emitting element is

emitting light for authentication, and is a video shooting mode which allows shooting in accordance with a cycle of light emissions.

[0858]

Accordingly, a user shoots a light emitting element of the transmitter terminal, first (step 5001d). Next, the receiver terminal receives the random number by shooting (step 5001e). Next, the receiver terminal which has received the random number inputs the random number as a PIN of WPS (step 5001f).

[0859]

Here, the transmitter and receiver terminals which share the PIN perform authentication processing according to the standard by WPS (step 5001g).

[0860]

Next, when the authentication is completed, the transmitter terminal deletes the random number from the registrar, and avoids accepting authentication from a plurality of terminals (5001h).

[0861]

It should be noted that this method is applicable not only to wireless LAN authentication, but also to all the wireless authentication methods which use a common key.

[0862]

In addition, this method is not limited to a wireless authentication method. For example it is also applicable for authentication of an application loaded on both the TV and the tablet terminal.

[0863]

FIG. 192 is a sequence diagram for when authentication is performed using an application according to the present embodiment. The following is a description of FIG. 192.

[0864]

First, a transmitter terminal creates a transmitter ID according to the state of the terminal (step 5002a). Here, the transmitter ID may be a random number or a key for coding. In addition, a terminal ID (a MAC address, an IP address) of the transmitter terminal may be included. Next, the transmitter

terminal emits light as indicated by the pattern of the transmitter ID (step 5002b).

[0865]

On the other hand, a receiver device receives the transmitter ID in the same process as in the case of wireless authentication (step 5002f). Next, upon the reception of the transmitter ID, the receiver device creates a receiver ID which can show that the transmitter ID has been received (step 5002g). For example, the receiver ID may be a terminal ID of the receiver terminal coded in the transmitter ID. In addition, the receiver ID may also include a process ID and a password of an application which has been activated in the receiver terminal. Next, the receiver terminal broadcasts the receiver ID wirelessly (step 5002h). It should be noted that if a terminal ID of the transmitter terminal is included in the transmitter ID, the receiver terminal may unicast the receiver ID

[0866]

Next, the transmitter terminal which has received the receiver ID wirelessly (5002c) performs authentication with a terminal which has transmitted the received receiver ID, using the transmitter ID shared in both the terminals (step 5002d).

[0867]

FIG. 193 is a flowchart illustrating operation of the transmitter terminal according to the present embodiment. The following is a description of FIG. 193.

[0868]

First, the transmitter terminal emits light indicating an ID, according to the state of the terminal (step 5003a).

[0869]

Next, light is emitted by the pattern according to the ID (step 5003b).

[0870]

Next, it is checked whether there is a wireless response corresponding to the ID indicated by emitted light (step 5003c). If there is a response (Yes in step 5003c), processing of authenticating the terminal which has transmitted the response is performed (step

5003d). It should be noted that if there is no response in step 5003c, the transmitter terminal waits until a timeout time elapses (step 5003i), and ends the processing after displaying there being no response (step 5003j).

[0871]

Next, it is checked whether authentication processing has succeeded in step 5003e, and when authentication processing has succeeded (Yes in step 5003e), if a command other than authentication is included in the ID indicated by light emission (Yes in step 5003f), processing in accordance with the command is performed (step 5003g).

[0872]

It should be noted that if authentication fails in step 5003e, an authentication error is displayed (step 5003h), and the processing ends.

[0873]

FIG. 194 is a flowchart illustrating operation of the receiver terminal according to the present embodiment. The following is a description of FIG. 194.

[0874]

First, a receiver terminal activates a camera in an optical authentication mode (step 5004a).

[0875]

Next, it is checked whether light has been received in a specific pattern (step 5004b), and if it is determined that such light has been received (Yes in step 5004b), a receiver ID is created which can show that a transmitter ID has been received (step 5004c). It should be noted that if it is not determined that such light has been received (No in step 5004b), the receiver terminal waits until a timeout time elapses (Yes in step 5004i), and displays timeout (step 5004j), and the processing ends.

[0876]

Next, it is checked whether the transmitter terminal holds an ID of the transmitter terminal (step 5004k), and if the transmitter terminal holds the ID of the terminal (Yes in step 5004k), the

transmitter terminal unicasts the receiver ID to the terminal (step 5004d). On the other hand, if the transmitter terminal does not hold the ID of the terminal (No in step 5004k), the transmitter terminal broadcasts the receiver ID (step 5004l).

[0877]

Next, authentication processing is started by the transmission terminal (step 5004e), and if the authentication processing has succeeded (Yes in step 5004e), it is determined whether a command is included in the ID obtained by receiving light (step 5004f). If it is determined in step 5004f that a command is included (YES in step 5004f), processing according to the ID is performed (step 5004g).

[0878]

It should be noted that if authentication fails in step 5004e (No in step 5004e), an authentication error is displayed (step 5004h), and the processing ends.

[0879]

As described above, according to the present embodiment, the communication using visible light is used for wireless authentication, whereby it can be determined that a user to be authenticated is certainly in a room, and wireless authentication of a home electric appliance can be performed with ease and in a secured manner.

[0880]

[Embodiment 11]

Although the flows for data exchange using NFC communication and high-speed wireless communication are described in the embodiments above, the present invention is not limited to those. An embodiment of the present invention can of course be achieved as the flows as illustrated in FIGS. 195 to 197, for example.

[0881]

FIG. 195 is a sequence diagram in which a mobile AV terminal 1 transmits data to a mobile AV terminal 2 according to the present embodiment. Specifically, FIG. 195 is a sequence diagram of data transmission and reception performed using NFC and wireless LAN communication. The following is a description of FIG. 195.

[0882]

First, the mobile AV terminal 1 displays, on a screen, data to be transmitted to the mobile AV terminal 2.

[0883]

Here, if the mobile AV terminals 1 and 2 are brought into contact with each other to perform NFC communication, the mobile AV terminal 1 displays, on the screen, a confirmation screen for checking whether data transmission is to be performed. This confirmation screen may be a screen for requesting a user to select "Yes/No" together with the words "Transmit data?" or may be an interface for starting data transmission by the screen of the mobile AV terminal 1 being touched again.

[0884]

In the case of "Yes" when it is checked whether data is intended to be transmitted, the mobile AV terminal 1 and the mobile AV terminal 2 exchange, by NFC communication, information on data to be transmitted and information for establishing high-speed wireless communication. The information on the data to be transmitted may be exchanged by wireless LAN communication. Information on establishment of wireless LAN communication may indicate a communication channel, or a service set identifier (SSID), and cryptographic key information, or may indicate a method of exchanging ID information created randomly and establishing a secure channel using this information

[0885]

If wireless LAN communication is established, the mobile AV terminals 1 and 2 perform data communication by wireless LAN communication, and the mobile AV terminal 1 transmits the transmission target data thereof to the mobile AV terminal 2.

[0886]

Next, a description is given using FIGS. 196 and 197, focusing on changes of the screens of the mobile AV terminal 1 and the mobile AV terminal 2. FIG. 196 is a diagram illustrating a screen changed when the mobile AV terminal 1 transmits data to the mobile AV terminal 2 according to the present embodiment. FIG. 197 is a

diagram illustrating a screen changed when the mobile AV terminal 1 transmits data to the mobile AV terminal 2 according to the present embodiment.

[0887]

In FIGS. 196 and 197, a user activates an application for reproducing video and a still image in the mobile AV terminal 1, first. This application displays a still image and video data stored in the mobile AV terminal 1.

[0888]

Here, NFC communication is performed by bringing the mobile AV terminals 1 and 2 to be almost in contact with each other. This NFC communication is processing for starting exchange of a still image and video data in the mobile AV terminal 1.

[0889]

First, when the mobile AV terminals 1 and 2 recognize the start of data exchange by NFC communication, a confirmation screen for checking whether data is to be transmitted is displayed on the screen of the mobile AV terminal 1. It should be noted that this confirmation screen may be an interface for facilitating a user to touch the screen to start data transmission or an interface for facilitating a user to select whether to allow data transmission by Yes/No, as in FIG. 196. In the case of Yes in determination as to whether data transmission is to be started, or specifically, when the mobile AV terminal 1 is to transmit data to the mobile AV terminal 2, the mobile AV terminal 1 transmits, to the mobile AV terminal 2, information on data to be exchanged and information on the start of high-speed wireless communication via a wireless LAN. It should be noted that information on this data to be exchanged may be transmitted using high-speed wireless communication.

[0890]

Next, upon receipt and transmission of the information on the start of high-speed wireless communication via the wireless LAN, the mobile AV terminals 1 and 2 perform processing for establishing connection by wireless LAN communication. This processing includes determining which channel is to be used for communication,

and which of the terminals is a parent terminal and which is a child terminal on communication topology, and exchanging password information, SSIDs of the terminals, and terminal information, for instance.

[0891]

Next, when the connection by wireless LAN communication is established, the mobile AV terminals 1 and 2 transmit data by wireless LAN communication. During data transmission, the mobile AV terminal 1 displays, on the screen, video being reproduced normally, whereas the mobile AV terminal 2 which receives data displays, on the screen, data being received. This is because if the mobile AV terminal 1 displays data being transmitted on the screen, the mobile AV terminal 1 cannot perform other processing, and thus data is transmitted in the background, thereby achieving an advantage of the improvement of a user's convenience. In addition, the mobile AV terminal 2 which is receiving data displays data being received on the screen so that the received data can be immediately displayed, thereby achieving an advantage of displaying data immediately after reception of the data is completed.

[0892]

Finally, the mobile AV terminal 2 displays the received data after the data reception is completed.

[0893]

FIGS. 198 to 200 are system outline diagrams when the mobile AV terminal 1 is a digital camera according to the present embodiment.

[0894]

As illustrated in FIG. 198, it is needless to say that the mobile phone according to the present embodiment is even applicable to the case where the mobile AV terminal 1 is a digital camera.

[0895]

In addition, if the mobile AV terminal 1 is a digital camera, the digital camera does not have a means of the Internet access by mobile-phone communication in many cases, although typical digital cameras have a means of the Internet access by wireless LAN.

[0896]

Accordingly, it is preferable to adopt a configuration in which as illustrated in FIGS. 199 and 200, the digital camera (the mobile AV terminal 1) transmits captured image data by a wireless LAN to picture sharing service in an environment where wireless LAN communication can be performed, whereas in an environment where wireless LAN communication cannot be performed, the digital camera transmits data to the mobile AV terminal 2 using a wireless LAN first, and the mobile AV terminal 2 transmits the as-is received data to picture sharing service by mobile phone communication.

[0897]

Since wireless LAN communication is performed at a higher speed than mobile phone communication, a picture can be transmitted to picture sharing service at high speed by performing wireless LAN communication if possible. In addition, the service area of a mobile phone communication network is generally larger than a wireless LAN communication network, and thus if wireless LAN environment is not available, a function of transmitting data to picture sharing service by mobile phone communication via the mobile AV terminal 2 is provided, thereby allowing a picture to be immediately transmitted to picture sharing service at various places.

[0898]

As described above, according to the present embodiment, data can be exchanged using NFC communication and high-speed wireless communication.

[0899]

The above is a description of, for instance, an information communication device according to one or more aspects of the present invention based on the embodiments. The present invention, however, is not limited to the embodiments. Various modifications to the embodiments that may be conceived by those skilled in the art and combinations of constituent elements in different embodiments may be included within the scope of one or more aspects of the present invention, without departing from the spirit of the present invention.

[0900]

It should be noted that in the above embodiments, each of the constituent elements may be constituted by dedicated hardware, or may be obtained by executing a software program suitable for the constituent element. Each constituent element may be achieved by a program execution unit such as a CPU or a processor reading and executing a software program stored in a recording medium such as a hard disk or semiconductor memory.

[0901]

[Embodiment 12]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as an LED blink pattern in Embodiments 1 to 11 described above.

[0902]

FIG. 201 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0903]

A transmitter 7001a such as a signage of a restaurant transmits identification information (ID) of the transmitter 7001a to a receiver 7001b such as a smartphone. The receiver 7001b obtains information associated with the ID from a server, and displays the information. Examples of the information include a route to the restaurant, availability, and a coupon.

[0904]

FIG. 202 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0905]

A transmitter 7042b such as a signage of a movie transmits identification information (ID) of the transmitter 7042b to a receiver 7042a such as a smartphone. The receiver 7042a obtains information associated with the ID from a server, and displays the information. Examples of the information include an image 7042c prompting to reserve a seat for the movie, an image 7042d showing scheduled times for the movie, an image 7042e showing availability,

and an image 7042f notifying reservation completion.

[0906]

FIG. 203 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0907]

A transmitter 7043b such as a signage of a drama transmits identification information (ID) of the transmitter 7043b to a receiver 7043a such as a smartphone. Having received the ID, the receiver 7043a obtains information associated with the ID from a server, and displays the information. Examples of the information include an image 7043c prompting to timer record the drama, an image 7043d prompting to select a recorder for recording the drama, and an image 7043e notifying timer recording completion.

[0908]

FIG. 204 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0909]

A transmitter 7044d or 7044c such as a signage of a store, e.g. a roof sign or a sign placed on a street, transmits identification information (ID) of the transmitter 7044d or 7044c to a receiver 7044a such as a smartphone. The receiver 7044a obtains information associated with the ID from a server, and displays the information. Examples of the information include an image 7044b showing availability, a coupon, and the like of the store.

[0910]

FIG. 205 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 12. This flowchart corresponds to the examples of application illustrated in FIGS. 201 to 204.

[0911]

First, the ID of the transmitter and the information to be provided to the receiver receiving the ID are stored in the server in association with each other (Step 7101a). The information to be provided to the receiver may include information such as a store name, a product name, map information to a store, availability

information, coupon information, stock count of a product, show time of a movie or a play, reservation information, and a URL of a server for reservation or purchase.

[0912]

Next, the transmitter transmits the ID (Step 7101b). The camera of the receiver is pointed to the transmitter, to receive the ID (Step 7101c).

[0913]

The receiver transmits the received ID to the server, and stores the information associated with the ID in the receiver (Step 7101d).

[0914]

The receiver also stores a terminal ID and a user ID in the server (Step 7101e). The receiver displays the information stored in the server as the information to be displayed on the receiver (Step 7101f).

[0915]

The receiver adjusts the display, based on a user profile stored in the receiver or the server (Step 7101g). For example, the receiver performs control such as changing the font size, hiding age-restricted content, or preferentially displaying content assumed to be preferred from the user's past behavior.

[0916]

The receiver displays the route from the current position to the store or the sales floor (Step 7101h). The receiver obtains information from the server according to need, and updates and displays availability information or reservation information (Step 7101i). The receiver displays a button for storing the obtained information and a button for cancelling the storage of the displayed information (Step 7101j).

[0917]

The user taps the button for storing the information obtained by the receiver (Step 7101k). The receiver stores the obtained information so as to be redisplayable by a user operation (Step 7101m). A reader in the store reads information transmitted from

the receiver (Step 7101n). Examples of the transmission method include visible light communication, communication via Wi-Fi or Bluetooth, and communication using 2D barcode. The transmission information may include the ID of the receiver or the user ID.

[0918]

The reader in the store stores the read information and an ID of the store in the server (Step 7101p). The server stores the transmitter, the receiver, and the store in association with each other (Step 7101q). This enables analysis of the advertising effectiveness of the signage.

[0919]

FIG. 206 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0920]

A transmitter 7002a such as a signage of a plurality of stores transmits identification information (ID) of the transmitter 7002a to a receiver 7002b such as a smartphone. Having received the ID, the receiver 7002b obtains information associated with the ID from a server, and displays the same information as the signage. When the user selects a desired store by tapping or voice, the receiver 7002b displays the details of the store.

[0921]

FIG. 207 is a flowchart illustrating an example of processing operation of the receiver 7002b and the transmitter 7002a in Embodiment 12.

[0922]

The ID of the transmitter 7002a and the information to be provided to the receiver 7002b receiving the ID are stored in the server in association with each other (Step 7102a). The information to be provided to the receiver 7002b may include information such as a store name, a product name, map information to a store, availability information, coupon information, stock count of a product, show time of a movie or a play, reservation information, and a URL of a server for reservation or purchase. The position relation of information displayed on the transmitter 7002a is stored in the

server.

[0923]

The transmitter 7002a such as a signage transmits the ID (Step 7102b). The camera of the receiver 7002b is pointed to the transmitter 7002a, to receive the ID (Step 7102c). The receiver 7002b transmits the received ID to the server, and obtains the information associated with the ID (Step 7102d). The receiver 7002b displays the information stored in the server as the information to be displayed on the receiver 7002b (Step 7102e). An image which is the information may be displayed on the receiver 7002b while maintaining the position relation of the image displayed on the transmitter 7002a.

[0924]

The user selects information displayed on the receiver 7002b, by designation by screen tapping or voice (Step 7102f). The receiver 7002b displays the details of the information designated by the user (Step 7102g).

[0925]

FIG. 208 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0926]

A transmitter 7003a such as a signage of a plurality of stores transmits identification information (ID) of the transmitter 7003a to a receiver 7003b such as a smartphone. Having received the ID, the receiver 7003b obtains information associated with the ID from a server, and displays information near (e.g. nearest) the center of the captured image of the camera of the receiver 7003b from among the information displayed on the signage.

[0927]

FIG. 209 is a flowchart illustrating an example of processing operation of the receiver 7003b and the transmitter 7003a in Embodiment 12.

[0928]

The ID of the transmitter 7003a and the information to be provided to the receiver 7003b receiving the ID are stored in the

server in association with each other (Step 7103a). The information to be provided to the receiver 7003b may include information such as a store name, a product name, map information to a store, availability information, coupon information, stock count of a product, show time of a movie or a play, reservation information, and a URL of a server for reservation or purchase. The position relation of information displayed on the transmitter 7003a is stored in the server.

[0929]

The transmitter 7003a such as a signage transmits the ID (Step 7103b). The camera of the receiver 7003b is pointed to the transmitter 7003a, to receive the ID (Step 7103c). The receiver 7003b transmits the received ID to the server, and obtains the information associated with the ID (Step 7103d). The receiver 7003b displays information nearest the center of the captured image or the designated part from among the information displayed on the signage (Step 7103e).

[0930]

FIG. 210 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0931]

A transmitter 7004a such as a signage of a plurality of stores transmits identification information (ID) of the transmitter 7004a to a receiver 7004b such as a smartphone. Having received the ID, the receiver 7004b obtains information associated with the ID from a server, and displays information (e.g. image showing the details of the store "B Cafe") near the center of the captured image of the camera of the receiver 7004b from among the information displayed on the signage. When the user flicks left the screen, the receiver 7004b displays an image showing the details of the store "C Bookstore" on the right side of the store "B Cafe" on the signage. Thus, the receiver 7004b displays the image in the same position relation as that in the transmitter signage.

[0932]

FIG. 211 is a flowchart illustrating an example of processing

operation of the receiver 7004b and the transmitter 7004a in Embodiment 12.

[0933]

The ID of the transmitter 7004a and the information to be provided to the receiver 7004b receiving the ID are stored in the server in association with each other (Step 7104a). The information to be provided to the receiver 7004b may include information such as a store name, a product name, map information to a store, availability information, coupon information, stock count of a product, show time of a movie or a play, reservation information, and a URL of a server for reservation or purchase. The position relation of information displayed on the transmitter 7004a is stored in the server.

[0934]

The transmitter 7004a such as a signage transmits the ID (Step 7104b). The camera of the receiver 7004b is pointed to the transmitter 7004a, to receive the ID (Step 7104c). The receiver 7004b transmits the received ID to the server, and obtains the information associated with the ID (Step 7104d). The receiver 7004b displays the information stored in the server as the information to be displayed on the receiver 7004b (Step 7104e).

[0935]

The user performs a flick operation on the receiver 7004b (Step 7104f). The receiver 7004b changes the display in the same position relation as the information displayed on the transmitter 7004a, according to the user operation (Step 7104g). For example, in the case where the user flicks left the screen to display the information on the right side of the currently displayed information, the information displayed on the transmitter 7004a on the right side of the information currently displayed on the receiver 7004b is displayed on the receiver 7004b.

[0936]

FIG. 212 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0937]

A transmitter 7005a such as a signage of a plurality of stores transmits identification information (ID) of the transmitter 7005a to a receiver 7005b such as a smartphone. Having received the ID, the receiver 7005b obtains information associated with the ID from a server, and displays information (e.g. image showing the details of the store "B Cafe") near the center of the captured image of the camera of the receiver 7005b from among the information displayed on the signage. When the user taps the left of the screen (or a left arrow on the screen) of the receiver 7005b, the receiver 7005b displays an image showing the details of the store "A Restaurant" on the left side of the store "B Cafe" on the signage. When the user taps the bottom of the screen (or a down arrow on the screen) of the receiver 7005b, the receiver 7005b displays an image showing the details of the store "E Office" below the store "B Cafe" on the signage. When the user taps the right of the screen (or a right arrow on the screen) of the receiver 7005b, the receiver 7005b displays an image showing the details of the store "C Bookstore" on the left side of the store "B Cafe" on the signage. Thus, the receiver 7004b displays the image in the same position relation as that in the transmitter signage.

[0938]

FIG. 213 is a flowchart illustrating an example of processing operation of the receiver 7005b and the transmitter 7005a in Embodiment 12.

[0939]

The ID of the transmitter 7005a and the information to be provided to the receiver 7005b receiving the ID are stored in the server in association with each other (Step 7105a). The information to be provided to the receiver 7005b may include information such as a store name, a product name, map information to a store, availability information, coupon information, stock count of a product, show time of a movie or a play, reservation information, and a URL of a server for reservation or purchase. The position relation of information displayed on the transmitter 7005a is stored in the server.

[0940]

The transmitter 7005a such as a signage transmits the ID (Step 7105b). The camera of the receiver 7005b is pointed to the transmitter 7005a, to receive the ID (Step 7105c). The receiver 7005b transmits the received ID to the server, and obtains the information associated with the ID (Step 7105d). The receiver 7005b displays the information stored in the server as the information to be displayed on the receiver 7005b (Step 7105e).

[0941]

The user taps the edge of the screen displayed on the receiver 7005b or the up, down, left, or right direction indicator displayed on the receiver 7005b (Step 7105f). The receiver changes the display in the same position relation as the information displayed on the transmitter 7005a, according to the user operation. For example, in the case where the user taps the right of the screen or the right direction indicator on the screen, the information displayed on the transmitter 7005a on the right side of the information currently displayed on the receiver 7005b is displayed on the receiver 7005b.

[0942]

FIG. 214 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12. A rear view of a vehicle is given in FIG. 214.

[0943]

A transmitter (vehicle) 7006a having, for instance, two car taillights (light emitting units or lights) transmits identification information (ID) of the transmitter 7006a to a receiver such as a smartphone. Having received the ID, the receiver obtains information associated with the ID from a server. Examples of the information include the ID of the vehicle or the transmitter, the distance between the light emitting units, the size of the light emitting units, the size of the vehicle, the shape of the vehicle, the weight of the vehicle, the number of the vehicle, the traffic ahead, and information indicating the presence/absence of danger. The receiver may obtain these information directly from the transmitter 7006a.

[0944]

FIG. 215 is a flowchart illustrating an example of processing operation of the receiver and the transmitter 7006a in Embodiment 12.

[0945]

The ID of the transmitter 7006a and the information to be provided to the receiver receiving the ID are stored in the server in association with each other (Step 7106a). The information to be provided to the receiver may include information such as the size of the light emitting unit as the transmitter 7006a, the distance between the light emitting units, the shape and weight of the object including the transmitter 7006a, the identification number such as a vehicle identification number, the state of an area not easily observable from the receiver, and the presence/absence of danger.

[0946]

The transmitter 7006a transmits the ID (Step 7106b). The transmission information may include the URL of the server and the information to be stored in the server.

[0947]

The receiver receives the transmitted information such as the ID (Step 7106c). The receiver obtains the information associated with the received ID from the server (Step 7106d). The receiver displays the received information and the information obtained from the server (Step 7106e).

[0948]

The receiver calculates the distance between the receiver and the light emitting unit by triangulation, from the information of the size of the light emitting unit and the apparent size of the captured light emitting unit or from the information of the distance between the light emitting units and the distance between the captured light emitting units (Step 7106f). The receiver issues a warning of danger or the like, based on the information such as the state of an area not easily observable from the receiver and the presence/absence of danger (Step 7106g).

[0949]

FIG. 216 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0950]

A transmitter (vehicle) 7007b having, for instance, two car taillights (light emitting units or lights) transmits information of the transmitter 7007b to a receiver 7007a such as a transmitter-receiver in a parking lot. The information of the transmitter 7007b indicates the identification information (ID) of the transmitter 7007b, the number of the vehicle, the size of the vehicle, the shape of the vehicle, or the weight of the vehicle. Having received the information, the receiver 7007a transmits information of whether or not parking is permitted, charging information, or a parking position. The receiver 7007a may receive the ID, and obtain information other than the ID from the server.

[0951]

FIG. 217 is a flowchart illustrating an example of processing operation of the receiver 7007a and the transmitter 7007b in Embodiment 12. Since the transmitter 7007b performs not only transmission but also reception, the transmitter 7007b includes an in-vehicle transmitter and an in-vehicle receiver.

[0952]

The ID of the transmitter 7007b and the information to be provided to the receiver 7007a receiving the ID are stored in the server (parking lot management server) in association with each other (Step 7107a). The information to be provided to the receiver 7007a may include information such as the shape and weight of the object including the transmitter 7007b, the identification number such as a vehicle identification number, the identification number of the user of the transmitter 7007b, and payment information.

[0953]

The transmitter 7007b (in-vehicle transmitter) transmits the ID (Step 7107b). The transmission information may include the URL of the server and the information to be stored in the server. The receiver 7007a (transmitter-receiver) in the parking lot transmits the received information to the server for managing the parking lot

(parking lot management server) (Step 7107c). The parking lot management server obtains the information associated with the ID of the transmitter 7007b, using the ID as a key (Step 7107d). The parking lot management server checks the availability of the parking lot (Step 7107e).

[0954]

The receiver 7007a (transmitter-receiver) in the parking lot transmits information of whether or not parking is permitted, parking position information, or the address of the server holding these information (Step 7107f). Alternatively, the parking lot management server transmits these information to another server. The transmitter (in-vehicle receiver) 7007b receives the transmitted information (Step 7107g). Alternatively, the in-vehicle system obtains these information from another server.

[0955]

The parking lot management server controls the parking lot to facilitate parking (Step 7107h). For example, the parking lot management server controls a multi-level parking lot. The transmitter-receiver in the parking lot transmits the ID (Step 7107i). The in-vehicle receiver (transmitter 7007b) inquires of the parking lot management server based on the user information of the in-vehicle receiver and the received ID (Step 7107j).

[0956]

The parking lot management server charges for parking according to parking time and the like (Step 7107k). The parking lot management server controls the parking lot to facilitate access to the parked vehicle (Step 7107m). For example, the parking lot management server controls a multi-level parking lot. The in-vehicle receiver (transmitter 7007b) displays the map to the parking position, and navigates from the current position (Step 7107n).

[0957]

FIG. 218 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0958]

A transmitter 7008a or 7008b such as a signage of a store, e.g. a roof sign or a sign placed on a street, transmits identification information (ID) of the transmitter 7008a or 7008b to a receiver 7008c such as a smartphone. Having received the ID, the receiver 7008c obtains information associated with the ID from a server, and displays the information. Examples of the information include an image showing availability, a coupon, 2D barcode, and the like of the store.

[0959]

FIG. 219 is a flowchart illustrating an example of processing operation of the receiver 7008c and the transmitter 7008a or 7008b in Embodiment 12. Though the following describes, of the transmitters 7008a and 7008b, the transmitter 7008a as an example, the processing operation of the transmitter 7008b is the same as that of the transmitter 7008a.

[0960]

The ID of the transmitter 7008a and the information to be provided to the receiver 7008c receiving the ID are stored in the server in association with each other (Step 7108a). The information to be provided to the receiver 7008c may include information such as a store name, a product name, map information to a store, availability information, coupon information, stock count of a product, show time of a movie or a play, reservation information, and a URL of a server for reservation or purchase.

[0961]

The transmitter 7008a such as a signage transmits the ID (Step 7108b). The camera of the receiver 7008c is pointed to the transmitter 7008a, to receive the ID (Step 7108c). The receiver 7008c transmits the received ID to the server, and stores the information associated with the ID in the receiver 7008c (Step 7108d). The receiver 7008c also stores a terminal ID and a user ID in the server (Step 7108e).

[0962]

The receiver 7008c displays the information stored in the server as the information to be displayed on the receiver 7008c (Step

7108f). The receiver 7008c displays the route from the current position to the store or the sales floor (Step 7108g). The receiver 7008c obtains information from the server according to need, and updates and displays availability information or reservation information (Step 7108h).

[0963]

The receiver 7008c displays a button for reserving or ordering a seat or a product (Step 7108i). The user taps the reserve button or the order button displayed on the receiver 7008c (Step 7108j). The receiver 7008c transmits the information of reservation or order to the server for managing reservation or order (Step 7108k).

[0964]

FIG. 220 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0965]

A receiver (terminal) 7009b such as a smartphone is placed on a table in front of a seat in a store. A transmitter 7009a such as a lighting device transmits identification information (ID) of the transmitter 7009a to the receiver 7009b. Having received the ID, the receiver 7009b obtains information associated with the ID from a server, and performs a process such as reserving the seat, confirming the provisional reservation, or extending the reserved time.

[0966]

FIG. 221 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0967]

Having obtained the information from the server, the receiver 7009b displays, for example, the availability of the store and buttons for selecting “check”, “extend”, and “additional order”.

[0968]

FIG. 222 is a flowchart illustrating an example of processing operation of the receiver 7009b and the transmitter 7009a in Embodiment 12.

[0969]

The ID of the transmitter 7009a and the information to be provided to the receiver 7009b receiving the ID are stored in the server in association with each other (Step 7109a). The information to be provided to the receiver 7009b may include information of the position and shape of the transmitter 7009a. The transmitter 7009a such as a ceiling lighting transmits the ID (Step 7109b).

[0970]

The user places the receiver 7009b on the table or the like (Step 7109c). The receiver 7009b recognizes the placement of the receiver 7009b on the table or the like from the information of the gyroscope or the 9-axis sensor, and starts the reception process (Step 7109d). The receiver 7009b identifies an upward facing camera from the upward direction of the 9-axis sensor, and receives the ID using the camera.

[0971]

The camera of the receiver 7009b is pointed to the transmitter 7009a, to receive the ID (Step 7109e). The receiver 7009b transmits the received ID to the server, and stores the information associated with the ID in the receiver 7009b (Step 7109f). The receiver 7009b estimates the position of the receiver 7009b (Step 7109g).

[0972]

The receiver 7009b transmits the position of the receiver 7009b to the store management server (Step 7109h). The store management server specifies the seat of the table on which the receiver 7009b is placed (Sep 7109i). The store management server transmits the seat number to the receiver 7009b (Step 7109j).

[0973]

FIG. 223 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0974]

A transmitter 7011a such as a ceiling lighting transmits identification information (ID) of the transmitter 7011a to a receiver 7011b such as a smartphone. Having received the ID, the receiver 7011b obtains information associated with the ID from a server, and

estimates (determines) the self-position. When the receiver 7011b is placed at an electronic device 7011c, the receiver 7011b functions as an operation terminal of the electronic device 7011c. Thus, the electronic device 7011c can be operated by a rich interface such as a touch panel or voice output.

[0975]

FIG. 224 is a flowchart illustrating an example of processing operation of the receiver 7011b and the transmitter 7011a in Embodiment 12.

[0976]

The position of the electronic device is stored in the server (Step 7110a). The ID, model, function, and operation interface information (screen, input/output voice, interactive model) of the electronic device may be stored in association with the position information.

[0977]

The ID of the transmitter 7011a and the information to be provided to the receiver 7011b receiving the ID are stored in the server in association with each other (Step 7110b). The information to be provided to the receiver 7011b may include information of the position and shape of the transmitter 7011a.

[0978]

The transmitter 7011a such as a ceiling lighting transmits the ID (Step 7110c). The camera of the receiver 7011b is pointed to the transmitter 7011a, to receive the ID (Step 7110d). The receiver 7011b transmits the received ID to the server, and stores the information associated with the ID in the receiver 7011b (Step 7110e). The receiver 7011b estimates the position of the receiver 7011b (Step 7110f).

[0979]

The user places the receiver 7011b at the electronic device (Step 7110g). The receiver 7011b recognizes that the receiver 7011b is stationary from the information of the gyroscope or the 9-axis sensor, and starts the following process (Step 7110h). The receiver 7011b estimates the self-position by the above-mentioned

method, in the case where at least a predetermined time has elapsed from the last estimation of the position of the receiver 7011b (Step 7110i).

[0980]

The receiver 7011b estimates the movement from the last self-position estimation from the information of the gyroscope or the 9-axis sensor, and estimates the current position (Step 7110j). The receiver 7011b obtains information of an electronic device nearest the current position, from the server (Step 7110k). The receiver 7011b obtains the information of the electronic device from the electronic device via Bluetooth or Wi-Fi (Step 7110m). Alternatively, the receiver 7011b obtains the information of the electronic device stored in the server.

[0981]

The receiver 7011b displays the information of the electronic device (Step 7110n). The receiver 7011b receives input as the operation terminal of the electronic device (Step 7110p). The receiver 7011b transmits the operation information of the electronic device to the electronic device via Bluetooth or Wi-Fi (Step 7110q). Alternatively, the receiver 7011b transmits the operation information of the electronic device to the electronic device via the server.

[0982]

FIG. 225 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0983]

A camera of a receiver 7012a such as a smartphone is pointed to a transmitter 7012b as an electronic device such as a television receiver (TV). The receiver 7012a receives identification information (ID) of the transmitter 7043b transmitted from the transmitter 7043b. The receiver 7043a obtains information associated with the ID from a server. Thus, the receiver 7012a functions as an operation terminal of the electronic device in the direction pointed by the camera. That is, the receiver 7012a wirelessly connects to the transmitter 7012b via Bluetooth, Wi-Fi, or

the like.

[0984]

FIG. 226 is a flowchart illustrating an example of processing operation of the receiver 7012a and the transmitter 7012b in Embodiment 12.

[0985]

The ID of the transmitter 7012b and the information to be provided to the receiver 7012a receiving the ID are stored in the server in association with each other (Step 7111a). The information to be provided to the receiver 7012a may include the ID, model, function, and operation interface information (screen, input/output voice, interactive model) of the electronic device.

[0986]

The transmitter 7012b included in the electronic device or associated with the electronic device transmits the ID (Step 7111b). The camera of the receiver 7012a is pointed to the transmitter 7012b, to receive the ID (Step 7111c). The receiver 7012a transmits the received ID to the server, and stores the information associated with the ID in the receiver 7012a (Step 7111d). The receiver 7012a obtains the information of the electronic device from the server, using the received ID as a key (Step 7111e).

[0987]

The receiver 7012a obtains the information of the electronic device from the electronic device via Bluetooth or Wi-Fi (Step 7111f). Alternatively, the receiver 7012a obtains the information of the electronic device stored in the server. The receiver 7012a displays the information of the electronic device (Step 7111g).

[0988]

The receiver 7012a receives input as the operation terminal of the electronic device (Step 7111h). The receiver 7012a transmits the operation information of the electronic device to the electronic device via Bluetooth or Wi-Fi (Step 7111i). Alternatively, the receiver 7012a transmits the operation information of the electronic device to the electronic device via the server.

[0989]

FIG. 227 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[0990]

A receiver 7013b such as a smartphone receives a destination input by the user. The camera of the receiver 7013b is then pointed to a transmitter 7013a such as a lighting device (light). The receiver 7013b receives identification information (ID) of the transmitter 7013a transmitted from the transmitter 7013a. The receiver 7013b obtains information associated with the ID from a server. The receiver 7013b estimates (determines) the self-position based on the obtained information. The receiver 7013b accordingly navigates the user to the destination by audio or the like. In the case where the user is visually impaired, the receiver 7013b reports any obstacle to the user in detail.

[0991]

FIG. 228 is a flowchart illustrating an example of processing operation of the receiver 7013b and the transmitter 7013a in Embodiment 12.

[0992]

The user inputs the destination to the receiver 7013b (Step 7112a). The user points the receiver 7013b to the light (transmitter 7013a) (Step 7112b). Even a visually impaired user can point the receiver 7013b to the light if he or she is capable of recognizing intense light.

[0993]

The receiver 7013b receives a signal superimposed on the light (Step 7112c). The receiver 7013b obtains information from the server, using the received signal as a key (Step 7112d). The receiver 7013b obtains a map from the current position to the destination from the server (Step 7112e). The receiver 7013b displays the map, and navigates from the current position to the destination (Step 7112f).

[0994]

FIG. 229 is a diagram illustrating a state of the receiver in Embodiment 12.

[0995]

A receiver (terminal) 7014a such as a smartphone includes a face camera 7014b. When the imaging direction of the face camera 7014b is upward at a predetermined angle or more with the ground plane, the receiver 7014a performs a signal reception process (process of receiving a signal from a transmitter by imaging) by the face camera 7014b. In the case where the receiver 7014a also includes a camera other than the face camera 7014b, the receiver 7014a assigns higher priority to the face camera 7014b than the other camera.

[0996]

FIG. 230 is a flowchart illustrating an example of processing operation of the receiver 7014a in Embodiment 12.

[0997]

The receiver 7014a determines whether or not the imaging direction of the face camera 7014b is upward at a predetermined angle or more with the ground plane (Step 7113a). In the case where the determination result is true (Y), the receiver 7014a starts the reception by the face camera 7014b (Step 7113b). Alternatively, the receiver 7014a assigns higher priority to the reception process by the face camera 7014b. When a predetermined time has elapsed (Step 7113c), the receiver 7014a ends the reception by the face camera 7014b (Step 7113d). Alternatively, the receiver 7014a assigns lower priority to the reception process by the face camera 7014b.

[0998]

FIG. 231 is a diagram illustrating a state of the receiver in Embodiment 12.

[0999]

A receiver (terminal) 7015a such as a smartphone includes an out camera 7015b. When the imaging direction of the out camera 7015b is at a predetermined angle or less with the ground plane, the receiver 7014a performs a signal reception process (process of receiving a signal from a transmitter by imaging) by the out camera 7015b. In the case where the receiver 7015a also includes a camera

other than the out camera 7015b, the receiver 7015a assigns higher priority to the out camera 7015b than the other camera.

[1000]

Note that, when the imaging direction of the out camera 7015b is at a predetermined angle or less with the ground plane, the receiver 7015a is in portrait orientation, and the surface of the receiver 7015a on which the out camera 7015b is provided is at a predetermined angle or more with the ground plane.

[1001]

FIG. 232 is a flowchart illustrating an example of processing operation of the receiver 7015a in Embodiment 12.

[1002]

The receiver 7015a determines whether or not the imaging direction of the out camera 7015b is at a predetermined angle or less with the ground plane (Step 7114a). In the case where the determination result is true (Y), the receiver 7015a starts the reception by the out camera 7015b (Step 7114b). Alternatively, the receiver 7015a assigns higher priority to the reception process by the out camera 7015b. When a predetermined time has elapsed (Step 7114c), the receiver 7015a ends the reception by the out camera 7015b (Step 7114d). Alternatively, the receiver 7015a assigns lower priority to the reception process by the out camera 7015b.

[1003]

FIG. 233 is a diagram illustrating a state of the receiver in Embodiment 12.

[1004]

A receiver (terminal) 7016a such as a smartphone includes an out camera. When the receiver 7016a is moved (stuck out) in the imaging direction of the out camera, the receiver 7016a performs a signal reception process (process of receiving a signal from a transmitter by imaging) by the out camera. In the case where the receiver 7016a also includes a camera other than the out camera, the receiver 7016a assigns higher priority to the out camera than the other camera.

[1005]

Note that, when the receiver 7016a is moved in the imaging direction of the out camera, the angle between the moving direction and the imaging direction (upon the end of the movement) is a predetermined angle or less.

[1006]

FIG. 234 is a flowchart illustrating an example of processing operation of the receiver 7016a in Embodiment 12.

[1007]

The receiver 7016a determines whether or not the receiver 7016a is moved and the angle between the moving direction and the imaging direction of the out camera upon the end of the movement is a predetermined angle or less (Step 7115a). In the case where the determination result is true (Y), the receiver 7016a starts the reception by the out camera (Step 7115b). Alternatively, the receiver 7016a assigns higher priority to the reception process by the out camera. When a predetermined time has elapsed (Step 7115c), the receiver 7016a ends the reception by the out camera (Step 7115d). Alternatively, the receiver 7016a assigns lower priority to the reception process by the out camera.

[1008]

FIG. 235 is a diagram illustrating a state of the receiver in Embodiment 12.

[1009]

A receiver (terminal) 7017a such as a smartphone includes a predetermined camera. When a display operation or specific button press corresponding to the predetermined camera is performed, the receiver 7017a performs a signal reception process (process of receiving a signal from a transmitter by imaging) by the predetermined camera. In the case where the receiver 7017a also includes a camera other than the predetermined camera, the receiver 7017a assigns higher priority to the predetermined camera than the other camera.

[1010]

FIG. 236 is a flowchart illustrating an example of processing operation of the receiver 7017a in Embodiment 12.

[1011]

The receiver 7017a determines whether or not a display operation or a specific button press is performed on the receiver 7017a (Step 7115h). In the case where the determination result is true (Y), the receiver 7017a starts the reception by the camera corresponding to the display operation or the specific button press (Step 7115i). Alternatively, the receiver 7017a assigns higher priority to the reception process by the camera. When a predetermined time has elapsed (Step 7115j), the receiver 7017a ends the reception by the camera corresponding to the display operation or the specific button press (Step 7115k). Alternatively, the receiver 7017a assigns lower priority to the reception process by the camera.

[1012]

FIG. 237 is a diagram illustrating a state of the receiver in Embodiment 12.

[1013]

A receiver (terminal) 7018a such as a smartphone includes a face camera 7018b. When the imaging direction of the face camera 7018b is upward at a predetermined angle or more with the ground plane and also the receiver 7014a is moving along a direction at a predetermined angle or less with the ground plane, the receiver 7018a performs a signal reception process (process of receiving a signal from a transmitter by imaging) by the face camera 7018b. In the case where the receiver 7018a also includes a camera other than the face camera 7018b, the receiver 7018a assigns higher priority to the face camera 7018b than the other camera.

[1014]

FIG. 238 is a flowchart illustrating an example of processing operation of the receiver 7018a in Embodiment 12.

[1015]

The receiver 7018a determines whether or not the imaging direction of the face camera 7018b is upward at a predetermined angle or more with the ground plane and the receiver 7018a is translated at a predetermined angle or less with the ground plane

(Step 7116a). In the case where the determination result is true (Y), the receiver 7018a starts the reception by the face camera 7018b (Step 7116b). Alternatively, the receiver 7018a assigns higher priority to the reception process by the face camera 7018b. When a predetermined time has elapsed (Step 7116c), the receiver 7018a ends the reception by the face camera 7018b (Step 7116d). Alternatively, the receiver 7018a assigns lower priority to the reception process by the face camera 7018b.

[1016]

FIG. 239 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1017]

A camera of a receiver 7019b such as a smartphone is pointed to a transmitter 7019a as an electronic device such as a television receiver (TV). The receiver 7019b receives identification information (ID) of a currently viewed channel, which is transmitted from the transmitter 7019a (the display of the transmitter 7019a). The receiver 7019b obtains information associated with the ID from a server. Thus, the receiver 7019b displays a page for buying a related product of the TV program, or related information of the TV program. The receiver 7019b also participates in the TV program through voting or applying for presents. The transmitter (TV) 7019a may include an address storage unit storing the address of the user, and transmit information relating to the address stored in the address storage unit. The receiver 7019b transmits the received ID and the time of receiving the ID, to the server. By doing so, the receiver 7019b can obtain data from the server, without being affected by a delay from ID reception to server access. The transmitter 7019a may obtain, from a built-in clock or a broadcast wave, time information or an ID that changes with time, and transmit it. This enables the server to transmit data set by the broadcaster to the receiver, regardless of the time setting in the receiver.

[1018]

FIG. 240 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1019]

As illustrated in (a) in FIG. 240, the transmitter 7019a and the receiver 7019b may directly transmit and receive the information necessary for realizing the example of application illustrated in FIG. 239.

[1020]

As illustrated in (b) in FIG. 240, the transmitter 7019a may transmit the ID of the currently viewed channel to the receiver 7019b. In this case, the receiver 7019b receives the information associated with the ID, i.e. the information necessary for realizing the example of application illustrated in FIG. 239, from the server.

[1021]

As illustrated in (c) in FIG. 240, the transmitter 7019a may transmit the ID of the transmitter (TV) 7019a or information necessary for wireless connection to the receiver 7019b. In this case, the receiver 7019b receives the ID or the information, and inquires of the transmitter 7019a or a recorder for the currently viewed channel, based on the ID or the information. The receiver 7019b then obtains the information relating to the channel identified as a result of the inquiry, i.e. the information necessary for realizing the example of application illustrated in FIG. 239, from the server.

[1022]

For example, the transmitter 7019a transmits an SSID (Service Set Identifier), a password, an IP address, a device ID, or the like, as the information necessary for wireless connection such as Wi-Fi or Bluetooth®. Having received such information, the receiver 7019b wirelessly connects to the transmitter 7019a based on the information. The receiver 7019b then obtains the information of the program viewed by the user from the transmitter 7019a via the wireless connection, and transmits the information of the program to the server. Having received the information of the program, the server transmits content held in association with the information of the program, to the receiver 7019b. The receiver 7019b obtains the content from the server, and displays the content.

[1023]

FIG. 241 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1024]

The transmitter 7019a may include a TV 2021b and a recorder 2021a. In the transmitter 7019a, the recorder 2021a stores the identification information (ID) and the recording time of the recorded channel, upon recording. Alternatively, the recorder 2021a obtains, from the server, information associated with the identification information (ID) and the recording time of the recorded channel, and stores the obtained information. Upon reproduction, the TV 2021b transmits part or all of the information stored in the recorder 2021a, to the receiver 7019b. Moreover, at least one of the TV 2021b and the recorder 2021a may act as the server. In the case where the recorder 2021a acts as the server, the recorder 2021a replaces the server address with the address of the recorder 2021a, and has the TV 202b transmit the address to the receiver 7019b.

[1025]

FIG. 242 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1026]

A camera of a receiver 7022c such as a smartphone is pointed to a transmitter 7022b as an electronic device such as a television receiver (TV). The receiver 7022c receives information transmitted from the transmitter 7022b (display of the transmitter 7022b). The receiver 7022c performs wireless communication with the transmitter 7022b, based on the information. When the transmitter 7022b obtains information including an image to be displayed on the receiver 7022c from a server 7022a and transmits the information to the receiver 7022c, the transmitter 7022b replaces the address of the server 7022a included in the information with the address of the transmitter 7022b.

[1027]

FIG. 243 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1028]

For instance, a recorder 7023b obtains all of the information necessary for realizing the example of application illustrated in FIG. 239 from a server 7023a, upon recording a TV program.

[1029]

Upon reproducing the TV program, the recorder 7023b transmits the reproduction screen and the information necessary for realizing the example of application illustrated in FIG. 239, to a TV 7023c as a transmitter. The TV 7023c receives the reproduction screen and the information, displays the reproduction image, and also transmits the information from the display. A receiver 7023d such as a smartphone receives the information, and performs wireless communication with the TV 7023c based on the information.

[1030]

As an alternative, upon reproducing the TV program, the recorder 7023b transmits the reproduction screen and the information necessary for wireless communication such as the address of the recorder 7023b, to the TV 7023c as a transmitter. The TV 7023c receives the reproduction screen and the information, displays the reproduction image, and also transmits the information from the display. The receiver 7023d such as a smartphone receives the information, and performs wireless communication with the recorder 7023b based on the information.

[1031]

FIG. 244 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1032]

A camera of a receiver 7045a such as a smartphone is pointed to a transmitter 7045b as an electronic device such as a television receiver (TV). The transmitter 7045b displays video of a TV program such as a music program, and transmits information from the display. The receiver 7045a receives the information transmitted from the transmitter 7045b (display of the transmitter 7045b). The receiver 7045a displays a screen 7045c prompting to buy a song in the music program, based on the information.

[1033]

FIG. 245 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 12. This flowchart corresponds to the examples of application illustrated in FIGS. 239 to 244.

[1034]

The transmitter included in the TV or the recorder obtains, from the server, the information to be provided to the receiver as the information relating to the currently broadcasted program (Step 7117a). The transmitter transmits the signal by superimposing the signal on the backlight of the display (Step 7117b). The transmission signal may include a URL of the transmitter, an SSID of the transmitter, and a password for accessing the transmitter.

[1035]

FIG. 246 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 12. This flowchart corresponds to the examples of application illustrated in FIGS. 239 to 244.

[1036]

The receiver receives the information from the display (Step 7118a). The receiver determines whether or not the currently viewed channel information is included in the received information (Step 7118b). In the case where the determination result is false (N), the receiver obtains the currently viewed channel information from the electronic device having the ID included in the received information (Step 7118c).

[1037]

In the case where the determination result is true (Y), the receiver obtains the information related to the currently viewed screen from the server (Step 7118d). The TV or the recorder may act as the server. The receiver displays the information obtained from the server (Step 7118e). The receiver adjusts the display, based on a user profile stored in the receiver or the server (Step 7118f). For example, the receiver performs control such as changing the font size, hiding age-restricted content, or preferentially displaying content assumed to be preferred from the

user’s past behavior.

[1038]

FIG. 247 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 12. This flowchart corresponds to the examples of application illustrated in FIGS. 239 to 244.

[1039]

The recorder obtains the information related to the program from the server and stores the information, when recording the program (Step 7119a). In the case where the related information changes with time, the recorder also stores the time.

[1040]

The recorder transmits the stored information to the display, when reproducing the recorded image (Step 7119b). The access information (URL or password) of the server in the stored information may be replaced with the access information of the display.

[1041]

The recorder transmits the stored information to the receiver, when reproducing the recorded image (Step 7119c). The access information (URL or password) of the server in the stored information may be replaced with the access information of the recorder.

[1042]

FIG. 248 is a diagram illustrating a luminance change of the transmitter in Embodiment 12.

[1043]

The transmitter codes the information transmitted to the receiver, by making the time length from a rapid rise in luminance to the next rapid rise in luminance different depending on code (0 or 1). In this way, the brightness perceived by humans can be adjusted by PWM (Pulse Width Modulation) control, without changing the transmission information. Here, the luminance waveform may not necessarily be a precise rectangular wave.

[1044]

FIG. 249 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12. This flowchart

illustrates the processing operation of the receiver that corresponds to the transmitter having the luminance change illustrated in FIG. 248.

[1045]

The receiver observes the luminance of light emitted from the transmitter (Step 7120a). The receiver measures the time from a rapid rise in luminance to the next rapid rise in luminance (Step 7120b). Alternatively, the receiver measures the time from a rapid fall in luminance to the next rapid fall in luminance. The receiver recognizes the signal value according to the time (Step 7120c). For example, the receiver recognizes "0" in the case where the time is less than or equal to 300 microseconds, and "1" in the case where the time is greater than or equal to 300 microseconds.

[1046]

FIG. 250 is a diagram illustrating a luminance change of the transmitter in Embodiment 12.

[1047]

The transmitter expresses the starting point of the information transmitted to the receiver, by changing the wavelength indicating luminance rise/fall. Alternatively, the transmitter superimposes information on the other information, by changing the wavelength.

[1048]

FIG. 251 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12. This flowchart illustrates the processing operation of the receiver that corresponds to the transmitter having the luminance change illustrated in FIG. 250.

[1049]

The receiver observes the luminance of light emitted from the transmitter (Step 7121a). The receiver determines the minimum value of the time width of the rapid change in luminance (Step 7121b). The receiver searches for a luminance change width that is not an integral multiple of the minimum value (Step 7121c). The receiver analyzes the signal, with the luminance change width that is not the integral multiple as the starting point (Step 7121d). The

receiver calculates the time width between the parts each having the luminance change width that is not the integral multiple (Step 7121e).

[1050]

FIG. 252 is a diagram illustrating a luminance change of the transmitter in Embodiment 12.

[1051]

The transmitter can adjust the brightness perceived by the human eye and also reset any luminance change accumulated over time, by changing the luminance at intervals shorter than the exposure time of the receiver.

[1052]

FIG. 253 is a flowchart illustrating an example of processing operation of the transmitter in Embodiment 12. This flowchart illustrates the processing operation of the receiver that corresponds to the transmitter having the luminance change illustrated in FIG. 252.

[1053]

The transmitter turns the current ON/OFF with a time width sufficiently shorter than the exposure time of the receiver, when the luminance or the current for controlling the luminance falls below a predetermined value (Step 7125a). This returns the current to its initial value, so that the luminance decrease of the light emitting unit can be prevented. The transmitter turns the current ON/OFF with a time width sufficiently shorter than the exposure time of the receiver, when the luminance or the current for controlling the luminance exceeds a predetermined value (Step 7125b). This returns the current to its initial value, so that the luminance increase of the light emitting unit can be prevented.

[1054]

FIG. 254 is a diagram illustrating a luminance change of the transmitter in Embodiment 12.

[1055]

The transmitter expresses different signals (information), by making the carrier frequency of the luminance different. The

receiver is capable of recognizing the carrier frequency earlier than the contents of the signal. Hence, making the carrier frequency different is suitable for expressing information, such as the ID of the transmitter, which needs to be recognized with priority.

[1056]

FIG. 255 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12. This flowchart illustrates the processing operation of the receiver that corresponds to the transmitter having the luminance change illustrated in FIG. 254.

[1057]

The receiver observes the luminance of light emitted from the transmitter (Step 7122a). The receiver determines the minimum value of the time width of the rapid change in luminance (Step 7122b). The receiver recognizes the minimum value as the carrier frequency (Step 7122c). The receiver obtains information from the server, using the carrier frequency as a key (Step 7122d).

[1058]

FIG. 256 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12. This flowchart illustrates the processing operation of the receiver that corresponds to the transmitter having the luminance change illustrated in FIG. 254.

[1059]

The receiver observes the luminance of light emitted from the transmitter (Step 7123a). The receiver Fourier transforms the luminance change, and recognizes the maximum component as the carrier frequency (Step 7123b). The receiver obtains information from the server, using the carrier frequency as a key (Step 7123c).

[1060]

FIG. 257 is a flowchart illustrating an example of processing operation of the transmitter in Embodiment 12. This flowchart illustrates the processing operation of the transmitter having the luminance change illustrated in FIG. 254.

[1061]

The transmitter expresses the transmission signal as the luminance change (Step 7124a). The transmitter generates the luminance change so that the maximum component of the Fourier transformed luminance change is the carrier frequency (Step 7124b). The transmitter causes the light emitting unit to emit light according to the generated luminance change (Step 7124c).

[1062]

FIG. 258 is a diagram illustrating an example of a structure of the transmitter in Embodiment 12.

[1063]

A transmitter 7028a has a part 7028b transmitting a signal A, a part 7028d transmitting a signal B, and a part 7028f transmitting a signal C. When such parts transmitting different signals are provided in the transmitter along the direction in which the imaging unit (camera) of the receiver is exposed simultaneously, the receiver can receive a plurality of signals simultaneously. Here, a part transmitting no signal or a buffer part 7028c or 7028e transmitting a special signal may be provided between the parts 7028b, 7028d, and 7028f.

[1064]

FIG. 259 is a diagram illustrating an example of a structure of the transmitter in Embodiment 12. The system of light emission by this structure of the transmitter extends the system of light emission by the structure illustrated in FIG. 258.

[1065]

Parts 7029a transmitting the signals illustrated in FIG. 258 may be arranged in the transmitter as illustrated in FIG. 259. By doing so, even when the receiver is tilted, the imaging unit (camera) of the receiver can simultaneously receive (capture) many parts of the signals A, B, and C.

[1066]

FIG. 260 is a diagram illustrating an example of a structure of the transmitter in Embodiment 12. The system of light emission by this structure of the transmitter extends the system of light emission by the structure illustrated in FIG. 258.

[1067]

A circular light emitting unit of the transmitter has a plurality of annular parts 7030a, 7030b, and 7030c arranged concentrically and transmitting the respective signals. The part 7030a transmits the signal C, the part 7030b transmits the signal B, and the part 7030c transmits the signal A. In the case where the light emitting unit of the transmitter is circular as in this example, the above-mentioned arrangement of the parts transmitting the respective signals enables the receiver to simultaneously receive (capture) many parts of the signals A, B, and C transmitted from the corresponding parts.

[1068]

FIG. 261 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 12. This flowchart illustrates the processing operation of the receiver and the transmitter that includes the light emitting device illustrated in any of FIGS. 258 to 260.

[1069]

The receiver measures the luminance of each position of the line that receives light simultaneously (Step 7126a). The receiver receives the signal at high speed, by receiving the separately transmitted signals in the direction perpendicular to the simultaneous light receiving line (Step 7126b).

[1070]

FIG. 262 is a diagram illustrating an example of display and imaging by the receiver and the transmitter in Embodiment 12.

[1071]

The transmitter displays a plurality of 1D barcodes each formed as an image uniform in the direction perpendicular to the direction in which the receiving unit (camera) of the receiver is exposed simultaneously, respectively as a frame 1 (7031a), a frame 2 (7031b), and a frame 3 (7031c) in sequence. A 1D barcode mentioned here is made of a line (bar) along the direction perpendicular to the above-mentioned simultaneous exposure direction. The receiver captures the image displayed on the

transmitter as described in each of the above embodiments, and as a result obtains a frame 1 (7031d) and a frame 2 (7031e). The receiver can recognize the successively displayed 1D barcodes in sequence, by dividing the 1D barcodes at an interruption of the bar of each 1D barcode. In this case, the receiver can recognize all information displayed on the transmitter, with there being no need to synchronize the imaging by the receiver to the display by the transmitter. The display by the transmitter may be at a higher frame rate than the imaging by the receiver. The display time of one frame in the display by the transmitter, however, needs to be longer than the blanking time between the frames captured by the receiver.

[1072]

FIG. 263 is a flowchart illustrating an example of processing operation of the transmitter in Embodiment 12. This flowchart illustrates the processing operation of the display device in the transmitter for performing the display illustrated in FIG. 262.

[1073]

The display device displays a 1D barcode (Step 7127a). The display device changes the barcode display at intervals longer than the blanking time in the imaging by the receiver (Step 7127b).

[1074]

FIG. 264 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12. This flowchart illustrates the processing operation of the receiver for performing the imaging illustrated in FIG. 262.

[1075]

The receiver captures the 1D barcode displayed on the display device (Step 7128a). The receiver recognizes that the display device displays the next barcode, at an interruption of the barcode line (Step 7128b). According to this method, the receiver can receive all displayed information, without synchronizing the imaging to the display. Besides, the receiver can receive the signal displayed at a frame rate higher than the imaging frame rate of the receiver.

[1076]

FIG. 265 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1077]

A transmitter 7032a such as a lighting device transmits encrypted identification information (ID) of the transmitter 7032a. A receiver 7032b such as a smartphone receives the encrypted ID, and transmits the encrypted ID to a server 7032c. The server 7032c receives the encrypted ID, and decrypts the encrypted ID. Alternatively, the receiver 7032b receives the encrypted ID, decrypts the encrypted ID, and transmits the decrypted ID to the server 7032c.

[1078]

FIG. 266 is a flowchart illustrating an example of processing operation of the receiver 7032b and the transmitter 7032a in Embodiment 12.

[1079]

The transmitter 7032a holds partially or wholly encrypted information (Step 7129a). The receiver 7032b receives the information transmitted from the transmitter 7032a, and decrypts the received information (Step 7129b). Alternatively, the receiver 7032b transmits the encrypted information to the server 7032c. In the case where the encrypted information is transmitted, the server 7032c decrypts the encrypted information (Step 7129c).

[1080]

FIG. 267 is a diagram illustrating a state of the receiver in Embodiment 12.

[1081]

For a phone call, the user puts a receiver 7033a such as a smartphone to his or her ear. At this time, an illuminance sensor provided near the speaker of the receiver 7033a detects an illuminance value indicating low illuminance. The receiver 7033a accordingly estimates that the receiver 7033a is in a call state, and stops receiving information from the transmitter.

[1082]

FIG. 268 is a flowchart illustrating an example of processing

operation of the receiver 7033a in Embodiment 12.

[1083]

The receiver 7033a determines whether or not the receiver 7033a is estimated to be in a call state from the sensor value of the illuminance sensor and the like (Step 7130a). In the case where the determination result is true (Y), the receiver 7033a ends the reception by the face camera (Step 7130b). Alternatively, the receiver 7033a assigns lower priority to the reception process by the face camera.

[1084]

FIG. 269 is a diagram illustrating a state of the receiver in Embodiment 12.

[1085]

A receiver 7034a such as a smartphone includes an illuminance sensor 7034b near a camera (e.g. face camera) which is an imaging device for receiving (capturing) information from a transmitter. When an illuminance value indicating low illuminance less than or equal to a predetermined value is detected by the illuminance sensor 7034b, the receiver 7034a stops receiving information from the transmitter. In the case where the receiver 7034a includes a camera other than the camera (e.g. face camera) near the illuminance sensor 7034b, the receiver 7034a assigns lower priority to the camera (e.g. face camera) near the illuminance sensor 7034b than the other camera.

[1086]

FIG. 270 is a flowchart illustrating an example of processing operation of the receiver 7034a in Embodiment 12.

[1087]

The receiver 7034a determines whether or not the sensor value of the illuminance sensor 7034b is less than or equal to a predetermined value (Step 7131a). In the case where the determination result is true (Y), the receiver 7034a ends the reception by the face camera (Step 7131b). Alternatively, the receiver 7034a assigns lower priority to the reception process by the face camera.

[1088]

FIG. 271 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12.

[1089]

The receiver measures the illuminance change from the sensor value of the illuminance sensor (Step 7132a). The receiver receives the signal from the illuminance change, as in the reception of the signal from the luminance change measured by the imaging device (camera) (Step 7132b). Since the illuminance sensor is less expensive than the imaging device, the receiver can be manufactured at low cost.

[1090]

FIG. 272 is a diagram illustrating an example of a wavelength of the transmitter in Embodiment 12.

[1091]

The transmitter expresses the information transmitted to the receiver, by outputting metameric light 7037a and 7037b as illustrated in (a) and (b) in FIG. 272.

[1092]

FIG. 273 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 12. This flowchart illustrates the processing operation of the receiver and the transmitter that outputs the light of the wavelengths illustrated in FIG. 272.

[1093]

The transmitter expresses different signals by light (metameric light) perceived as isochromatic by humans but different in spectral distribution, and causes the light emitting unit to emit light (Step 7135a). The receiver measures the spectral distributions and receives the signals (Step 7135b). According to this method, the signal can be transmitted without concern for flicker.

[1094]

FIG. 274 is a diagram illustrating an example of a structure of a system including the receiver and the transmitter in Embodiment 12.

[1095]

The system includes an ID solution server 7038a, a relay server 7038b, a receiver 7038c, a transmitter 7038d, and a transmitter control device 7038e.

[1096]

FIG. 275 is a flowchart illustrating an example of processing operation of the system in Embodiment 12.

[1097]

The ID solution server 7038a stores the ID of the transmitter 7038d and the method of communication between the transmitter control device 7038e and the receiver 7038c, in association with each other (Step 7136a). The receiver 7038c receives the ID of the transmitter 7038d, and obtains the method of communication with the transmitter control device 7038e from the ID solution server 7038a (Step 7136b). The receiver 7038c determines whether or not the receiver 7038c and the transmitter control device 7038e are directly communicable (Step 7136c). In the case where the determination result is false (N), the receiver 7038c communicates with the transmitter control device 7038e via the relay server 7038b (Step 7136d). In the case where the determination result is true (Y), the receiver 7038c communicates directly with the transmitter control device 7038e (Step 7136e).

[1098]

FIG. 276 is a diagram illustrating an example of a structure of the system including the receiver and the transmitter in Embodiment 12.

[1099]

The system includes a server 7039g, a store device 7039a, and a mobile device 7039b. The store device 7039a includes a transmitter 7039c and an imaging unit 7039d. The mobile device 7039b includes a receiver 7039e and a display unit 7039f.

[1100]

FIG. 277 is a flowchart illustrating an example of processing operation of the system in Embodiment 12.

[1101]

The mobile device 7039b displays information on the display unit 7039f in 2D barcode or the like (Step 7137a). The store device 7039a captures the information displayed on the display unit 7039f by the imaging unit 7039d, to obtain the information (Step 7137b). The store device 7039a transmits some kind of information from the transmitter 7039c (Step 7137c).

[1102]

The mobile device 7039b receives the transmitted information by the receiver 7039e (Step 7137d). The mobile device 7039b changes the display on the display unit 7039f, based on the received information (Step 7137e). The information displayed on the display unit 7039f may be determined by the mobile device 7039b, or determined by the server 7039g based on the received information.

[1103]

The store device 7039a captures the information displayed on the display unit 7039f by the imaging unit 7039d, to obtain the information (Step 7137f). The store device 7039a determines the consistency between the obtained information and the transmitted information (Step 7137g). The determination may be made by the store device 7039a or by the server 7039g. In the case where the obtained information and the transmitted information are consistent, the transaction is completed successfully (Step 7137h).

[1104]

According to this method, coupon information displayed on the display unit 7039f can be protected from unauthorized copy and use. It is also possible to exchange an encryption key by this method.

[1105]

FIG. 278 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12.

[1106]

The receiver starts the reception process (Step 7138a). The receiver sets the exposure time of the imaging device (Step 7138b). The receiver sets the gain of the imaging device (Step 7138c). The receiver receives information from the luminance of the captured image (Step 7138d).

[1107]

FIG. 279 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12.

[1108]

The receiver sets the exposure time (Step 7139a). The receiver determines whether or not there is an API (Application Program Interface) that changes the exposure time (Step 7139b). In the case where the determination result is false (N), the imaging device is pointed to a high-luminance object such as a light source (Step 7139c). The receiver performs automatic exposure setting (Step 7139d). The receiver fixes the automatic exposure set value once the change of the automatic exposure set value has become sufficiently small (Step 7139e).

[1109]

In the case where the determination result is true (Y), the receiver starts setting the exposure time using the API (Step 7139f).

[1110]

FIG. 280 is a diagram illustrating an example of a structure of the system including the receiver and the transmitter in Embodiment 12.

[1111]

The system includes a server 7036a, a receiver 7036b, and one or more transmitters 7036c. The receiver 7036b obtains information relating to the one or more transmitters 7036c present near the receiver 7036b, from the server.

[1112]

FIG. 281 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12.

[1113]

The receiver 7036b performs self-position estimation from information of GPS, a base station, and the like (Step 7133a). The receiver 7036b transmits the estimated self-position and the estimation error range to the server 7036a (Step 7133b). The receiver 7036b obtains, from the server 7036a, IDs of transmitters 7036c present near the position of the receiver 7036b and

information associated with the IDs, and stores the IDs and the information (Step 7133c). The receiver 7036b receives an ID from a transmitter 7036c (Step 7133d).

[1114]

The receiver 7036b determines whether or not information associated with the received ID is stored in the receiver 7036b (Step 7133e). In the case where the determination result is false (N), the receiver 7036b obtains the information from the server 7036a, using the received ID as a key (Step 7133f). The receiver 7036b performs self-position estimation from the information received from the server 7036a and the position relation with the transmitter 7036bc, obtains IDs of other nearby transmitters 7036c and information associated with the IDs from the server 7036a, and stores the IDs and the information (Step 7133g).

[1115]

In the case where the determination result is true (Y) in Step 7133e or after Step 7133g, the receiver 7036b displays the information associated with the received ID (Step 7133h).

[1116]

FIG. 282 is a diagram illustrating an example of application of the receiver and the transmitter in Embodiment 12.

[1117]

Transmitters 7040c and 7040d such as lighting devices are disposed in a building a (7040a), and transmitters 7040e and 7040f such as lighting devices are disposed in a building b (7040b). The transmitters 7040c and 7040e transmit a signal A, and the transmitters 7040d and 7040f transmit a signal B. A receiver (terminal) 7040g such as a smartphone receives a signal transmitted from any of the transmitters.

[1118]

FIG. 283 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12.

[1119]

The receiver 7040g detects the entry into a building (Step 7134a). The receiver 7040g transmits the estimated self-position,

the estimation error range, and the name or the like of the building in which the receiver 7040g is estimated to be present, to the server (Step 7134b). The receiver 7040g obtains, from the server, IDs of transmitters present in the building in which the receiver 7040g is present and information associated with the IDs, and stores the IDs and the information (Step 7134c). The receiver 7040g receives an ID from a transmitter (Step 7134d).

[1120]

The receiver 7040g determines whether or not information associated with the received ID is stored in the receiver 7040g (Step 7134e). In the case where the determination result is false (N), the receiver 7040g obtains the information from the server, using the received ID as a key (Step 7134f). The receiver 7040g obtains, from the server, IDs of other transmitters present in the same building as the transmitter from which the receiver 7040g receives the ID and information associated with the IDs, and stores the IDs and the information (Step 7134g).

[1121]

In the case where the determination result is true (Y) in Step 7134e or after Step 7134g, the receiver 7040g displays the information associated with the received ID (Step 7134h).

[1122]

FIG. 284 is a diagram illustrating an example of a structure of the system including the receiver and the transmitter in Embodiment 12.

[1123]

Transmitters 7041a, 7041b, 7041c, and 7041d such as lighting devices transmit a signal A, a signal B, a signal C, and the signal B, respectively. A receiver (terminal) 7041e such as a smartphone receives a signal transmitted from any of the transmitters. Here, the transmitters 7041a, 7041b, and 7041c are included in the error range of the self-position of the receiver 7041e estimated based on information of GPS, a base station, and the like (other means).

[1124]

FIG. 285 is a flowchart illustrating an example of processing

operation of the system in Embodiment 12.

[1125]

The receiver 7041e receives an ID from a transmitter (Step 7140a). The receiver 7041e performs self-position estimation (Step 7140b). The receiver 7041e determines whether or not the self-position estimation is successful (Step 7140c). In the case where the determination result is false (N), the receiver 7041e displays a map or an input form, and prompts the user to input the current position (Step 7140d).

[1126]

The receiver 7041e transmits the received ID, the estimated self-position, and the self-position estimation error range to the server (Step 7140e).

[1127]

The server determines whether or not only one transmitter transmitting the ID received by the receiver 7041e is present within the estimation error range (estimation error radius) from the estimated self-position of the receiver 7041e (Step 7140f). In the case where the determination result is false (N), the receiver 7041e repeats the process from Step 7140d. In the case where the determination result is true (Y), the server transmits information associated with the transmitter to the receiver 7041e (Step 7140g).

[1128]

FIG. 286 is a flowchart illustrating an example of processing operation of the receiver in Embodiment 12.

[1129]

The receiver detects a light emitting device (transmitter) emitting a signal (Step 7141a), and receives the signal (Step 7141b). The receiver displays the reception state, the received data amount, the transmission data amount, and the ratio of the received data amount to the transmission data amount (Step 7141c).

[1130]

The receiver then determines whether or not the receiver has received all transmission data (Step 7141d). In the case of determining that the receiver has received all transmission data

(Step 7141d: Y), the receiver stops the reception process (Step 7141e), and displays the reception completion (Step 7141f). The receiver also outputs notification sound (Step 7141g), and vibrates (7141h).

[1131]

In the case of determining that the receiver has not received all transmission data in Step 7141d (Step 7141d: N), the receiver determines whether or not a predetermined time has elapsed from when the transmitter disappears from the frame of the imaging device (camera) of the receiver (Step 7141i). In the case of determining that the predetermined time has elapsed (Step 7141i: Y), the receiver abandons the received data and stops the reception process (Step 7141m). The receiver also outputs notification sound (Step 7141n), and vibrates (Step 7141p).

[1132]

In the case of determining that the predetermined time has not elapsed in Step 7141i (Step 7141i: N), the receiver determines whether or not the sensor value of the 9-axis sensor of the receiver changes by a predetermined value or more, or whether or not the receiver is estimated to be pointed in another direction (Step 7141j). In the case of determining that the sensor value changes by the predetermined value or more or the receiver is estimated to be pointed in another direction (Step 7141i: Y), the receiver performs the process from Step 7141m mentioned above.

[1133]

In the case of determining that the sensor value does not change by the predetermined value or more or the receiver is not estimated to be pointed in another direction (Step 7141i: N), the receiver determines whether or not the sensor value of the 9-axis sensor of the receiver changes in a predetermined rhythm, or whether or not the receiver is estimated to be shaken (Step 7141k). In the case of determining that the sensor value changes in the predetermined rhythm or the receiver is estimated to be shaken, the receiver performs the process from Step 7141m mentioned above. In the case of determining that the sensor value does not change in

the predetermined rhythm or the receiver is not estimated to be shaken (Step 7141k: N), the receiver repeats the process from Step 7141b.

[1134]

FIG. 287A is a diagram illustrating an example of a structure of the transmitter in Embodiment 12.

[1135]

A transmitter 7046a includes a light emitting unit 7046b, a 2D barcode 7046c, and an NFC chip 7046d. The light emitting unit 7046b transmits information common with at least one of the 2D barcode 7046c and the NFC chip 7046d, by the method according to any of the above embodiments. Alternatively, the light emitting unit 7046b may transmit information different from at least one of the 2D barcode 7046c and the NFC chip 7046d, by the method according to any of the above embodiments. In this case, the receiver may obtain the information common with at least one of the 2D barcode 7046c and the NFC chip 7046d from the server, using the information transmitted from the light emitting unit 7046b as a key. The receiver may perform a common process in the case of receiving information from the light emitting unit 7046b and in the case of receiving information from at least one of the 2D barcode 7046c and the NFC chip 7046d. In either case, the receiver accesses a common server and displays common information.

[1136]

FIG. 287B is a diagram illustrating another example of a structure of the transmitter in Embodiment 12.

[1137]

A transmitter 7046e includes a light emitting unit 7046f, and causes the light emitting unit 7046f to display a 2D barcode 7046g. That is, the light emitting unit 7046f has the functions of both the light emitting unit 7046b and the 2D barcode 7046c illustrated in FIG. 287A.

[1138]

Here, the light emitting unit 7046b or 7046f may transmit information indicating the size of the light emitting unit 7046b or

7046f, to cause the receiver to estimate the distance from the receiver to the transmitter 7046a or 7046e. This enables the receiver to capture the 2D barcode 7046c or 7046g more easily or clearly.

[1139]

FIG. 288 is a flowchart illustrating an example of processing operation of the receiver and the transmitter 7046a or 7046e in Embodiment 12. Though the following describes, of the transmitters 7046a and 7046e, the transmitter 7046a as an example, the processing operation of the transmitter 7046e is the same as that of the transmitter 7046a.

[1140]

The transmitter 7046a transmits information indicating the size of the light emitting unit 7046b (Step 7142a). Here, the maximum distance between arbitrary two points in the light emitting unit 7046b is set as the size of the light emitting unit 7046b. Since speed is important in this series of processes, it is desirable that the transmitter 7046a directly transmits the information indicating the size of the light emitting unit 7046b of the transmitter 7046a and the receiver obtains the information indicating the size without server communication. It is also desirable that the transmission is performed by a method that facilitates fast reception, such as the frequency of the brightness change of the transmitter 7046a.

[1141]

The receiver receives the signal which is the above-mentioned information, and obtains the size of the light emitting unit 7046b of the transmitter 7046a (Step 7142b). The receiver calculates the distance from the receiver to the light emitting unit 7046b, based on the size of the light emitting unit 7046b, the size of the captured image of the light emitting unit 7046b, and the characteristics of the imaging unit (camera) of the receiver (Step 7142c). The receiver adjusts the focal length of the imaging unit to the calculated distance, and captures the image (Step 7142d). The receiver obtains the 2D barcode in the case of capturing the 2D barcode (Step 7142e).

[1142]

[Embodiment 13]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as an LED or organic EL blink pattern in Embodiments 1 to 12 described above.

[1143]

FIG. 289 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 13.

[1144]

In Step 7201a, the transmitter outputs a sound of a specific frequency or a sound that changes in a specific pattern (the sound desirably has a frequency that is difficult to be heard by humans and collectable by a typical sound collector, e.g. 2 kHz to 20 kHz. A typical sound collector has a sampling frequency of about 44.1 kHz, and is only capable of precisely recognizing up to half of the frequency due to the sampling theorem. If the transmission signal is known, however, whether or not the signal is collected can be estimated with high accuracy. Based on this property, a signal of a frequency greater than or equal to 20 kHz may be used).

[1145]

In Step 7201b, the user presses a button on the receiver to switch from the power off state or the sleep state to the power on state. In Step 7201c, the receiver activates a sound collecting unit. In Step 7201d, the receiver collects the sound output from the transmitter. In Step 7201e, the receiver notifies the user that the transmitter is present nearby, by screen display, sound output, or vibration. In Step 7201f, the receiver starts reception, and then ends the process.

[1146]

FIG. 290 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 13.

[1147]

In Step 7202a, the user presses a button on the receiver to switch from the power off state or the sleep state to the power on state. In Step 7202b, the receiver activates an illuminance sensor.

In Step 7202c, the receiver recognizes a change of illuminance from the illuminance sensor. In Step 7202d, the receiver receives a transmission signal from the illuminance sensor. In Step 7202e, the receiver notifies the user that the transmitter is present nearby, by screen display, sound output, or vibration. In Step 7202f, the receiver starts reception, and then ends the process.

[1148]

FIG. 291 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 13.

[1149]

In Step 7203a, the user operates the receiver to start reception, or the receiver automatically starts reception by a trigger. In Step 7203b, the reception is performed preferentially by an imaging unit whose average luminance of the entire screen is high or whose luminance at the maximum luminance point is high. The receiver then ends the process.

[1150]

FIG. 292 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 13.

[1151]

In Step 7204a, the imaging unit captures, at high speed, the image of the simultaneous imaging lines or pixels in which the transmitter is shown, by not capturing the simultaneous imaging lines or pixels in which the transmitter is not shown. In Step 7204b, the receiver detects the movement of the receiver or the hand movement using a gyroscope or a 9-axis sensor, makes adjustment by electronic correction so that the transmitter is always shown, and ends the process.

[1152]

FIG. 293 is a flowchart illustrating an example of processing operation of the receiver and the transmitter in Embodiment 13.

[1153]

In Step 7205a, the receiver displays a 2D barcode A. In Step 7205b, the transmitter reads the 2D barcode A. In Step 7205c, the transmitter transmits a display change instruction. In Step 7205d,

the receiver displays a 2D barcode B. In Step 7205e, the transmitter reads the 2D barcode B, and ends the process.

[1154]

FIG. 294 is a diagram illustrating an example of application of the transmitter in Embodiment 13.

[1155]

A transmitter 7211a has a mark 7211b indicating that the transmitter 7211a is a transmitter. Though humans cannot distinguish a transmission signal from ordinary light, they are able to recognize from the mark 7211b that the transmitter 7211a is a transmitter. Likewise, a transmitter 7211c has a mark 7211d indicating that the transmitter 7211c is a transmitter. A transmitter 7211e displays a mark 7211f indicating that the transmitter 7211e is a transmitter, only during signal transmission.

[1156]

FIG. 295 is a diagram illustrating an example of application of the transmitter in Embodiment 13.

[1157]

A transmitter 7212a such as a TV transmits a signal by changing the luminance of a backlight or a screen 7212b. A transmitter 7212c such as a TV transmits a signal by changing the luminance of a part other than the screen, such as a bezel 7212d or a logo mark.

[1158]

FIG. 296 is a diagram illustrating an example of application of the transmitter in Embodiment 13.

[1159]

A transmitter 7213a such as a TV transmits a signal, when displaying a display 7213c such as urgent news, subtitles, or an on-screen display on a screen 7213b. The display 7213c is displayed wide in the horizontal direction of the screen, with dark letters on a bright background. This eases the signal reception by the receiver.

[1160]

FIG. 297 is a diagram illustrating an example of application of

the transmitter and the receiver in Embodiment 13.

[1161]

When the user operates a remote control 7214a of a receiver or a TV, the remote control 7214a transmits a start signal to a transmitter 7214b. The transmitter 7214b transmits a signal for a predetermined time after receiving the start signal. The transmitter 7214b displays a display 7214c indicating that the signal is being transmitted. This eases the signal reception by the receiver, even in the case where the display of the TV itself is dark. The receiver can receive the signal more easily when the display 7214c has more bright portions and is wide in the horizontal direction.

[1162]

The transmitter 7214b may have the area 7214c for signal transmission, apart from the area for displaying TV images. The transmitter 7214b may recognize the movement of the user or the movement of the remote control 7214a by a camera 7214d or a microphone 7214e, and start signal transmission.

[1163]

FIG. 298 is a diagram illustrating an example of application of the transmitter and the receiver in Embodiment 13.

[1164]

Transmitters 7215a and 7215b each transmit the ID number of the transmitter. The ID of the transmitter may be an ID that is completely unique, or an ID that is unique within a region, a building, or a room. In the latter case, it is desirable that the same ID is not present within several tens of meters. A receiver 7215c transmits the received ID to a server 7215d. The receiver 7215c may also transmit the position information of the receiver 7215c recognized by a position sensor such as GPS, the terminal ID of the receiver 7215c, a user ID, a session ID, and the like to the server.

[1165]

A database 7215e stores, in association with the ID transmitted from the transmitter, another ID, the position information (latitude, longitude, altitude, room number) of the transmitter, the model, shape, or size of the transmitter, content

such as text, image, video, and music, an instruction or program executed by the receiver, a URL of another server, information of the owner of the transmitter, the registration date or expiration date of the ID, and so on.

[1166]

The server 7215d reads the information associated with the received ID from the database, and transmits the information to the receiver 7215c. The receiver 7215c performs a process such as displaying the received information, accessing another server based on the received information, or executing the received instruction.

[1167]

FIG. 299 is a diagram illustrating an example of application of the transmitter and the receiver in Embodiment 13.

[1168]

As in the case of FIG. 298, transmitters 7216a and 7216b each transmit an ID 1 of the transmitter. A receiver 7216c transmits the received ID 1 to a server A 7216d. The server A transmits an ID 2 and information (URL, password, etc.) for accessing another server B, which are associated with the ID 1. The receiver 7216c transmits the ID 2 to the server B 7216f. The server B 7216f transmits information associated with the ID 2 to the receiver 7216c, and performs a process associated with the ID 2.

[1169]

FIG. 300 is a diagram illustrating an example of application of the transmitter and the receiver in Embodiment 13.

[1170]

As in the case of FIG. 298, transmitters 7217a and 7217b each transmit an ID 1 of the transmitter. A receiver 7217c transmits the received ID 1 to a server A 7217d. The server A transmits information associated with the ID 1 and randomly generated key information to a server B. The key information may be generated by the server B and transmitted to the server A. The server A transmits the key information and information (URL, password, etc.) for accessing the server B, to the receiver. The receiver 7217c transmits the key information to the server B 7217f. The server B

7217f transmits information associated with the ID 2 to the receiver 7217c, or performs a process associated with the ID 2.

[1171]

FIG. 301A is a diagram illustrating an example of the transmission signal in Embodiment 13.

[1172]

The signal is made up of a header unit 7218a, a data unit 7218b, a padding unit 7218c, and an End of Data unit 7218e. The signal repeatedly carries the same data for 1/15 second. Hence, even in the case where the receiver receives only part of the signal, the receiver can decode the signal. The receiver extracts the header unit from the received signal, and decodes the data by treating the part between two header units as the data unit. A shorter data unit per frame enables decoding even in the case where the transmitter is shown in a small size in the imaging unit of the receiver. A longer data unit per frame, on the other hand, contributes to faster communication. By repeating the same data for 1/15 second, a receiver that captures 30 frames per second can reliably capture the signal of the data unit even when there is blanking. In addition, the same signal is received in either one of adjacent frames, with it being possible to confirm the reception result. The signal can be received even in the case where nonconsecutive frames are not processed due to the operation of another application or the receiver is only capable of capturing 15 frames per second. Since data nearer the header unit can be received more easily, important data may be located near the header unit.

[1173]

FIG. 301B is a diagram illustrating another example of the transmission signal in Embodiment 13.

[1174]

As in the example in FIG. 301A, the signal is made up of the header unit 7218a, the data unit 7218b, the padding unit 7218c, and the End of Data unit 7218e. The signal repeatedly carries the same data for 1/30 second. Hence, even in the case where the receiver receives only part of the signal, the receiver can decode the signal.

A shorter data unit enables decoding even in the case where the transmitter is shown in a small size in the imaging unit of the receiver. A longer data unit, on the other hand, contributes to faster communication. By repeating the same data for 1/30 second, a receiver that captures 30 frames per second can reliably capture the signal of the data unit even when there is blanking. In addition, the same signal is received in either one of adjacent frames, with it being possible to confirm the reception result. Since data nearer the header unit can be received more easily, important data may be located near the header unit.

[1175]

FIG. 302 is a diagram illustrating an example of the transmission signal in Embodiment 13.

[1176]

A modulation scheme 7219a for modulating a 2-bit signal to a 5-bit signal, though lower in modulation efficiency than a modulation scheme such as 2200.2a for modulating a 2-bit signal to a 4-bit signal, can express a header pattern in the same form as data, and therefore suppress flicker as compared with inserting a header pattern of a different form. End of Data may be expressed using a header in the data unit.

[1177]

FIG. 303A is a diagram illustrating an example of the transmission signal in Embodiment 13.

[1178]

The signal is made up of a data unit 7220a, a buffer unit 7220b, and an End of Data unit 7220d. The buffer unit may be omitted. The signal repeatedly carries the same data for 1/15 second. A header such as the header 7218a is unnecessary in the case of using, for example, FM modulation of transmitting a signal by a light emission frequency.

[1179]

FIG. 303B is a diagram illustrating another example of the transmission signal in Embodiment 13.

[1180]

As in the example in FIG. 303A, the signal is made up of the data unit 7220a, the buffer unit 7220b, and the End of Data unit 7220d. The buffer unit may be omitted. The signal repeatedly carries the same data for 1/30 second. A header such as the header 7218a is unnecessary in the case of using, for example, FM modulation of transmitting a signal by a light emission frequency.

[1181]

FIG. 304 is a diagram illustrating an example of the transmission signal in Embodiment 13.

[1182]

Signals are assigned according to frequency. Since the receiver detects frequencies from signal periods, reception errors can be reduced by assigning signals so that the inverses or logarithms of frequencies are at regular intervals, rather than by assigning frequencies to signals at regular intervals. In the case where the imaging unit of the receiver captures light for transmitting data 1 and data 2 within one frame, Fourier transforming the luminance in the direction perpendicular to the exposure lines results in the occurrence of weaker peaks in the frequencies of the data 1 and the data 2 than in the case where light for transmitting single data is captured.

[1183]

According to this method, the transmission frequency can be analyzed even in the case where light transmitted at a plurality of frequencies in sequence is captured in one frame, and the transmission signal can be received even when the frequency of the transmission signal is changed at time intervals shorter than 1/15 second or 1/30 second.

[1184]

The transmission signal sequence can be recognized by performing Fourier transform in a range shorter than one frame. Alternatively, captured frames may be concatenated to perform Fourier transform in a range longer than one frame. In this case, the luminance in the blanking time in imaging is treated as unknown.

[1185]

FIGS. 305A and 305B are diagrams illustrating an example of the transmission signal in Embodiment 13.

[1186]

In the case where the frequency of the transmission signal is less than or equal to 200 Hz, the light appears to blink to humans. In the case where the frequency exceeds 200 Hz, the light appears to be continuous to humans. A camera captures blinking light in frequencies up to about 500 Hz (1 kHz depending on conditions). It is therefore desirable that the signal frequency (carrier frequency) is greater than or equal to 1 kHz. The signal frequency may be greater than or equal to 200 Hz if there is little effect of the camera capturing flicker. Harmonic noise of a lighting device increases in frequencies greater than or equal to 20 kHz. This can be avoided by setting the signal frequency to less than or equal to 20 kHz. Besides, since sound due to coil oscillation occurs in a range from 500 Hz to 3 kHz, it is necessary to set the signal frequency to greater than or equal to 3 kHz or fix the coil. When the signal frequency is 1 kHz (period of 1 millisecond), the exposure time of the imaging device needs to be set to less than or equal to half, i.e. 0.5 millisecond (= 1/2000 second), in order to recognize the signal asynchronously. In the case of employing frequency modulation in the signal modulation scheme, too, the exposure time of the imaging device needs to be set to less than or equal to half the signal period, due to the sampling theorem. In the case of the modulation scheme that expresses the value by the frequency itself as in FIG. 304, on the other hand, the exposure time of the imaging device can be set to less than or equal to about 4 times the signal period, because the frequency can be estimated from signal values at a plurality of points.

[1187]

FIG. 306 is a diagram illustrating an example of application of the transmitter in Embodiment 13.

[1188]

A transmitter 7223a such as a lighting transmits an ID. A receiver 7223b such as a personal computer receives the ID, and transmits the ID and a file 7223e to a server 7223d. The server

7223d stores the file 7223e and the ID in association with each other, and permits a personal computer transmitting the same ID to access the file. Here, a plurality of access controls, such as read-only permission and read and write permission, may be applied according to the ID. A receiver 7223c such as a personal computer receives the ID, transmits the ID to the server 7223d, and accesses the file 7223e on the server. The server 7223d deletes the file or initializes access control, in the case where a predetermined time has elapsed from when the file is accessed last time or in the case where the personal computer 7223b transmits a different ID. The personal computer 7223b or the personal computer 7223c may transmit an ID.

[1189]

FIG. 307 is a diagram illustrating an example of application of the transmitter in Embodiment 13.

[1190]

A transmitter 7224b registers its ID information in a server 7224d. A receiver 7224a displays a coupon, an admission ticket, member information, or prepaid information on the screen. The transmitter 7224b transmits the ID. The receiver 7224a receives the ID, and transmits the received ID, a user ID, a terminal ID, and the information displayed on the screen to the server 7224d. The server 7224d determines whether or not the information displayed on the receiver 7224a is valid, and transmits the result to a display device 7224c. The server 7224d may transmit key information that changes with time to the transmitter 7224b, which then transmits the key information. Here, the server 7224d may be implemented as the same device as the transmitter 7224b or the display device 7224c. In a system of displaying a coupon, an admission ticket, member information, or prepaid information on the screen of the receiver 7224a in 2D barcode or the like and reading the displayed information, the information can be easily falsified by displaying an image obtained by copying the screen. According to this method, however, it is possible to prevent the falsification of the screen by copying.

[1191]

FIGS. 308 to 310 are diagrams for describing the imaging element in Embodiment 13.

[1192]

FIG. 308 is a front view of an imaging element 800 according to the present invention. As described with the drawings in the foregoing embodiments, to improve the optical communication speed according to the present invention, only the data of scan lines, e.g. n = 4 to 7, of an area 830a in a light signal generation unit 830 is obtained by repetitive scan by supplying a scan line selection signal to vertical access means 802, while tracking the light signal generation unit 830 as illustrated in FIG. 310. As a result, continuous light signals according to the present invention can be extracted as illustrated in the lower part of FIG. 310. In detail, continuous signals such as 4, 5, 6, 7 followed by the blanking time and 4, 5, 6, 7 followed by the blanking time can be obtained. The blanking can be limited to 2 μs or less in the current imaging element process. When the blanking is limited to 2 μs or less, the data can be demodulated substantially continuously because, in the case of 30 fps, one frame is 33 ms and, in the case of 1000 lines, one line is 33 μs.

[1193]

In the present invention, in the imaging element (image sensor) in a rolling shutter mode, first the shutter speed is increased to display the lines according to the present invention, and then the signal is obtained. After this, the image 830 of the light source moves up, down, left, or right due to hand movement of the user of the camera. This causes the image 830 to be partially outside the lines n = 4 to 7, as a result of which the signal is interrupted and an error occurs. In view of this, hand movement detection and correction means 832 is used for correction, to fix the image 830. Alternatively or in combination with this, means 834 of detecting the line number of the position of the image 830 is used to specify the line number n of the image 830, and a line selection unit 835 controls the vertical access means to change the line number to a desired line n (e.g. n = 7 to 10). As a result, the image 830 is obtained and so

the continuous signals are obtained. Thus, data with few errors can be received at high speed.

[1194]

Referring back to FIG. 308, the imaging element 800 is further described below. There are horizontal pixels a to k, which are accessible by horizontal access means 801. Meanwhile, there are 12 vertical pixels where n = 1 to 12. 803a to 803n are read for each column to a line memory 805 and output from an output unit 808.

[1195]

As illustrated in FIG. 309, in the present invention, first the data is sequentially read in a normal imaging mode as in (a). A blanking time 821 is provided between normal frames, during which various adjustment operations for video signals, such as color, are conducted.

[1196]

The signal cannot be obtained in a time period of 5% to 20%, though this differs depending on the imaging element. Since the reception pattern specific to the present invention is unable to be obtained, when the imaging device enters a data signal reception mode in Step 820c, first the shutter speed is increased to increase the gain, thus receiving the data. In the case of Yes, the blanking time 821 is reduced to a blanking time 821a by stopping part of the above-mentioned video imaging operations for color, brightness, sensitivity, and so on. As a result of such a reduction by omitting adjustment operations, the blanking time 821a can be limited to 2 μs or less in the current process. This delivers a significant reduction in burst error of the input signal, and so enables much faster transmission.

[1197]

In the case where only a partial image is captured as the image 830 as in FIG. 310, the information of the lines other than n = 4 to 8 is not obtained. This causes a large burst error, leading to lower reception efficiency and a significant decrease in transmission amount.

[1198]

The image position detection means 834 in FIG. 310 detects the position and size of the image 830. In the case where the image is small, the imaging element is switched to a high-speed read mode in Step 820d, and scans only the lines (n = 4 to 7) in which the image 830 is captured. Line signals 803d, 803e, 803f, and 803g are repeatedly read as in (c), as a result of which the pattern specific to the present invention is read seamlessly. Continuous data reception with almost no burst error can thus be performed at a significantly improved data rate.

[1199]

In detail, a transmission rate of about 2400 bps is achieved when the carrier is 4.8 kHz in the current imaging element. A transmission rate of several tens of kbps is expected with faster imaging elements in the future.

[1200]

After the data read is completed in Step 820e, the shutter speed is decreased to increase the blanking time, and the imaging element returns to the normal imaging mode in (a).

[1201]

The above-mentioned blanking time reduction and repetitive reading of specific lines ensures that synchronous signals or addresses are read, and enables much faster transmission in the pattern transmission method according to the present invention.

[1202]

(Variations)

The following describes variations or supplements to each of the above embodiments.

[1203]

FIG. 311A is a flowchart illustrating processing operation of the reception device (imaging device). FIG. 311A illustrates more detailed processing operation than that in FIG. 71.

[1204]

Here, the imaging unit of the receiver employs not a mode (global shutter mode) of simultaneously exposing all light receiving elements but a mode (rolling shutter mode, focal plane shutter

mode) of sequentially exposing the light receiving elements one by one with a time difference. The term "exposure" used in the description of the present invention includes an exposure mode of controlling the time during which an imaging element is exposed to light by a physical shutter, and an exposure mode of extracting only the output of an imaging element during a specific time by an electronic shutter.

[1205]

First, in Step 7340a, in the case where the imaging mode is the global shutter mode, the receiver changes the imaging mode to the rolling shutter mode. Next, in Step 7340b, the receiver sets the shutter speed so that a bright line is captured when capturing a subject whose moving average luminance with a time width greater than or equal to 5 milliseconds is unchanged and that changes in luminance in a region less than or equal to 5 milliseconds.

[1206]

In Step 7340c, the receiver sets the sensitivity of the light receiving element to increase the difference between the bright part and the dark part of the bright line. In Step 7340d, the receiver sets the imaging mode to a macro imaging mode, or sets a shorter focal length than focusing on the transmitter. Capturing the transmitter in a larger size in a blurred state enables an increase in the number of exposure lines in which the bright line is captured.

[1207]

In Step 7340e, the receiver observes the change in luminance of the bright line in the direction perpendicular to the exposure line. In Step 7340f, the receiver calculates the interval between the parts of rapid rise in luminance or the interval between the parts of rapid fall in luminance and reads the transmission signal from the interval, or calculates the period of luminance change and reads the transmission signal from the period.

[1208]

FIG. 311B is a diagram illustrating an image obtained in the normal imaging mode and an image obtained in the macro imaging mode in comparison. As illustrated in FIG. 311B, an image 7307b

obtained by capturing the light emitting subject in the macro imaging mode includes a larger bright area than an image 7307a obtained by capturing the same subject in the normal imaging mode. Thus, the bright line can be generated in more exposure lines for the subject in the macro imaging mode.

[1209]

FIG. 312 is a diagram illustrating a display device that displays video and the like.

[1210]

A display device 7300a including a liquid display or the like displays video in a video area 7300b, and various information in an information display area 7300c. The display device 7300a is configured as a transmitter (transmission device), and transmits a signal by changing the luminance of the backlight.

[1211]

FIG. 313 is a diagram illustrating an example of processing operation of the display device 7300a.

[1212]

First, in Step 7350a, the display device 7300a enters the signal transmission mode. Next, in Step 7350b, the display device 7300a transmits the signal by changing the luminance of the backlight in the information display area 7300c.

[1213]

FIG. 314 is a diagram illustrating an example of the signal transmission part in the display device 7300a.

[1214]

The display device 7300a transmits the signal by changing the luminance of each part (7301d, 7301f, 7301g, 7301i) where the backlight is ON, and transmits no signal from the other parts (7301c, 7301e, 7301h, 7301j).

[1215]

FIG. 315 is a diagram illustrating another example of processing operation of the display device 7300a.

[1216]

First, in Step 7351a, the display device 7300a enters the

signal transmission mode. Next, in Step 7351b, the display device 7300a transmits the signal only from the part where the backlight is ON, in the case where the backlight is turned OFF upon screen change for improved dynamic resolution. In Step 7351c, the display device 7300a transmits no signal when the backlight is OFF in the entire screen.

[1217]

FIG. 316 is a diagram illustrating another example of the signal transmission part in the display device 7300a.

[1218]

The display device 7300a turns OFF the backlight control for improved dynamic resolution in each part (7302b, 7302e, 7302g, 7302j), and transmits the signal from these parts. Meanwhile, the display device 7300a turns ON the backlight control for improved dynamic resolution in the other parts (7302c, 7302d, 7302h, 7301i).

[1219]

FIG. 317 is a diagram illustrating yes another example of processing operation of the display device 7300a.

[1220]

First, in Step 7352a, the display device 7300a enters the signal transmission mode. Next, in Step 7352b, the display device 7300a turns OFF the backlight control for improved dynamic resolution in the part (7302b, 7302e, 7302g, 7202j) of the screen, and transmits the signal from the part.

[1221]

In Step 7352c, the display device 7300a adjusts the average luminance of the backlight so that the brightness of the part transmitting the signal is equal to the average luminance of the backlight in the part transmitting no signal. This adjustment may be made by adjusting the time ratio of blinking of the backlight during signal transmission or by adjusting the maximum luminance of the backlight.

[1222]

FIG. 318 is a diagram illustrating a structure of a communication system including the transmitter and the receiver.

[1223]

The communication system includes transmitters 7303a and 7303b, a control device 7303c, a network 7303d, an ID management server 7303e, a wireless access point 7303f, and receivers 7303g and 7303h.

[1224]

FIG. 319 is a flowchart illustrating processing operation of the communication system in FIG. 318.

[1225]

First, in Step 7353a, the ID of the transmitter, the information (SSID, password, ID of wireless access point, radio frequency, position information of access point, connectable position information, etc.) of the wireless access point 7303f, and the information (IP address, etc.) of the control device 7303c are stored in the ID management server 7303e in association with each other. Next, in Step 7353b, the transmitter 7303a or 7303b transmits the ID of the transmitter 7303a or 7303b. The transmitter 7303a or 7303b may also transmit the information of the wireless access point 7303f and the information of the control device 7303c. In Step 7353c, the receiver 7303g or 7303h receives the ID of the transmitter 7303a or 7303b and obtains the information of the wireless access point 7303f and the information of the control device 7303c from the ID management server 7303e, or receives the ID of the transmitter 7303a or 7303b and the information of the wireless access point 7303f.

[1226]

In Step 7353d, the transmitter 7303a or 7303b connects to the wireless access point 7303f. In Step 7353e, the transmitter 7303a or 7303b transmits the address of the ID management server 7303e on the network, an instruction to the ID management server 7303e, and the ID of the transmitter 7303a or 7303b to the control device 7303c.

[1227]

In Step 7353f, the control device 7303c transmits the received ID to the receiver 7303g or 7303h. In Step 7353g, the control

device 7303c issues the instruction to the ID management server 7303e on the network, and obtains a response. Here, the control device 7303c operates as a proxy server.

[1228]

In Step 7353h, the control device 7303c transmits the response and the received ID, from the transmitter 7303a or 7303b indicated by the transmitter ID. The transmission may be repeatedly performed until the reception completion is notified from the receiver 7303g or 7303h or a predetermined time elapses.

[1229]

In Step 7353i, the receiver 7303g or 7303h receives the response. In Step 7353j, the receiver 7303g or 7303h transmits the received ID to the control device 7303c, and notifies the reception completion.

[1230]

In Step 7353k, in the case where the receiver 7303g or 7303h is at a position where the signal from the transmitter 7303a or 7303b cannot be received, the receiver 7303g or 7303h may notify the control device 7303c to return the response via the wireless access point 7303f.

[1231]

FIG. 320 is a diagram illustrating a variation of signal transmission in each of the above embodiments.

[1232]

In the reception method according to the present invention, the signal transmission efficiency is higher when the light emitting unit of the transmitter is captured in a larger size in the imaging unit of the receiver. That is, the signal transmission efficiency is low in the case where a small electric bulb or a high ceiling lighting is used as the light emitting unit of the transmitter. The signal transmission efficiency can be enhanced by applying light of a transmitter 7313a to a wall, a ceiling, a floor, a lamp shade, or the like and capturing reflected light 7313b by a receiver 7313c.

[1233]

FIG. 321 is a diagram illustrating a variation of signal

transmission in each of the above embodiments.

[1234]

Signal transmission is performed by a transmitter 7314d projecting light including a transmission signal onto an exhibit 7314a and a receiver 7314c capturing reflected light 7314b.

[1235]

FIG. 322 is a diagram illustrating a variation of signal transmission in each of the above embodiments.

[1236]

A signal transmitted from a transmitter 7315a is received by a receiver 7315b including an illuminance sensor. The receiver 7315b receives the signal not by an imaging element but by an illuminance sensor. Such a receiver is low in power consumption, suitable for constant signal reception, lightweight, and manufacturable at low cost.

[1237]

The receiver 7315b is formed as a part of glasses, an earring, a hair accessory, a wristwatch, a hearing aid, a necklace, a cane, a trolley, or a shopping cart. The receiver 7315b performs video display, audio reproduction, or vibration, according to the received signal. The receiver 7315b also transmits the received signal to a mobile information terminal 7315c via a wireless or wired transmission path.

[1238]

FIG. 323A is a diagram illustrating a variation of signal transmission in each of the above embodiments.

[1239]

A projector 7316a transmits a signal, using projection light as the transmission signal. A receiver 7316c captures reflected light from a screen 7316b, to receive the signal. The receiver 7316c displays content and its ancillary information projected by the projector 7316a, on a screen 7316d. The content displayed on the screen 7316d may be transmitted as the transmission signal, or obtained from a server 7316e based on an ID included in the transmission signal.

[1240]

FIG. 323B is a diagram illustrating a variation of signal transmission in each of the above embodiments.

[1241]

A receiver 7317b receives a signal transmitted from a transmitter 7317a. The receiver 7317b transmits audio to an earphone or hearing aid 7317c registered in the receiver 7317b. In the case where visual impairment is included in a user profile registered in the receiver 7317b, the receiver 7317b transmits audio commentary for the visually impaired to the earphone 7317c.

[1242]

FIG. 323C is a diagram illustrating a variation of signal transmission in each of the above embodiments.

[1243]

A receiver 7318c receives a signal transmitted from a transmitter 7318a or 7318b. The receiver 7318c may receive the signal using an illuminance sensor. The inclusion of an illuminance sensor with high directivity enables the receiver 7318c to accurately estimate the direction to the transmitter. Moreover, the inclusion of a plurality of illuminance sensors enables the receiver 7318c to receive the transmission signal in a wider range. The receiver 7318c transmits the received signal to an earphone 7318d or a head-mounted display 7318e.

[1244]

FIG. 323D is a flowchart illustrating processing operation of a communication system including the receiver and the display or the projector. This flowchart illustrates processing operation corresponding to any of the examples of signal transmission illustrated in FIGS. 323A to 323C.

[1245]

First, in Step 7357a, the ID of the transmitter, the display content ID, and the content displayed on the display or the projector are stored in the ID management server in association with each other. Next, in Step 7357b, the transmitter displays the content on the display or the projector, and transmits the signal using the

backlight of the display or the projection light of the projector. The transmission signal may include the ID of the transmitter, the display content ID, the URL in which the display content is stored, and the display content itself.

[1246]

In Step 7357c, the receiver receives the transmission signal. In Step 7357d, the receiver obtains the content displayed on the display or the projector by the transmitter, based on the received signal.

[1247]

In Step 7357e, in the case where a user profile is set in the receiver, the receiver obtains content suitable for the profile. For example, the receiver obtains subtitle data or audio content for at hand reproduction in the case where a profile of hearing impairment is set, and obtains content for audio commentary in the case where a profile of visual impairment is set.

[1248]

In Step 7357f, the receiver displays the obtained image content on the display of the receiver, and reproduces the obtained audio content from the speaker of the receiver, the earphone, or the hearing aid.

[1249]

FIG. 324 is a diagram illustrating an example of the transmission signal in Embodiment 12. FIG. 324 illustrates the transmission signal in FIG. 250 in detail.

[1250]

In the case of coding the transmission signal by the method in any of FIGS. 27 to 87, 302, and the like, the receiver can decode the transmission signal by detecting points 7308c, 7308d, and 7308e at which the luminance rises rapidly. In this case, transmission signals 7308a and 7308b are equivalent and represent the same signal.

[1251]

Accordingly, the average luminance can be changed by adjusting the time of luminance fall, as in the transmission signals 7308a and 7308b. When there is a need to change the luminance of

the transmitter, by adjusting the average luminance in this way, the luminance can be adjusted without changing the transmission signal itself.

[1252]

FIG. 325 is a diagram illustrating an example of the transmission signal in Embodiment 3. FIG. 325 illustrates the transmission signal in FIG. 34 in detail.

[1253]

Transmission signals 7309a and 7309b can be regarded as equivalent to a transmission signal 7309c, when taking the average luminance of a length such as 7309d. Another signal can be superimposed by changing the luminance with a time width unobservable by other receivers, as in the transmission signals 7309a and 7309b.

[1254]

FIG. 326 is a diagram illustrating another example of the transmission signal in Embodiment 3. FIG. 326 illustrates the transmission signal in FIG. 34 in detail.

[1255]

Another signal is superimposed by adding a luminance change with a time width unobservable by other receivers to a transmission signal 7310a, as in 7310c. In the case where the signal cannot be superimposed in a luminance fall section in the transmission signal 7310a, a high-speed modulation signal can be transmitted intermittently by adding a start signal and an end signal to a high-speed modulation part as in 7310e.

[1256]

FIG. 327A is a diagram illustrating an example of the imaging element of the receiver in each of the above embodiments.

[1257]

Many imaging elements have a layout 7311a, and so cannot capture the transmitter while capturing the optical black. A layout 7311b, on the other hand, enables the imaging element to capture the transmitter for a longer time.

[1258]

FIG. 327B is a diagram illustrating an example of a structure of an internal circuit of the imaging device of the receiver in each of the above embodiments.

[1259]

An imaging device 7319a includes a shutter mode change unit 7319b that switches between the global shutter mode and the rolling shutter mode. Upon reception start, the receiver changes the shutter mode to the rolling shutter mode. Upon reception end, the receiver changes the shutter mode to the global shutter mode, or returns the shutter mode to a mode before reception start.

[1260]

FIG. 327C is a diagram illustrating an example of the transmission signal in each of the above embodiments.

[1261]

In the case where the carrier is set to 1 kHz as a frequency at which no flicker is captured by a camera, one slot is 1 millisecond (7320a). In the modulation scheme (4-value PPM modulation) in FIG. 28, the average of one symbol (4 slots) is 75% (7320b), and the range of the moving average for 4 milliseconds is 75% ± (modulation factor)/4. Flicker is smaller when the modulation factor is lower. Assuming one symbol as one period, the carrier is greater than or equal to 800 Hz in the case where the frequency at which no flicker is perceived by humans is greater than or equal to 200 Hz, and the carrier is greater than or equal to 4 kHz in the case where the frequency at which no flicker is captured by a camera is greater than or equal to 1 kHz.

[1262]

Likewise, in the case where the carrier is set to 1 kHz, in the modulation scheme (5-value PPM modulation) in FIG. 302, the average of one symbol (5 slots) is 80% (7320c), and the range of the moving average for 5 milliseconds is 80% ± (modulation factor)/5. Flicker is smaller when the modulation factor is lower. Assuming one symbol as one period, the carrier is greater than or equal to 1 kHz in the case where the frequency at which no flicker is perceived by humans is greater than or equal to 200 Hz, and the carrier is

greater than or equal to 5 kHz in the case where the frequency at which no flicker is captured by a camera is greater than or equal to 1 kHz.

[1263]

FIG. 327D is a diagram illustrating an example of the transmission signal in each of the above embodiments.

[1264]

A header pattern is different from a pattern representing data, and also needs to be equal in average luminance to the pattern representing data, in order to eliminate flicker. Patterns such as 7321b, 7321c, 7321d, and 7321e are available as patterns equal in average luminance to the data pattern in the modulation scheme of 2200.2a. The pattern 7321b is desirable in the case where the luminance value can be controlled in levels. In the case where the luminance change is sufficiently faster than the exposure time of the imaging device in the receiver as in the pattern 7321e, the signal is observed as in 7321b by the receiver. The modulation scheme 7219a is defined in the form that includes the header pattern.

[1265]

FIG. 328A is a diagram for describing an imaging mode of the receiver.

[1266]

In the normal imaging mode, the receiver obtains an image 7304a by performing imaging using all exposure lines (imaging lines) included in the image sensor. As an example, the total number of exposure lines is 3000. Through such imaging, the receiver obtains one image from time t1 to time t4, and further obtains one image from time t5 to time t8.

[1267]

In the case where the subject which is the transmitter is shown in only one part of the image, there is a possibility that the receiver cannot receive the signal from the subject. Suppose only the exposure lines 1001 to 2000 capture the subject and the other exposure lines do not capture the subject. When the exposure lines 1001 to 2000 are not exposed, that is, when the exposure lines 1 to

1000 are exposed (time t1 to time t2, time t5 to time t6) and when the exposure lines 2001 to 3000 are exposed (time t3 to time t4, time t7 to time t8), the receiver cannot receive the signal from the subject.

[1268]

When the imaging mode is switched from the normal imaging mode to a special imaging mode A, the receiver uses, for imaging, only the exposure lines capturing the subject from among all exposure lines. That is, the receiver uses only the exposure lines 1001 to 2000 for imaging, from time t1 to time t4 and from time t5 to time t8. In the special imaging mode A, the exposure lines 1001 to 2000 are uniformly exposed in sequence only once throughout the imaging time of one frame, e.g. from time t1 to time t4 or from time t5 to time t8. The receiver can thus be prevented from missing the reception of the signal from the subject.

[1269]

FIG. 328B is a flowchart illustrating processing operation of the receiver using the special imaging mode A.

[1270]

First, in Step 7354a, the receiver detects the part in which the bright line is captured, from the captured image. Next, in Step 7354b, the receiver sets the hand movement correction function to ON.

[1271]

In Step 7354c, the receiver switches to the special imaging mode A in which the imaging is performed using only the pixels of the exposure lines in which the bright line is captured. In the special imaging mode A, the exposure time of each exposure line is set so that the time from when the exposure of one exposure line starts to when the exposure of the next exposure line starts is uniform during the imaging time of one image (e.g. from time t1 to time t4). Here, one or more pixels in the direction perpendicular to the exposure lines may be omitted in the imaging.

[1272]

Since the number of frames output from the imaging unit of the receiver is the same as that in the normal imaging mode, the

special imaging mode A is suitable for a receiver that includes a low-performance processor or a receiver that includes a processor also engaged in other processes.

[1273]

In Step 7354d, the receiver designates the area of imaging in the special imaging mode A. By designating a narrower area than the area in which the bright line is captured as the area of imaging, it is possible to keep capturing the bright line even when the imaging direction changes due to hand movement and the like.

[1274]

In Step 7354e, the receiver detects the movement of the captured image. By moving the area of imaging in the moving direction, it is possible to keep capturing the bright line even when the position of the captured image changes. In Step 7354f, the receiver obtains the transmitted information from the pattern of the bright line.

[1275]

FIG. 329A is a diagram for describing another imaging mode of the receiver.

[1276]

When the imaging mode is switched from the normal imaging mode to a special imaging mode B, the receiver uses, for imaging, only the exposure lines capturing the subject from among all exposure lines. That is, the receiver uses only the exposure lines 1001 to 2000 for imaging, from time t1 to time t4 and from time t5 to time t8. In the special imaging mode B, the exposure lines 1001 to 2000 are exposed in sequence a plurality of times throughout the imaging time of one frame, e.g. from time t1 to time t4 or from time t5 to time t8. The receiver can thus be prevented from missing the reception of the signal from the subject.

[1277]

FIG. 329B is a flowchart illustrating processing operation of the receiver using the special imaging mode B.

[1278]

First, in Step 7355a, the receiver detects the part in which the

bright line is captured, from the captured image. Next, in Step 7355b, the receiver sets the hand movement correction function to ON.

[1279]

In Step 7355c, the receiver switches to the special imaging mode B in which the imaging is performed using only the pixels of the exposure lines in which the bright line is captured. In the special imaging mode B, the imaging is performed at high speed by subjecting only the area in which the bright line is captured to the imaging. Here, one or more pixels in the direction perpendicular to the exposure lines may be omitted in the imaging.

[1280]

In Step 7355d, the receiver designates the area of imaging in the special imaging mode B. By designating a narrower area than the area in which the bright line is captured as the area of imaging, it is possible to keep capturing the bright line even when the imaging direction changes due to hand movement and the like.

[1281]

In Step 7355e, the receiver detects the movement of the captured image. By moving the area of imaging in the moving direction, it is possible to keep capturing the bright line even when the position of the captured image changes. In Step 7355f, the receiver obtains the transmitted information from the pattern of the bright line.

[1282]

FIG. 330A is a diagram for describing yet another imaging mode of the receiver.

[1283]

When the imaging mode is switched from the normal imaging mode to a special imaging mode C, the receiver uses, for imaging, only the exposure lines capturing the subject from among all exposure lines. That is, the receiver uses only the exposure lines 1001 to 2000 for imaging, from time t1 to time t4 and from time t5 to time t8. In the special imaging mode C, the exposure lines 1001 to 2000 are exposed in sequence a plurality of times throughout the

imaging time of one frame, e.g. from time t1 to time t4 or from time t5 to time t8. In addition, in the special imaging mode C, a plurality of images obtained by performing the exposure a plurality of times are not output individually, but one image (image of the same size as the image generated in the normal imaging mode) including the plurality of images is output. The receiver can thus be prevented from missing the reception of the signal from the subject.

[1284]

FIG. 330B is a flowchart illustrating processing operation of the receiver using the special imaging mode C.

[1285]

First, in Step 7356a, the receiver detects the part in which the bright line is captured, from the captured image. Next, in Step 7356b, the receiver sets the hand movement correction function to ON.

[1286]

In Step 7356c, the receiver switches to the special imaging mode C in which the imaging is performed using only the pixels of the exposure lines in which the bright line is captured. In the special imaging mode C, the imaging is performed only in the area in which the bright line is captured, and the imaging results are arranged to form one image while ignoring the original pixel positions. Here, one or more pixels in the direction perpendicular to the exposure lines may be omitted in the imaging.

[1287]

Since the number of frames output from the imaging unit of the receiver is the same as that in the normal imaging mode, the special imaging mode C is suitable for a receiver that includes a low-performance processor or a receiver that includes a processor also engaged in other processes.

[1288]

In Step 7356d, the receiver designates the area of imaging in the special imaging mode C. By designating a narrower area than the area in which the bright line is captured as the area of imaging, it is possible to keep capturing the bright line even when the imaging

direction changes due to hand movement and the like.

[1289]

In Step 7356e, the receiver detects the movement of the captured image. By moving the area of imaging in the moving direction, it is possible to keep capturing the bright line even when the position of the captured image changes. In Step 7356f, the receiver obtains the transmitted information from the pattern of the bright line.

[1290]

Though the information communication method according to one or more aspects has been described by way of the embodiments, the present invention is not limited to these embodiments. Other embodiments realized by application of modifications conceivable by those skilled in the art to the embodiments and any combination of the structural elements in the embodiments are also included in the scope of one or more aspects without departing from the subject matter of the present invention.

[1291]

FIG. 331A is a flowchart of an information communication method according to an aspect of the present invention.

[1292]

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, and includes steps SA11, SA12, and SA13.

[1293]

In detail, the information communication method includes: an exposure time setting step (SA11) of setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; an imaging step (SA12) of capturing the subject that changes in luminance by the image sensor with the set exposure time, to obtain the image including the bright line; and an information obtainment step (SA13) of obtaining the information by

demodulating data specified by a pattern of the bright line included in the obtained image.

[1294]

FIG. 331B is a block diagram of an information communication device according to an aspect of the present invention.

[1295]

An information communication device A10 according to an aspect of the present invention is an information communication device that obtains information from a subject, and includes structural elements A11, A12, and A13.

[1296]

In detail, the information communication device A10 includes: an exposure time setting unit A11 that sets an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; an imaging unit A12 which is the image sensor that captures the subject that changes in luminance by the image sensor with the set exposure time, to obtain the image including the bright line; and a demodulation unit A13 that obtains the information by demodulating data specified by a pattern of the bright line included in the obtained image.

[1297]

FIG. 331C is a flowchart of an information communication method according to an aspect of the present invention.

[1298]

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, and includes steps SA21 to SA26.

[1299]

In detail, the information communication method includes: a first imaging step (SA21) of obtaining a first image by capturing the subject using an image sensor that includes a plurality of exposure lines; a detection step (SA22) of detecting a range in which the

subject is captured, from the first image; a determination step (SA23) of determining, from among the plurality of exposure lines, predetermined exposure lines for capturing the range in which the subject is captured; an exposure time setting step (SA24) of setting an exposure time of the image sensor so that, in a second image obtained using the predetermined exposure lines, a bright line corresponding to the predetermined exposure lines appears according to a change in luminance of the subject; a second imaging step (SA25) of obtaining the second image including the bright line, by capturing the subject that changes in luminance using the predetermined exposure lines with the set exposure time; and an information obtainment step (SA26) of obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained second image.

[1300]

FIG. 331D is a block diagram of an information communication device according to an aspect of the present invention.

[1301]

An information communication device A20 according to an aspect of the present invention is an information communication device that obtains information from a subject, and includes structural elements A21 to A26.

[1302]

In detail, the information communication device A20 includes: a first image obtainment unit A21 that obtains a first image by capturing the subject using an image sensor that includes a plurality of exposure lines; a imaging range detection unit A22 that detects a range in which the subject is captured, from the first image; an exposure line determination unit A23 that determines, from among the plurality of exposure lines, predetermined exposure lines for capturing the range in which the subject is captured; an exposure time setting unit A24 that sets an exposure time of the image sensor so that, in a second image obtained using the predetermined exposure lines, a bright line corresponding to the predetermined exposure lines appears according to a change in luminance of the

subject; a second image obtainment unit A25 that obtains the second image including the bright line, by capturing the subject that changes in luminance using the predetermined exposure lines with the set exposure time; and a demodulation unit A26 that obtains the information by demodulating data specified by a pattern of the bright line included in the obtained second image.

[1303]

Note that the pattern of the bright line mentioned above is synonymous with the difference of the interval of each bright line.

[1304]

FIG. 332 is a diagram illustrating an image obtained by an information communication method according to an aspect of the present invention.

[1305]

For example, the exposure time is set to less than 10 milliseconds for the subject that changes in luminance at a frequency greater than or equal to 200 Hz. A plurality of exposure lines included in the image sensor are exposed sequentially, each at a different time. In this case, several bright lines appear in an image obtained by the image sensor, as illustrated in FIG. 332. That is, the image includes the bright line parallel to the exposure line. In the information obtainment step (SA13 or SA26), data specified by a pattern in a direction perpendicular to the exposure line in the pattern of the bright line is demodulated.

[1306]

In the information communication method illustrated in FIG. 331A and the information communication device A10 illustrated in FIG. 331B, the information transmitted using the change in luminance of the subject is obtained by the exposure of the exposure line in the image sensor. This enables communication between various devices, with no need for, for example, a special communication device for wireless communication. Furthermore, in the information communication method illustrated in FIG. 331C and the information communication device A20 illustrated in FIG. 331D, from among all exposure lines included in the image sensor, only the

exposure lines in which the subject is captured are used for obtaining the second image including the bright line, so that the process for the exposure lines in which the subject is not captured can be omitted. This enhances the efficiency of information obtainment, and prevents missing the reception of the information from the subject.

[1307]

FIG. 333A is a flowchart of an information communication method according to another aspect of the present invention.

[1308]

An information communication method according to another aspect of the present invention is an information communication method of transmitting a signal using a change in luminance, and includes steps SB11, SB12, and SB13.

[1309]

In detail, the information communication method includes: a determination step (SB11) of determining a pattern of the change in luminance by modulating the signal to be transmitted; a first transmission step (SB12) of transmitting the signal by a light emitter changing in luminance according to the determined pattern; and a second transmission step (SB13) of transmitting the same signal as the signal by the light emitter changing in luminance according to the same pattern as the determined pattern within 33 milliseconds from the transmission of the signal. In the determination step (SB11), the pattern is determined so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range.

[1310]

FIG. 333B is a block diagram of an information communication device according to another aspect of the present invention.

[1311]

An information communication device B10 according to another aspect of the present invention is an information communication device that transmits a signal using a change in luminance, and includes structural elements B11 and B12.

[1312]

In detail, the information communication device B10 includes: a luminance change pattern determination unit B11 that determines a pattern of the change in luminance by modulating the signal to be transmitted; and a light emitter B12 that transmits the signal by changing in luminance according to the determined pattern, and transmits the same signal as the signal by changing in luminance according to the same pattern as the determined pattern within 33 milliseconds from the transmission of the signal. The luminance change pattern determination unit B11 determines the pattern so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range.

[1313]

In the information communication method illustrated in FIG. 333A and the information communication device B10 illustrated in FIG. 333B, the pattern of the change in luminance is determined so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range. As a result, the signal can be transmitted using the change in luminance without humans perceiving flicker. Moreover, the same signal is transmitted within 33 milliseconds, ensuring that, even when the receiver receiving the signal has blanking, the signal is transmitted to the receiver.

[1314]

FIG. 334A is a flowchart of an information communication method according to yet another aspect of the present invention.

[1315]

An information communication method according to yet another aspect of the present invention is an information communication method of transmitting a signal using a change in luminance, and includes steps SC11, SC12, SC13, and SC14.

[1316]

In detail, the information communication method includes: a determination step (SC11) of determining a plurality of frequencies by modulating the signal to be transmitted; a transmission step

(SC12) of transmitting the signal by a light emitter changing in luminance according to a constant frequency out of the determined plurality of frequencies; and a change step (SC14) of changing the frequency used for the change in luminance to an other one of the determined plurality of frequencies in sequence, in a period greater than or equal to 33 milliseconds. After the transmission step SC12, whether or not all of the determined frequencies have been used for the change in frequency may be determined (SC13), where the update step SC14 is performed in the case of determining that all of the frequencies have not been used (SC13: N). In the transmission step (SC12), the light emitter changes in luminance so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range.

[1317]

FIG. 334B is a block diagram of an information communication device according to yet another aspect of the present invention.

[1318]

An information communication device C10 according to yet another aspect of the present invention is an information communication device that transmits a signal using a change in luminance, and includes structural elements C11, C12, and C13.

[1319]

In detail, the information communication device C10 includes: a frequency determination unit C11 that determines a plurality of frequencies by modulating the signal to be transmitted; a light emitter C13 that transmits the signal by changing in luminance according to a constant frequency out of the determined plurality of frequencies; and a frequency change unit C12 that changes the frequency used for the change in luminance to an other one of the determined plurality of frequencies in sequence, in a period greater than or equal to 33 milliseconds. The light emitter C13 changes in luminance so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range.

[1320]

In the information communication method illustrated in FIG. 334A and the information communication device C10 illustrated in FIG. 334B, the pattern of the change in luminance is determined so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range. As a result, the signal can be transmitted using the change in luminance without humans perceiving flicker. In addition, a lot of FM modulated signals can be transmitted.

[1321]

Moreover, an information communication device may include: an information management unit that manages device information which includes an ID unique to the information communication device and state information of a device; a light emitting element; and a light transmission unit that transmits information using a blink pattern of the light emitting element, wherein when an internal state of the device has changed, the light transmission unit converts the device information into the blink pattern of the light emitting element, and transmits the converted device information.

[1322]

The information communication device may further include an activation history management unit that stores information sensed in the device, the information indicating an activation state of the device or a user usage history, wherein the light transmission unit obtains previously registered performance information of a clock generation device to be utilized, and changes a transmission speed.

[1323]

The light emitting element may include a first light emitting element and a second light emitting element, the second light emitting element being disposed in vicinity of the first light emitting element for transmitting information by blinking, wherein when information transmission is repeatedly performed a certain number of times by the first light emitting element blinking, the second light emitting element emits light during an interval between an end of the

information transmission and a start of the information transmission.

[1324]

The information communication device may include: an imaging unit that exposes imaging elements with a time difference; and a signal analysis unit that reads, from one captured image, a change in time-average luminance of an imaging object less than or equal to 1 millisecond, using a difference between exposure times of the imaging elements.

[1325]

The time-average luminance may be time-average luminance greater than or equal to 1/30000 second.

[1326]

The information communication device may further modulate transmission information to a light emission pattern, and transmit the information using the light emission pattern.

[1327]

The information communication device may express a transmission signal by a change in time-average luminance less than or equal to 1 millisecond, and change a light emitting unit in luminance to ensure that time-average luminance greater than or equal to 60 milliseconds is uniform.

[1328]

The information communication device may express the transmission signal by a change in time-average luminance greater than or equal to 1/30000 second.

[1329]

A part common between the transmission signal and a signal expressed by time-average luminance in a same type of information communication device located nearby may be transmitted by causing the light emitting unit to emit light at a same timing as a light emitting unit of the same type of information communication device.

[1330]

A part not common between the transmission signal and the signal expressed by time-average luminance in the same type of information communication device located nearby may be expressed

by time-average luminance of the light emitting unit during a time slot in which the same type of information communication device does not express the signal by time-average luminance.

[1331]

The information communication device may include: a first light emitting unit that expresses the transmission signal by a change in time-average luminance; and a second light emitting unit that expresses the transmission signal not by a change in time-average luminance, wherein the signal is transmitted using a position relation between the first light emitting unit and the second light emitting unit.

[1332]

A centralized control device may include a control unit that performs centralized control on any of the information communication devices described above.

[1333]

A building may include any of the information communication devices described above or the centralized control device described above.

[1334]

A train may include any of the information communication devices described above or the centralized control device described above.

[1335]

An imaging device may be an imaging device that captures a two-dimensional image, wherein the image is captured by exposing only an arbitrary imaging element, at a higher speed than in the case where the image is captured by exposing all imaging elements.

[1336]

The arbitrary imaging element may be an imaging element that captures an image of a pixel having a maximum change in time-average luminance less than or equal to 1 millisecond, or a line of imaging elements including the imaging element.

[1337]

Each of the structural elements in each of the above-described

embodiments may be configured in the form of an exclusive hardware product, or may be realized by executing a software program suitable for the structural element. Each of the structural elements may be realized by means of a program executing unit, such as a CPU and a processor, reading and executing the software program recorded on a recording medium such as a hard disk or a semiconductor memory. For example, the program causes a computer to execute the information communication method illustrated in any of the flowcharts in FIGS. 331A, 331C, 333A, and 334A.

[1338]

(Summary of each of the above embodiments and variations)

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, the information communication method including: a first imaging step of obtaining a first image by capturing the subject using an image sensor that includes a plurality of exposure lines; a detection step of detecting a range in which the subject is captured, from the first image; a determination step of determining, from among the plurality of exposure lines, predetermined exposure lines for capturing the range in which the subject is captured; an exposure time setting step of setting an exposure time of the image sensor so that, in a second image obtained using the predetermined exposure lines, a bright line corresponding to the predetermined exposure lines appears according to a change in luminance of the subject; a second imaging step of obtaining the second image including the bright line, by capturing the subject that changes in luminance using the predetermined exposure lines with the set exposure time; and an information obtainment step of obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained second image.

[1339]

In this way, the information transmitted using the change in luminance of the subject is obtained by the exposure of the exposure

line in the image sensor. This enables communication between various devices, with no need for, for example, a special communication device for wireless communication. Besides, from among all exposure lines included in the image sensor, only the exposure lines in which the subject is captured are used for obtaining the second image including the bright line, so that the process for the exposure lines in which the subject is not captured can be omitted. This enhances the efficiency of information obtainment, and prevents missing the reception of the information from the subject. Note that the exposure line is a column or a row of a plurality of pixels that are simultaneously exposed in the image sensor, and the bright line is a line included in a captured image illustrated, for instance, in FIG. 22.

[1340]

For example, the predetermined exposure lines may include only exposure lines for capturing the range in which the subject is captured and not include exposure lines for capturing a range in which the subject is not captured, from among the plurality of exposure lines.

[1341]

In this way, it is possible to enhance the efficiency of information obtainment more reliably, and prevent missing the reception of the information from the subject.

[1342]

For example, in the second imaging step, a first imaging time when obtaining the first image may be equally divided by the number of exposure lines included in the predetermined exposure lines to obtain a second imaging time, wherein the second imaging time is set as an imaging time of each exposure line included in the predetermine exposure lines.

[1343]

In this way, the information can be appropriately obtained from the subject which is a transmitter, for instance as illustrated in FIGS. 328A and 328B.

[1344]

For example, in the second imaging step, an imaging time of

each exposure line in the image sensor in the first imaging step may be set as an imaging time of each exposure line included in the predetermined exposure lines.

[1345]

In this way, the information can be appropriately obtained from the subject which is a transmitter, for instance as illustrated in FIGS. 329A and 329B.

[1346]

For example, in the second imaging step, a plurality of second images obtained using the predetermined exposure lines may be combined to form a third image equal in image size to the first image, wherein in the information obtainment step, the information is obtained by demodulating the data specified by the pattern of the bright line included in the third image.

[1347]

In this way, the information can be appropriately obtained from the subject which is a transmitter, for instance as illustrated in FIGS. 330A and 330B.

[1348]

For example, in the determination step, exposure lines for capturing a narrower range than the range in which the subject is captured may be determined as the predetermined exposure lines, from among the plurality of exposure lines.

[1349]

In this way, the information can be appropriately obtained from the subject which is a transmitter without being affected by hand movement and the like, for instance as illustrated in FIGS. 328B, 329B, and 330B.

[1350]

For example, an imaging mode may be switchable between a first mode in which the subject is captured using all of the plurality of exposure lines in the image sensor and a second mode in which the subject is captured using the predetermined exposure lines from among the plurality of exposure lines in the image sensor.

[1351]

In this way, the information can be appropriately obtained from the subject which is a transmitter, by switching the imaging mode.

[1352]

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, the information communication method including: an exposure time setting step of setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; an imaging step of capturing the subject that changes in luminance by the image sensor with the set exposure time, to obtain the image including the bright line; and an information obtainment step of obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained image.

[1353]

In this way, the information transmitted using the change in luminance of the subject is obtained by the exposure of the exposure line in the image sensor. This enables communication between various devices, with no need for, for example, a special communication device for wireless communication. Note that the exposure line is a column or a row of a plurality of pixels that are simultaneously exposed in the image sensor, and the bright line is a line included in a captured image illustrated, for instance, in FIG. 22.

[1354]

For example, in the imaging step, a plurality of exposure lines included in the image sensor may be exposed sequentially, each at a different time.

[1355]

In this way, the bright line generated by capturing the subject in a rolling shutter mode is included in the position corresponding to each exposure line in the image, and therefore a lot of information can be obtained from the subject.

[1356]

For example, in the information obtainment step, the data specified by a pattern in a direction perpendicular to the exposure line in the pattern of the bright line may be demodulated.

[1357]

In this way, the information corresponding to the change in luminance can be appropriately obtained.

[1358]

For example, in the exposure time setting step, the exposure time may be set to less than 10 milliseconds.

[1359]

In this way, the bright line can be generated in the image more reliably.

[1360]

For example, in the imaging step, the subject that changes in luminance at a frequency greater than or equal to 200 Hz may be captured.

[1361]

In this way, a lot of information can be obtained from the subject without humans perceiving flicker, for instance as illustrated in FIGS. 305A and 305B.

[1362]

For example, in the imaging step, the image including the bright line parallel to the exposure line may be obtained.

[1363]

In this way, the information corresponding to the change in luminance can be appropriately obtained.

[1364]

For example, in the information obtainment step, for each area in the obtained image corresponding to a different one of exposure lines included in the image sensor, the data indicating 0 or 1 specified according to whether or not the bright line is present in the area may be demodulated.

[1365]

In this way, a lot of PPM modulated information can be

obtained from the subject. For instance as illustrated in FIG. 22, in the case of obtaining information based on whether or not each exposure line receives at least a predetermined amount of light, information can be obtained at a speed of fl bits per second at the maximum where f is the number of images per second (frame rate) and l is the number of exposure lines constituting one image.

[1366]

For example, in the information obtainment step, whether or not the bright line is present in the area may be determined according to whether or not a luminance value of the area is greater than or equal to a threshold.

[1367]

In this way, information can be appropriately obtained from the subject.

[1368]

For example, in the imaging step, for each predetermined period, the subject that changes in luminance at a constant frequency corresponding to the predetermined period may be captured, wherein in the information obtainment step, the data specified by the pattern of the bright line generated, for each predetermined period, according to the change in luminance at the constant frequency corresponding to the predetermined period is demodulated.

[1369]

In this way, a lot of FM modulated information can be obtained from the subject. For instance as illustrated in FIG. 14, appropriate information can be obtained using a bright line pattern corresponding to a frequency f1 and a bright line pattern corresponding to a frequency f2.

[1370]

For example, in the imaging step, the subject that changes in luminance to transmit a signal by adjusting a time from one change to a next change in luminance may be captured, the one change and the next change being the same one of a rise and a fall in luminance, wherein in the information obtainment step, the data specified by the

pattern of the bright line is demodulated, the data being a code associated with the time.

[1371]

In this way, the brightness of the subject (e.g. lighting device) perceived by humans can be adjusted by PWM control without changing the information transmitted from the subject, for instance as illustrated in FIG. 248.

[1372]

For example, in the imaging step, the subject that changes in luminance so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range may be captured.

[1373]

In this way, a lot of information can be obtained from the subject without humans perceiving flicker. For instance as illustrated in FIG. 28, when a modulated signal "0" indicates no light emission and a modulated signal "1" indicates light emission and there is no bias in a transmission signal, each luminance average obtained by moving averaging is about 75% of the luminance at the time of light emission. This can prevent humans from perceiving flicker.

[1374]

For example, the pattern of the bright line may differ according to the exposure time of the image sensor, wherein in the information obtainment step, the data specified by the pattern corresponding to the set exposure time is demodulated.

[1375]

In this way, different information can be obtained from the subject according to the exposure time, for instance as illustrated in FIG. 34.

[1376]

For example, the information communication method may further include detecting a state of an imaging device including the image sensor, wherein in the information obtainment step, the information indicating a position of the subject is obtained, and a

position of the imaging device is calculated based on the obtained information and the detected state.

[1377]

In this way, the position of the imaging device can be accurately specified even in the case where GPS or the like is unavailable or more accurately specified than in the case where GPS or the like is used, for instance as illustrated in FIG. 11.

[1378]

For example, in the imaging step, the subject that includes a plurality of areas arranged along the exposure line and changes in luminance for each area may be captured.

[1379]

In this way, a lot of information can be obtained from the subject, for instance as illustrated in FIG. 258.

[1380]

For example, in the imaging step, the subject that emits a plurality of types of metameric light each at a different time may be captured.

[1381]

In this way, a lot of information can be obtained from the subject without humans perceiving flicker, for instance as illustrated in FIG. 272.

[1382]

For example, the information communication method may further include estimating a location where an imaging device including the image sensor is present, wherein in the information obtainment step, identification information of the subject is obtained as the information, and related information associated with the location and the identification information is obtained from a server.

[1383]

In this way, even in the case where the same identification information is transmitted from a plurality of lighting devices using a luminance change, appropriate related information can be obtained according to the location (building) in which the imaging device is present, i.e. the location (building) in which the lighting device is

present, for instance as illustrated in FIGS. 282 and 283.

[1384]

An information communication method according to an aspect of the present invention is an information communication method of transmitting a signal using a change in luminance, the information communication method including: a determination step of determining a pattern of the change in luminance by modulating the signal to be transmitted; a first transmission step of transmitting the signal by a light emitter changing in luminance according to the determined pattern; and a second transmission step of transmitting the same signal as the signal by the light emitter changing in luminance according to the same pattern as the determined pattern within 33 milliseconds from the transmission of the signal, wherein in the determination step, the pattern is determined so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range.

[1385]

In this way, the pattern of the change in luminance is determined so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range. As a result, the signal can be transmitted using the change in luminance without humans perceiving flicker. Moreover, for instance as illustrated in FIG. 301B, the same signal is transmitted within 33 milliseconds, ensuring that, even when the receiver receiving the signal has blanking, the signal is transmitted to the receiver.

[1386]

For example, in the determination step, the signal may be modulated by a scheme of modulating a signal expressed by 2 bits to a signal expressed by 4 bits made up of 3 bits each indicating a same value and 1 bit indicating a value other than the same value.

[1387]

In this way, for instance as illustrated in FIG. 28, when a modulated signal "0" indicates no light emission and a modulated

signal "1" indicates light emission and there is no bias in a transmission signal, each luminance average obtained by moving averaging is about 75% of the luminance at the time of light emission. This can more reliably prevent humans from perceiving flicker.

[1388]

For example, in the determination step, the pattern of the change in luminance may be determined by adjusting a time from one change to a next change in luminance according to the signal, the one change and the next change being the same one of a rise and a fall in luminance.

[1389]

In this way, the brightness of the light emitter (e.g. lighting device) perceived by humans can be adjusted by PWM control without changing the transmission signal, for instance as illustrated in FIG. 248.

[1390]

For example, in the first transmission step and the second transmission step, the light emitter may change in luminance so that a signal different according to an exposure time of an image sensor that captures the light emitter changing in luminance is obtained by an imaging device including the image sensor.

[1391]

In this way, different signals can be transmitted to the imaging device according to the exposure time, for instance as illustrated in FIG. 34.

[1392]

For example, in the first transmission step and the second transmission step, a plurality of light emitters may change in luminance synchronously to transmit common information, wherein after the transmission of the common information, each light emitter changes in luminance individually to transmit information different depending on the light emitter.

[1393]

In this way, for instance as illustrated in FIG. 41, when the plurality of light emitters simultaneously transmit the common

information, the plurality of light emitters can be regarded as one large light emitter. Such a light emitter is captured in a large size by the imaging device receiving the common information, so that information can be transmitted faster from a longer distance. Moreover, for instance as illustrated in FIG. 12A, by the plurality of light emitters transmitting the common information, it is possible to reduce the amount of individual information transmitted from each light emitter.

[1394]

For example, the information communication method may further include an instruction reception step of receiving an instruction of whether or not to modulate the signal, wherein the determination step, the first transmission step, and the second transmission step are performed in the case where an instruction to modulate the signal is received, and the light emitter emits light or stops emitting light without the determination step, the first transmission step, and the second transmission step being performed in the case where an instruction not to modulate the signal is received.

[1395]

In this way, whether or not to perform modulation is switched, with it being possible to reduce the noise effect on luminance changes of other light emitters, for instance as illustrated in FIG. 12A.

[1396]

For example, the light emitter may include a plurality of areas arranged along an exposure line of an image sensor that captures the light emitter, wherein in the first transmission step and the second transmission step, the light emitter changes in luminance for each area.

[1397]

In this way, a lot of information can be transmitted, for instance as illustrated in FIG. 258.

[1398]

For example, in the first transmission step and the second transmission step, the light emitter may change in luminance by

emitting a plurality of types of metameric light each at a different time.

[1399]

In this way, a lot of information can be transmitted without humans perceiving flicker, for instance as illustrated in FIG. 272.

[1400]

For example, in the first transmission step and the second transmission step, identification information of the light emitter may be transmitted as the signal or the same signal.

[1401]

In this way, the identification information of the light emitter is transmitted, for instance as illustrated in FIG. 282. The imaging device receiving the identification information can obtain more information associated with the identification information from a server or the like via a communication line such as the Internet.

[1402]

An information communication method according to an aspect of the present invention is an information communication method of transmitting a signal using a change in luminance, the information communication method including: a determination step of determining a plurality of frequencies by modulating the signal to be transmitted; a transmission step of transmitting the signal by a light emitter changing in luminance according to a constant frequency out of the determined plurality of frequencies; and a change step of changing the frequency used for the change in luminance to an other one of the determined plurality of frequencies in sequence, in a period greater than or equal to 33 milliseconds, wherein in the transmission step, the light emitter changes in luminance so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5 milliseconds is within a predetermined range.

[1403]

In this way, the pattern of the change in luminance is determined so that each average obtained by moving-averaging the changing luminance with a width greater than or equal to 5

milliseconds is within a predetermined range. As a result, the signal can be transmitted using the change in luminance without humans perceiving flicker. Moreover, a lot of FM modulated signals can be transmitted. For instance as illustrated in FIG. 14, appropriate information can be transmitted by changing the luminance change frequency (f1, f2, etc.) in a period greater than or equal to 33 milliseconds.

[1404]

[Embodiment 14]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as a blink pattern of an LED, an organic EL device, or the like in Embodiments 1 to 13 described above.

[1405]

FIG. 335 is a diagram illustrating an example of each mode of a receiver in this embodiment.

[1406]

In the normal imaging mode, a receiver 8000 performs imaging at a shutter speed of 1/100 second as an example to obtain a normal captured image, and displays the normal captured image on a display. For example, a subject such as a street lighting or a signage as a store sign and its surroundings are clearly shown in the normal captured image.

[1407]

In the visible light communication mode, the receiver 8000 performs imaging at a shutter speed of 1/10000 second as an example, to obtain a visible light communication image. For example, in the case where the above-mentioned street lighting or signage is transmitting a signal by a luminance change as the transmitter described in any of Embodiments 1 to 13, one or more bright lines (hereafter referred to as "bright line pattern") are shown in the signal transmission part of the visible light communication image, while nothing is shown in the other part. That is, in the visible light communication image, only the bright line pattern is shown and the part of the subject not changing in luminance and the

surroundings of the subject are not shown.

[1408]

In the intermediate mode, the receiver 8000 performs imaging at a shutter speed of 1/3000 second as an example, to obtain an intermediate image. In the intermediate image, the bright line pattern is shown, and the part of the subject not changing in luminance and the surroundings of the subject are shown, too. By the receiver 8000 displaying the intermediate image on the display, the user can find out from where or from which position the signal is being transmitted. Note that the bright line pattern, the subject, and its surroundings shown in the intermediate image are not as clear as the bright line pattern in the visible light communication image and the subject and its surroundings in the normal captured image respectively, but have the level of clarity recognizable by the user.

[1409]

In the following description, the normal imaging mode or imaging in the normal imaging mode is referred to as "normal imaging", and the visible light communication mode or imaging in the visible light communication mode is referred to as "visible light imaging" (visible light communication). Imaging in the intermediate mode may be used instead of normal imaging and visible light imaging, and the intermediate image may be used instead of the below-mentioned synthetic image.

[1410]

FIG. 336 is a diagram illustrating an example of imaging operation of a receiver in this embodiment.

[1411]

The receiver 8000 switches the imaging mode in such a manner as normal imaging, visible light communication, normal imaging, …. The receiver 8000 synthesizes the normal captured image and the visible light communication image to generate a synthetic image in which the bright line pattern, the subject, and its surroundings are clearly shown, and displays the synthetic image on the display. The synthetic image is an image generated by

superimposing the bright line pattern of the visible light communication image on the signal transmission part of the normal captured image. The bright line pattern, the subject, and its surroundings shown in the synthetic image are clear, and have the level of clarity sufficiently recognizable by the user. Displaying such a synthetic image enables the user to more distinctly find out from which position the signal is being transmitted.

[1412]

FIG. 337 is a diagram illustrating another example of imaging operation of a receiver in this embodiment.

[1413]

The receiver 8000 includes a camera Ca1 and a camera Ca2. In the receiver 8000, the camera Ca1 performs normal imaging, and the camera Ca2 performs visible light imaging. Thus, the camera Ca1 obtains the above-mentioned normal captured image, and the camera Ca2 obtains the above-mentioned visible light communication image. The receiver 8000 synthesizes the normal captured image and the visible light communication image to generate the above-mentioned synthetic image, and displays the synthetic image on the display.

[1414]

FIG. 338A is a diagram illustrating another example of imaging operation of a receiver in this embodiment.

[1415]

In the receiver 8000 including two cameras, the camera Ca1 switches the imaging mode in such a manner as normal imaging, visible light communication, normal imaging, …. Meanwhile, the camera Ca2 continuously performs normal imaging. When normal imaging is being performed by the cameras Ca1 and Ca2 simultaneously, the receiver 8000 estimates the distance (hereafter referred to as "subject distance") from the receiver 8000 to the subject based on the normal captured images obtained by these cameras, through the use of stereoscopy (triangulation principle). By using such estimated subject distance, the receiver 8000 can superimpose the bright line pattern of the visible light

communication image on the normal captured image at the appropriate position. The appropriate synthetic image can be generated in this way.

[1416]

FIG. 338B is a diagram illustrating another example of imaging operation of a receiver in this embodiment.

[1417]

The receiver 8000 includes three cameras (cameras Ca1, Ca2, and Ca3) as an example. In the receiver 8000, two cameras (cameras Ca2 and Ca3) continuously perform normal imaging, and the remaining camera (camera Ca1) continuously performs visible light communication. Hence, the subject distance can be estimated at any timing, based on the normal captured images obtained by two cameras engaged in normal imaging.

[1418]

FIG. 338C is a diagram illustrating another example of imaging operation of a receiver in this embodiment.

[1419]

The receiver 8000 includes three cameras (cameras Ca1, Ca2, and Ca3) as an example. In the receiver 8000, each camera switches the imaging mode in such a manner as normal imaging, visible light communication, normal imaging, …. The imaging mode of each camera is switched per period so that, in one period, two cameras perform normal imaging and the remaining camera performs visible light communication. That is, the combination of cameras engaged in normal imaging is changed periodically. Hence, the subject distance can be estimated in any period, based on the normal captured images obtained by two cameras engaged in normal imaging.

[1420]

FIG. 339A is a diagram illustrating an example of camera arrangement of a receiver in this embodiment.

[1421]

In the case where the receiver 8000 includes two cameras Ca1 and Ca2, the two cameras Ca1 and Ca2 are positioned away from

each other as illustrated in FIG. 339A. The subject distance can be accurately estimated in this way. In other words, the subject distance can be estimated more accurately when the distance between two cameras is longer.

[1422]

FIG. 339B is a diagram illustrating another example of camera arrangement of a receiver in this embodiment.

[1423]

In the case where the receiver 8000 includes three cameras Ca1, Ca2, and Ca3, the two cameras Ca1 and Ca2 for normal imaging are positioned away from each other as illustrated in FIG. 339B, and the camera Ca3 for visible light communication is, for example, positioned between the cameras Ca1 and Ca2. The subject distance can be accurately estimated in this way. In other words, the subject distance can be accurately estimated by using two farthest cameras for normal imaging.

[1424]

FIG. 340 is a diagram illustrating an example of display operation of a receiver in this embodiment.

[1425]

The receiver 8000 switches the imaging mode in such a manner as visible light communication, normal imaging, visible light communication, …, as mentioned above. Upon performing visible light communication first, the receiver 8000 starts an application program. The receiver 8000 then estimates its position based on the signal received by visible light communication, as described in Embodiments 1 to 13. Next, when performing normal imaging, the receiver 8000 displays AR (Augmented Reality) information on the normal captured image obtained by normal imaging. The AR information is obtained based on, for example, the position estimated as mentioned above. The receiver 8000 also estimates the change in movement and direction of the receiver 8000 based on the detection result of the 9-axis sensor, the motion detection in the normal captured image, and the like, and moves the display position of the AR information according to the estimated change in

movement and direction. This enables the AR information to follow the subject image in the normal captured image.

[1426]

When switching the imaging mode from normal imaging to visible light communication, in visible light communication the receiver 8000 superimposes the AR information on the latest normal captured image obtained in immediately previous normal imaging. The receiver 8000 then displays the normal captured image on which the AR information is superimposed. The receiver 8000 also estimates the change in movement and direction of the receiver 8000 based on the detection result of the 9-axis sensor, and moves the AR information and the normal captured image according to the estimated change in movement and direction, in the same way as in normal imaging. This enables the AR information to follow the subject image in the normal captured image according to the movement of the receiver 8000 and the like in visible light communication, as in normal imaging. Moreover, the normal image can be enlarged or reduced according to the movement of the receiver 8000 and the like.

[1427]

FIG. 341 is a diagram illustrating an example of display operation of a receiver in this embodiment.

[1428]

For example, the receiver 8000 may display the synthetic image in which the bright line pattern is shown, as illustrated in (a) in FIG. 341. As an alternative, the receiver 8000 may superimpose, instead of the bright line pattern, a signal specification object which is an image having a predetermined color for notifying signal transmission on the normal captured image to generate the synthetic image, and display the synthetic image, as illustrated in (b) in FIG. 341.

[1429]

As another alternative, the receiver 8000 may display, as the synthetic image, the normal captured image in which the signal transmission part is indicated by a dotted frame and an identifier (e.g.

ID: 101, ID: 102, etc.), as illustrated in (c) in FIG. 341. As another alternative, the receiver 8000 may superimpose, instead of the bright line pattern, a signal identification object which is an image having a predetermined color for notifying transmission of a specific type of signal on the normal captured image to generate the synthetic image, and display the synthetic image, as illustrated in (d) in FIG. 341. In this case, the color of the signal identification object differs depending on the type of signal output from the transmitter. For example, a red signal identification object is superimposed in the case where the signal output from the transmitter is position information, and a green signal identification object is superimposed in the case where the signal output from the transmitter is a coupon.

[1430]

FIG. 342 is a diagram illustrating an example of operation of a receiver in this embodiment.

[1431]

For example, in the case of receiving the signal by visible light communication, the receiver 8000 may output a sound for notifying the user that the transmitter has been discovered, while displaying the normal captured image. In this case, the receiver 8000 may change the type of output sound, the number of outputs, or the output time depending on the number of discovered transmitters, the type of received signal, the type of information specified by the signal, or the like.

[1432]

FIG. 343 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1433]

For example, when the user touches the bright line pattern shown in the synthetic image, the receiver 8000 generates an information notification image based on the signal transmitted from the subject corresponding to the touched bright line pattern, and displays the information notification image. The information notification image indicates, for example, a coupon or a location of a store. The bright line pattern may be the signal specification object,

the signal identification object, or the dotted frame illustrated in FIG. 341. The same applies to the below-mentioned bright line pattern.

[1434]

FIG. 344 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1435]

For example, when the user touches the bright line pattern shown in the synthetic image, the receiver 8000 generates an information notification image based on the signal transmitted from the subject corresponding to the touched bright line pattern, and displays the information notification image. The information notification image indicates, for example, the current position of the receiver 8000 by a map or the like.

[1436]

FIG. 345 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1437]

For example, the receiver 8000 receives signals from two street lightings which are subjects as transmitters. The receiver 8000 estimates the current position of the receiver 8000 based on these signals, as in Embodiments 1 to 13. The receiver 8000 then displays the normal captured image, and also superimposes an information notification image (an image showing latitude, longitude, and the like) indicating the estimation result on the normal captured image. The receiver 8000 may also display an auxiliary information notification image on the normal captured image. For instance, the auxiliary information notification image prompts the user to perform an operation for calibrating the 9-axis sensor (particularly the geomagnetic sensor), i.e. an operation for drift cancellation. As a result of such an operation, the current position can be estimated with high accuracy.

[1438]

When the user touches the displayed information notification image, the receiver 8000 may display the map showing the estimated position, instead of the normal captured image.

[1439]

FIG. 346 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1440]

For example, when the user swipes on the receiver 8000 on which the synthetic image is displayed, the receiver 8000 displays the normal captured image including the dotted frame and the identifier like the normal captured image illustrated in (c) in FIG. 341, and also displays a list of information to follow the swipe operation. The list includes information specified by the signal transmitted from the part (transmitter) identified by each identifier. The swipe may be, for example, an operation of moving the user's finger from outside the display of the receiver 8000 on the right side into the display. The swipe may be an operation of moving the user's finger from the top, bottom, or left side of the display into the display.

[1441]

When the user taps information included in the list, the receiver 8000 may display an information notification image (e.g. an image showing a coupon) indicating the information in more detail.

[1442]

FIG. 347 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1443]

For example, when the user swipes on the receiver 8000 on which the synthetic image is displayed, the receiver 8000 superimposes an information notification image on the synthetic image, to follow the swipe operation. The information notification image indicates the subject distance with an arrow so as to be easily recognizable by the user. The swipe may be, for example, an operation of moving the user's finger from outside the display of the receiver 8000 on the bottom side into the display. The swipe may be an operation of moving the user's finger from the left, top, or right side of the display into the display.

[1444]

FIG. 348 is a diagram illustrating another example of

operation of a receiver in this embodiment.

[1445]

For example, the receiver 8000 captures, as a subject, a transmitter which is a signage showing a plurality of stores, and displays the normal captured image obtained as a result. When the user taps a signage image of one store included in the subject shown in the normal captured image, the receiver 8000 generates an information notification image based on the signal transmitted from the signage of the store, and displays an information notification image 8001. The information notification image 8001 is, for example, an image showing the availability of the store and the like.

[1446]

FIG. 349 is a diagram illustrating an example of operation of a receiver, a transmitter, and a server in this embodiment.

[1447]

A transmitter 8012 as a television transmits a signal to a receiver 8011 by a luminance change. The signal includes information prompting the user to buy content relating to a program being viewed. Having received the signal by visible light communication, the receiver 8011 displays an information notification image prompting the user to buy content, based on the signal. When the user performs an operation for buying the content, the receiver 8011 transmits at least one of information included in a SIM (Subscriber Identity Module) card inserted in the receiver 8011, a user ID, a terminal ID, credit card information, charging information, a password, and a transmitter ID, to a server 8013. The server 8013 manages a user ID and payment information in association with each other, for each user. The server 8013 specifies a user ID based on the information transmitted from the receiver 8011, and checks payment information associated with the user ID. By this check, the server 8013 determines whether or not to permit the user to buy the content. In the case of determining to permit the user to buy the content, the server 8013 transmits permission information to the receiver 8011. Having received the permission information, the receiver 8011 transmits the permission

information to the transmitter 8012. Having received the permission information, the transmitter 8012 obtains the content via a network as an example, and reproduces the content.

[1448]

The transmitter 8012 may transmit information including the ID of the transmitter 8012 to the receiver 8011, by a luminance change. In this case, the receiver 8011 transmits the information to the server 8013. Having obtained the information, the server 8013 can determine that, for example, the television program is being viewed on the transmitter 8012, and conduct television program rating research.

[1449]

The receiver 8011 may include information of an operation (e.g. voting) performed by the user in the above-mentioned information and transmit the information to the server 8013, to allow the server 8013 to reflect the information on the television program. An audience participation program can be realized in this way. Besides, in the case of receiving a post from the user, the receiver 8011 may include the post in the above-mentioned information and transmit the information to the server 8013, to allow the server 8013 to reflect the post on the television program, a network message board, or the like.

[1450]

Furthermore, by the transmitter 8012 transmitting the above-mentioned information, the server 8013 can charge for television program viewing by paid broadcasting or on-demand TV. The server 8013 can also cause the receiver 8011 to display an advertisement, or the transmitter 8012 to display detailed information of the displayed television program or an URL of a site showing the detailed information. The server 8013 may also obtain the number of times the advertisement is displayed on the receiver 8011, the price of a product bought from the advertisement, or the like, and charge the advertiser according to the number of times or the price. Such price-based charging is possible even in the case where the user seeing the advertisement does not buy the product

immediately. When the server 8013 obtains information indicating the manufacturer of the transmitter 8012 from the transmitter 8012 via the receiver 8011, the server 8013 may provide a service (e.g. payment for selling the product) to the manufacturer indicated by the information.

[1451]

FIG. 350 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1452]

For example, the user points a camera of a receiver 8021 at a plurality of transmitters 8020a to 8020d as lightings. Here, the receiver 8021 is moved so that the transmitters 8020a to 8020d are sequentially captured as a subject. By performing visible light communication during the movement, the receiver 8021 receives a signal from each of the transmitters 8020a to 8020d. The signal includes information indicating the position of the transmitter. The receiver 8021 estimates the position of the receiver 8021 using the triangulation principle, based on the positions indicated by the signals received from the transmitters 8020a to 8020d, the detection result of the 9-axis sensor included in the receiver 8021, and the movement of the captured image. In this case, the drift of the 9-axis sensor (particularly the geomagnetic sensor) is canceled by moving the receiver 8021, so that the position can be estimated with higher accuracy.

[1453]

FIG. 351 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1454]

For example, a receiver 8030 is a head-mounted display including a camera. When a start button is pressed, the receiver 8030 starts imaging in the visible light communication mode, i.e. visible light communication. In the case of receiving a signal by visible light communication, the receiver 8030 notifies the user of information corresponding to the received signal. The notification is made, for example, by outputting a sound from a speaker included in

the receiver 8030, or by displaying an image. Visible light communication may be started not only when the start button is pressed, but also when the receiver 8030 receives a sound instructing the start or when the receiver 8030 receives a signal instructing the start by wireless communication. Visible light communication may also be started when the change width of the value obtained by a 9-axis sensor included in the receiver 8030 exceeds a predetermined range or when a bright line pattern, even if only slightly, appears in the normal captured image.

[1455]

FIG. 352 is a diagram illustrating an example of initial setting of a receiver in this embodiment.

[1456]

The receiver 8030 displays an alignment image 8031 upon initial setting. The alignment image 8031 is used to align the position pointed by the user in the image captured by the camera of the receiver 8030 and the image displayed on the receiver 8030. When the user places his or her fingertip at the position of a circle shown in the alignment image 8031, the receiver associates the position of the fingertip and the position of the circle, and performs alignment. That is, the position pointed by the user is calibrated.

[1457]

FIG. 353 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1458]

The receiver 8030 specifies a signal transmission part by visible light communication, and displays a synthetic image 8034 in which a bright line pattern is shown in the part. The user performs an operation such as a tap or a double tap, on the bright line pattern. The receiver 8030 receives the operation, specifies the bright line pattern subjected to the operation, and displays an information notification image 8032 based on a signal transmitted from the part corresponding to the bright line pattern.

[1459]

FIG. 354 is a diagram illustrating another example of

operation of a receiver in this embodiment.

[1460]

The receiver 8030 displays the synthetic image 8034 in the same way as above. The user performs an operation of moving his or her fingertip so as to encircle the bright line pattern in the synthetic image 8034. The receiver 8030 receives the operation, specifies the bright line pattern subjected to the operation, and displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1461]

FIG. 355 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1462]

The receiver 8030 displays the synthetic image 8034 in the same way as above. The user performs an operation of placing his or her fingertip at the bright line pattern in the synthetic image 8034 for a predetermined time or more. The receiver 8030 receives the operation, specifies the bright line pattern subjected to the operation, and displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1463]

FIG. 356 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1464]

The receiver 8030 displays the synthetic image 8034 in the same way as above. The user performs an operation of moving his or her fingertip toward the bright line pattern in the synthetic image 8034 by a swipe. The receiver 8030 receives the operation, specifies the bright line pattern subjected to the operation, and displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1465]

FIG. 357 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1466]

The receiver 8030 displays the synthetic image 8034 in the same way as above. The user performs an operation of continuously directing his or her gaze to the bright line pattern in the synthetic image 8034 for a predetermined time or more. Alternatively, the user performs an operation of blinking a predetermined number of times while directing his or her gaze to the bright line pattern. The receiver 8030 receives the operation, specifies the bright line pattern subjected to the operation, and displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1467]

FIG. 358 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1468]

The receiver 8030 displays the synthetic image 8034 in the same way as above, and also displays an arrow associated with each bright line pattern in the synthetic image 8034. The arrow of each bright line pattern differs in direction. The user performs an operation of moving his or her head along one of the arrows. The receiver 8030 receives the operation based on the detection result of the 9-axis sensor, and specifies the bright line pattern associated with the arrow corresponding to the operation, i.e. the arrow in the direction in which the head is moved. The receiver 8030 displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1469]

FIG. 359A is a diagram illustrating a pen used to operate a receiver in this embodiment.

[1470]

A pen 8033 includes a transmitter 8033a for transmitting a signal by a luminance change, and buttons 8033b and 8033c. When the button 8033b is pressed, the transmitter 8033a transmits a predetermined first signal. When the button 8033c is pressed, the transmitter 8033a transmits a predetermined second signal different

from the first signal.

[1471]

FIG. 359B is a diagram illustrating operation of a receiver using a pen in this embodiment.

[1472]

The pen 8033 is used instead of the user's finger mentioned above, like a stylus pen. By selective use of the buttons 8033b and 8033c, the pen 8033 can be used like a normal pen or an eraser.

[1473]

FIG. 360 is a diagram illustrating an example of appearance of a receiver in this embodiment.

[1474]

The receiver 8030 includes a first touch sensor 8030a and a second touch sensor 8030b. These touch sensors are attached to the frame of the receiver 8030. For example, when the user places his or her fingertip on the first touch sensor 8030a and moves the fingertip, the receiver 8030 moves the pointer in the image displayed to the user, according to the movement of the fingertip. When the user touches the second touch sensor 8030b, the receiver 8030 selects the object pointed by the pointer in the image displayed to the user.

[1475]

FIG. 361 is a diagram illustrating another example of appearance of a receiver in this embodiment.

[1476]

The receiver 8030 includes a touch sensor 8030c. The touch sensor 8030c is attached to the frame of the receiver 8030. For example, when the user places his or her fingertip on the touch sensor 8030c and moves the fingertip, the receiver 8030 moves the pointer in the image displayed to the user, according to the movement of the fingertip. When the user presses the touch sensor 8030c, the receiver 8030 selects the object pointed by the pointer in the image displayed to the user. The touch sensor 8030c is thus realized as a clickable touch sensor.

[1477]

FIG. 362 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1478]

The receiver 8030 displays the synthetic image 8034 in the same way as above, and also displays a pointer 8035 in the synthetic image 8034. In the case where the receiver 8030 includes the first touch sensor 8030a and the second touch sensor 8030b, the user places his or her fingertip on the first touch sensor 8030a and moves the fingertip, to move the pointer to the object as the bright line pattern. The user then touches the second touch sensor 8030b, to cause the receiver 8030 to select the bright line pattern. Having selected the bright line pattern, the receiver 8030 displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1479]

In the case where the receiver 8030 includes the touch sensor 8030c, the user places his or her fingertip on the touch sensor 8030c and moves the fingertip, to move the pointer to the object as the bright line pattern. The user then presses the touch sensor 8030c, to cause the receiver 8030 to select the bright line pattern. Having selected the bright line pattern, the receiver 8030 displays the information notification image 8032 based on the signal transmitted from the part corresponding to the bright line pattern.

[1480]

FIG. 363A is a diagram illustrating another example of operation of a receiver in this embodiment.

[1481]

The receiver 8030 displays a gesture confirmation image 8036 based on a signal obtained by visible light communication. The gesture confirmation image 8036 prompts the user to make a predetermined gesture, to provide a service to the user as an example.

[1482]

FIG. 363B is a diagram illustrating an example of application using a receiver in this embodiment.

[1483]

A user 8038 carrying the receiver 8030 is in a shop or the like. Here, the receiver 8030 displays the above-mentioned gesture confirmation image 8036 to the user 8038. The user 8038 makes the predetermined gesture according to the gesture confirmation image 8036. A staff 8039 in the shop carries a receiver 8037. The receiver 8037 is a head-mounted display including a camera, and may have the same structure as the receiver 8030. The receiver 8037 displays the gesture confirmation image 8036 based on a signal obtained by visible light communication, too. The staff 8039 determines whether or not the predetermined gesture indicated by the displayed gesture confirmation image 8036 and the gesture made by the user 8038 match. In the case of determining that the predetermined gesture and the gesture made by the user 8038 match, the staff 8039 provides the service associated with the gesture confirmation image 8036, to the user 8038.

[1484]

FIG. 364A is a diagram illustrating another example of operation of a receiver in this embodiment.

[1485]

The receiver 8030 displays a gesture confirmation image 8040 based on a signal obtained by visible light communication. The gesture confirmation image 8040 prompts the user to make a predetermined gesture, to permit wireless communication as an example.

[1486]

FIG. 364B is a diagram illustrating an example of application using a receiver in this embodiment.

[1487]

The user 8038 carries the receiver 8030. Here, the receiver 8030 displays the above-mentioned gesture confirmation image 8040 to the user 8038. The user 8038 makes the predetermined gesture according to the gesture confirmation image 8040. A person around the user 8038 carries the receiver 8037. The receiver 8037 is a head-mounted display including a camera, and

may have the same structure as the receiver 8030. The receiver 8037 captures the predetermined gesture made by the user 8038, to obtain authentication information such as a password included in the gesture. In the case where the receiver 8037 determines that the authentication information matches predetermined information, the receiver 8037 establishes wireless connection with the receiver 8030. Subsequently, the receivers 8030 and 8037 can wirelessly communicate with each other.

[1488]

FIG. 365A is a diagram illustrating an example of operation of a transmitter in this embodiment.

[1489]

The transmitter alternately transmits signals 1 and 2, for example in a predetermined period. The transmission of the signal 1 and the transmission of the signal 2 are each carried out by a luminance change such as blinking of visible light. A luminance change pattern for transmitting the signal 1 and a luminance change pattern for transmitting the signal 2 are different from each other.

[1490]

FIG. 365B is a diagram illustrating another example of operation of a transmitter in this embodiment.

[1491]

The transmitter may transmit the signals 1 and 2 intermittently with a buffer time, instead of continuously transmitting the signals 1 and 2 as mentioned above. In the buffer time, the transmitter does not change in luminance. Alternatively, in the buffer time, the transmitter may transmit a signal indicating that the transmitter is in the buffer time by a luminance change, or perform a luminance change different from the luminance change for transmitting the signal 1 or the luminance change for transmitting the signal 2. This enables the receiver to appropriately receive the signals 1 and 2 without interference.

[1492]

FIG. 366 is a diagram illustrating another example of operation of a transmitter in this embodiment.

[1493]

The transmitter repeatedly transmits a signal sequence made up of a preamble, a block 1, a block 2, a block 3, and a check signal, by a luminance change. The block 1 includes a preamble, an address 1, data 1, and a check signal. The blocks 2 and 3 each have the same structure as the block 1. Specific information is obtained by using data included in the blocks 1, 2, and 3.

[1494]

In detail, in the above-mentioned signal sequence, one set of data or information is stored in a state of being divided into three blocks. Accordingly, even when a receiver that needs a blanking time for imaging as described in Embodiments 1 to 13 cannot receive all data of the blocks 1, 2, and 3 from one signal sequence, the receiver can receive the remaining data from another signal sequence. As a result, even a receiver that needs a blanking time can appropriately obtain the specific information from at least one signal sequence.

[1495]

In the above-mentioned signal sequence, a preamble and a check signal are provided for a set of three blocks. Hence, a receiver capable of receiving light without needing a blanking time, such as a receiver including an illuminance sensor, can receive one signal sequence at one time through the use of the preamble and the check signal provided for the set, thus obtaining the specific information in a short time.

[1496]

FIG. 367 is a diagram illustrating another example of operation of a transmitter in this embodiment.

[1497]

When repeatedly transmitting the signal sequence including the blocks 1, 2, and 3 as described above, the transmitter may change, for each signal sequence, the order of the blocks included in the signal sequence. For example, the blocks 1, 2, and 3 are included in this order in the first signal sequence, and the blocks 3, 1, and 2 are included in this order in the next signal sequence. A

receiver that requires a periodic blanking time can therefore avoid obtaining only the same block.

[1498]

FIG. 368 is a diagram illustrating an example of communication form between a plurality of transmitters and a receiver in this embodiment.

[1499]

A receiver 8050 may receive signals (visible light) transmitted from transmitters 8051a and 8051b as lightings and reflected by a reflection surface. The receiver 8050 can thus receive signals from many transmitters all together. In this case, the transmitters 8051a and 8051b transmit signals of different frequencies or protocols. As a result, the receiver 8050 can receive the signals from the transmitters without interference.

[1500]

FIG. 369 is a diagram illustrating an example of operation of a plurality of transmitters in this embodiment.

[1501]

One of the transmitters 8051a and 8051b may monitor the signal transmission state of the other transmitter, and transmit a signal to avoid interference with a signal of the other transmitter. For instance, one transmitter receives a signal transmitted from the other transmitter, and transmits a signal of a protocol different from the received signal. Alternatively, one transmitter detects a time period during which no signal is transmitted from the other transmitter, and transmits a signal during the time period.

[1502]

FIG. 370 is a diagram illustrating another example of communication form between a plurality of transmitters and a receiver in this embodiment.

[1503]

The transmitters 8051a and 8051b may transmit signals of the same frequency or protocol. In this case, the receiver 8050 specifies the strength of the signal transmitted from each of the transmitters, i.e. the edge strength of the bright line included in the

captured image. The strength is lower when the distance between the receiver 8050 and the transmitter is longer. In the case where the distance between the receiver 8050 and the transmitter 8051a and the distance between the receiver 8050 and the transmitter 8051b are different from each other, the difference in distance can be exploited in this way. Thus, the receiver 8050 can separately receive the signals transmitted from the transmitters 8051a and 8051b appropriately, according to the specified strengths.

[1504]

FIG. 371 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1505]

The receiver 8050 receives a signal transmitted from the transmitter 8051a and reflected by a reflection surface. Here, the receiver 8050 may estimate the position of the transmitter 8051a, based on the strength distribution of luminance (the difference in luminance between a plurality of positions) in the captured image.

[1506]

FIG. 372 is a diagram illustrating an example of application of a receiver in this embodiment.

[1507]

A receiver 7510a such as a smartphone captures a light source 7510b by a back camera (out camera) 7510c to receive a signal transmitted from the light source 7510b, and obtains the position and direction of the light source 7510b from the received signal. The receiver 7510a estimates the position and direction of the receiver 7510a, from the state of the light source 7510b in the captured image and the sensor value of the 9-axis sensor included in the receiver 7510a. The receiver 7510a captures a user 7510e by a front camera (face camera, in camera) 7510f, and estimates the position and direction of the head and the gaze direction (the position and direction of the eye) of the user 7510e by image processing. The receiver 7510a changes the behavior (display content or playback sound) according to the gaze direction of the user 7510e. the imaging by the back camera 7510c and the imaging by the front

camera 7510f may be performed simultaneously or alternately.

[1508]

FIG. 373 is a diagram illustrating an example of application of a receiver in this embodiment.

[1509]

Receivers 7511d and 7511i such as smartphones respectively receive signals from light sources 7511b and 7511g, estimate the positions and directions of the receivers 7511d and 7511i, and estimate the gaze directions of users 7511e and 7511i, as in the above-mentioned way. The receivers 7511d and 7511i respectively obtain information of surrounding objects 7511a to 7511c and 7511f to 7511h from a server, based on the received data. The receivers 7511d and 7511i change their display contents as if the users can see the objects on the opposite side through the receivers 7511d and 7511i. The receivers 7511d and 7511i display an AR (Augmented Reality) object such as 7511k, according to the display contents. When the gaze of the user 7511j exceeds the imaging range of the camera, the receiver 7511i displays that the range is exceeded, as in 7511l. As an alternative, the receiver 7511i displays an AR object or other information in the area outside the range. As another alternative, the receiver 7511i displays a previously captured image in the area outside the range in a state of being connected to the current image.

[1510]

FIG. 374 is a diagram illustrating an example of application of a receiver in this embodiment.

[1511]

A receiver 7512c such as a smartphone receives a signal from a light source 7512a, estimates the position and direction of the receiver 7512c, and estimates the gaze direction of a user 7512d, as in the above-mentioned way. The receiver 7512c performs a process relating to an object 7512b in the gaze direction of the user 7512d. For example, the receiver 7512c displays information about the object 7512b on the screen. When the gaze direction of a user 7512h moves from an object 7512f to a receiver 7512g, the receiver

7512g determines that the user 7512h is interested in the object 7512h, and continues the process relating to the object 7512h. For example, the receiver 7512g keeps displaying the information of the object 7512f on the screen.

[1512]

FIG. 375 is a diagram illustrating an example of application of a transmitter in this embodiment.

[1513]

A transmitter 7513a such as a lighting is high in luminance. Regardless of whether the luminance is high or low as a transmission signal, the transmitter 7513a captured by a receiver exceeds an upper limit of brightness, and as a result no bright line appears as in 7513b. Accordingly, a transmitter 7513c includes a part 7513d such as a diffusion plate or a prism for diffusing or weakening light, to reduce the luminance. As a result, the receiver can capture bright lines as in 7513e.

[1514]

FIG. 376 is a diagram illustrating an example of application of a transmitter in this embodiment.

[1515]

A transmitter 7514a such as a lighting does not have a uniform light source, and so the luminance is not uniform in a captured image 7514b, causing a reception error. Accordingly, a transmitter 7514c includes a part 7514d such as a diffusion plate or a prism for diffusing light, to attain uniform luminance as in 7514c. A reception error can be prevented in this way.

[1516]

FIG. 377 is a diagram illustrating an example of application of a reception method in this embodiment.

[1517]

Transmitters 7515a and 7515b are each high in luminance in the center part, so that bright lines appear not in the center part but in the peripheral part in an image captured by a receiver. Since the bright lines are discontinuous, the receiver cannot receive a signal from a part 7515d, but can receive a signal from a part 7515c. By

reading bright lines along a path 7515e, the receiver can receive a signal from more bright lines than in the part 7515c.

[1518]

FIG. 378 is a diagram illustrating an example of application of a transmitter in this embodiment.

[1519]

Transmitters 7516a, 7516b, 7516c, and 7516d such as lightings are high in luminance like 7513a, and bright lines tend not to appear when captured by a receiver. Accordingly, a diffusion plate / prism 7516e, a reflection plate 7516f, a reflection plate / half mirror 7516g, a reflection plate 7516h, or a diffusion plate / prism 7516j is included to diffuse light, with it being possible to widen the part where bright lines appear. These transmitters are each captured with bright lines appearing in the periphery, like 7515a. Since the receiver estimates the distance between the receiver and the transmitter using the size of the transmitter in the captured image, the part where light is diffused is set as the size of the light source and stored in a server or the like in association with the transmission ID, as a result of which the receiver can accurately estimate the distance to the transmitter.

[1520]

FIG. 379 is a diagram illustrating an example of application of a transmitter in this embodiment.

[1521]

A transmitter 7517a such as a lighting is high in luminance like 7513a, and bright lines tend not to appear when captured by a receiver. Accordingly, a reflection plate 7517b is included to diffuse light, with it being possible to widen the part where bright lines appear.

[1522]

FIG. 380 is a diagram illustrating an example of application of a transmitter in this embodiment.

[1523]

A transmitter 7518a reflects light from a light source by a reflection plate 7518c, as a result of which a receiver can capture

bright lines in a wide range. A transmitter 7518d directs a light source toward a diffusion plate or prism 7518e, as a result of which a receiver can capture bright lines in a wide range.

[1524]

FIG. 381 is a diagram illustrating another example of operation of a receiver in this embodiment.

[1525]

A receiver displays a bright line pattern using the above-mentioned synthetic image, intermediate image, or the like. Here, the receiver may be incapable of receiving a signal from a transmitter corresponding to the bright line pattern. When the user performs an operation (e.g. a tap) on the bright line pattern to select the bright line pattern, the receiver displays the synthetic image or intermediate image in which the bright line pattern is enlarged by optical zoom. Through such optical zoom, the receiver can appropriately receive the signal from the transmitter corresponding to the bright line pattern. That is, even when the captured image is too small to obtain the signal, the signal can be appropriately received by performing optical zoom. In the case where the displayed image is large enough to obtain the signal, too, faster reception is possible by optical zoom.

[1526]

(Summary of this embodiment)

An information communication method in this embodiment is an information communication method of obtaining information from a subject, the information communication method including: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image by capturing the subject that changes in luminance by the image sensor with the set exposure time, the bright line image being an image including the bright line; displaying, based on the bright line image, a display image in which the subject and surroundings of the subject are shown, in a form that enables

identification of a spatial position of a part where the bright line appears; and obtaining transmission information by demodulating data specified by a pattern of the bright line included in the obtained bright line image.

[1527]

In this way, a synthetic image or an intermediate image illustrated in, for instance, FIGS. 335 to 337 and 341 is displayed as the display image. In the display image in which the subject and the surroundings of the subject are shown, the spatial position of the part where the bright line appears is identified by a bright line pattern, a signal specification object, a signal identification object, a dotted frame, or the like. By looking at such a display image, the user can easily find the subject that is transmitting the signal through the change in luminance.

[1528]

For example, the information communication method may further include: setting a longer exposure time than the exposure time; obtaining a normal captured image by capturing the subject and the surroundings of the subject by the image sensor with the longer exposure time; and generating a synthetic image by specifying, based on the bright line image, the part where the bright line appears in the normal captured image, and superimposing a signal object on the normal captured image, the signal object being an image indicating the part, wherein in the displaying, the synthetic image is displayed as the display image.

[1529]

In this way, the signal object is, for example, a bright line pattern, a signal specification object, a signal identification object, a dotted frame, or the like, and the synthetic image is displayed as the display image as illustrated in FIGS. 336, 337, and 341. Hence, the user can more easily find the subject that is transmitting the signal through the change in luminance.

[1530]

For example, in the setting of an exposure time, the exposure time may be set to 1/3000 second, in the obtaining of a bright line

image, the bright line image in which the surroundings of the subject are shown may be obtained, and in the displaying, the bright line image may be displayed as the display image.

[1531]

In this way, the bright line image is obtained and displayed as an intermediate image, for instance as illustrated in FIG. 335. This eliminates the need for a process of obtaining a normal captured image and a visible light communication image and synthesizing them, thus contributing to a simpler process.

[1532]

For example, the image sensor may include a first image sensor and a second image sensor, in the obtaining of the normal captured image, the normal captured image may be obtained by image capture by the first image sensor, and in the obtaining of a bright line image, the bright line image may be obtained by image capture by the second image sensor simultaneously with the first image sensor.

[1533]

In this way, the normal captured image and the visible light communication image which is the bright line image are obtained by the respective cameras, for instance as illustrated in FIG. 337. As compared with the case of obtaining the normal captured image and the visible light communication image by one camera, the images can be obtained promptly, contributing to a faster process.

[1534]

For example, the information communication method may further include presenting, in the case where the part where the bright line appears is designated in the display image by an operation by a user, presentation information based on the transmission information obtained from the pattern of the bright line in the designated part. Examples of the operation by the user include: a tap; a swipe; an operation of continuously placing the user's fingertip on the part for a predetermined time or more; an operation of continuously directing the user's gaze to the part for a predetermined time or more; an operation of moving a part of the

user’s body according to an arrow displayed in association with the part; an operation of placing a pen tip that changes in luminance on the part; and an operation of pointing to the part with a pointer displayed in the display image by touching a touch sensor.

[1535]

In this way, the presentation information is displayed as an information notification image, for instance as illustrated in FIGS. 343 to 348 and 353 to 362. Desired information can thus be presented to the user.

[1536]

For example, the image sensor may be included in a head-mounted display, and in the displaying, the display image may be displayed by a projector included in the head-mounted display.

[1537]

In this way, the information can be easily presented to the user, for instance as illustrated in FIGS. 351 to 358.

[1538]

For example, an information communication method of obtaining information from a subject may include: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image by capturing the subject that changes in luminance by the image sensor with the set exposure time, the bright line image being an image including the bright line; and obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained bright line image, wherein in the obtaining of a bright line image, the bright line image including a plurality of parts where the bright line appears is obtained by capturing a plurality of subjects in a period during which the image sensor is being moved, and in the obtaining of the information, a position of each of the plurality of subjects is obtained by demodulating, for each of the plurality of parts, the data specified by the pattern of the bright line in the part, and the information

communication method may further include estimating a position of the image sensor, based on the obtained position of each of the plurality of subjects and a moving state of the image sensor.

[1539]

In this way, the position of the receiver including the image sensor can be accurately estimated based on the changes in luminance of the plurality of subjects such as lightings, for instance as illustrated in FIG. 350.

[1540]

For example, an information communication method of obtaining information from a subject may include: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image by capturing the subject that changes in luminance by the image sensor with the set exposure time, the bright line image being an image including the bright line; obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained bright line image; and presenting the obtained information, wherein in the presenting, an image prompting to make a predetermined gesture is presented to a user of the image sensor as the information.

[1541]

In this way, user authentication and the like can be conducted according to whether or not the user makes the gesture as prompted, for instance as illustrated in FIGS. 363A to 364B. This enhances convenience.

[1542]

For example, an information communication method of obtaining information from a subject may include: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining

a bright line image by capturing the subject that changes in luminance by the image sensor with the set exposure time, the bright line image being an image including the bright line; and obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained bright line image, wherein in the obtaining of a bright line image, the bright line image is obtained by capturing a plurality of subjects reflected on a reflection surface, and in the obtaining of the information, the information is obtained by separating a bright line corresponding to each of the plurality of subjects from bright lines included in the bright line image according to a strength of the bright line and demodulating, for each of the plurality of subjects, the data specified by the pattern of the bright line corresponding to the subject.

[1543]

In this way, even in the case where the plurality of subjects such as lightings each change in luminance, appropriate information can be obtained from each subject, for instance as illustrated in FIG. 370.

[1544]

For example, an information communication method of obtaining information from a subject may include: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image by capturing the subject that changes in luminance by the image sensor with the set exposure time, the bright line image being an image including the bright line; and obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained bright line image, wherein in the obtaining of a bright line image, the bright line image is obtained by capturing the subject reflected on a reflection surface, and the information communication method may further include estimating a position of the subject based on a luminance distribution in the bright line image.

[1545]

In this way, the appropriate position of the subject can be estimated based on the luminance distribution, for instance as illustrated in FIG. 371.

[1546]

For example, an information communication method of transmitting a signal using a change in luminance may include: determining a first pattern of the change in luminance, by modulating a first signal to be transmitted; determining a second pattern of the change in luminance, by modulating a second signal to be transmitted; and transmitting the first signal and the second signal by a light emitter alternately changing in luminance according to the determined first pattern and changing in luminance according to the determined second pattern.

[1547]

In this way, the first signal and the second signal can each be transmitted without a delay, for instance as illustrated in FIG. 365A.

[1548]

For example, in the transmitting, a buffer time may be provided when switching the change in luminance between the change in luminance according to the first pattern and the change in luminance according to the second pattern.

[1549]

In this way, interference between the first signal and the second signal can be suppressed, for instance as illustrated in FIG. 365B.

[1550]

For example, an information communication method of transmitting a signal using a change in luminance may include: determining a pattern of the change in luminance by modulating the signal to be transmitted; and transmitting the signal by a light emitter changing in luminance according to the determined pattern, wherein the signal is made up of a plurality of main blocks, each of the plurality of main blocks includes first data, a preamble for the first data, and a check signal for the first data, the first data is made

up of a plurality of sub-blocks, and each of the plurality of sub-blocks includes second data, a preamble for the second data, and a check signal for the second data.

[1551]

In this way, data can be appropriately obtained regardless of whether or not the receiver needs a blanking time, for instance as illustrated in FIG. 366.

[1552]

For example, an information communication method of transmitting a signal using a change in luminance may include: determining, by each of a plurality of transmitters, a pattern of the change in luminance by modulating the signal to be transmitted; and transmitting, by each of the plurality of transmitters, the signal by a light emitter in the transmitter changing in luminance according to the determined pattern, wherein in the transmitting, the signal of a different frequency or protocol is transmitted.

[1553]

In this way, interference between signals from the plurality of transmitters can be suppressed, for instance as illustrated in FIG. 368.

[1554]

For example, an information communication method of transmitting a signal using a change in luminance may include: determining, by each of a plurality of transmitters, a pattern of the change in luminance by modulating the signal to be transmitted; and transmitting, by each of the plurality of transmitters, the signal by a light emitter in the transmitter changing in luminance according to the determined pattern, wherein in the transmitting, one of the plurality of transmitters receives a signal transmitted from an other one of the plurality of transmitters, and transmits an other signal in a form that does not interfere with the received signal.

[1555]

In this way, interference between signals from the plurality of transmitters can be suppressed, for instance as illustrated in FIG. 369.

[1556]

[Embodiment 15]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as a blink pattern of an LED, an organic EL device, or the like in Embodiments 1 to 14 described above.

[1557]

FIG. 382 is a flowchart illustrating an example of operation of a receiver in Embodiment 15.

[1558]

First, a receiver receives a signal by an illuminance sensor (Step 8101). Next, the receiver obtains information such as position information from a server, based on the received signal (Step 8102). The receiver then activates an image sensor capable of capturing the light reception direction of the illuminance sensor (Step 8103). The receiver receives all or part of a signal by the image sensor, and determines whether or not all or part of the signal is the same as the signal received by the illuminance sensor (Step 8104). Following this, the receiver estimates the position of the receiver, from the position of the transmitter in the captured image, information from a 9-axis sensor included in the receiver, and the position information of the transmitter (Step 8105). Thus, the receiver activates the illuminance sensor of low power consumption and, in the case where the signal is received by the illuminance sensor, activates the image sensor. The receiver then performs position estimation using image capture by the image sensor. In this way, the position of the receiver can be accurately estimated while saving power.

[1559]

FIG. 383 is a flowchart illustrating another example of operation of a receiver in Embodiment 15.

[1560]

A receiver recognizes a periodic change of luminance from the sensor value of an illuminance sensor (Step 8111). The receiver then activates an image sensor capable of capturing the light

reception direction of the illuminance sensor, and receives a signal (Step 8112). Thus, the receiver activates the illuminance sensor of low power consumption and, in the case where the periodic change of luminance is received by the illuminance sensor, activates the image sensor, in the same way as above. The receiver then receives the accurate signal using image capture by the image sensor. In this way, the accurate signal can be received while saving power.

[1561]

FIG. 384A is a block diagram illustrating an example of a transmitter in Embodiment 15.

[1562]

A transmitter 8115 includes a power supply unit 8115a, a signal control unit 8115b, a light emitting unit 8115c, and a light emitting unit 8115d. The power supply unit 8115a supplies power to the signal control unit 8115b. The signal control unit 8115b divides the power supplied from the power supply unit 8115a into the light emitting units 8115c and 8115d, and controls the luminance changes of the light emitting units 8115c and 8115d.

[1563]

FIG. 384B is a block diagram illustrating another example of a transmitter in Embodiment 15.

[1564]

A transmitter 8116 includes a power supply unit 8116a, a signal control unit 8116b, a light emitting unit 8116c, and a light emitting unit 8116d. The power supply unit 8116a supplies power to the light emitting units 8116c and 8116d. The signal control unit 8116b controls the power supplied from the power supply unit 8116a, thereby controlling the luminance changes of the light emitting units 8116c and 8116d. The power use efficiency can be enhanced by the signal control unit 8116b controlling the power supply unit 8116a that supplies power to each of the light emitting units 8116c and 8116d.

[1565]

FIG. 385 is a diagram illustrating an example of a structure of a system including a plurality of transmitters in Embodiment 15.

[1566]

The system includes a centralized control unit 8118, a transmitter 8117, and a transmitter 8120. The centralized control unit 8118 controls signal transmission by a change in luminance of each of the transmitters 8117 and 8120. For example, the centralized control unit 8118 causes the transmitters 8117 and 8120 to transmit the same signal at the same time, or causes one of the transmitters to transmit a signal unique to the transmitter.

[1567]

The transmitter 8120 includes two transmission units 8121 and 8122, a signal change unit 8123, a signal storage unit 8124, a synchronous signal input unit 8125, a synchronous control unit 8126, and a light receiving unit 8127.

[1568]

The two transmission units 8121 and 8122 each have the same structure as the transmitter 8115 illustrated in FIG. 384A, and transmits a signal by changing in luminance. In detail, the transmission unit 8121 includes a power supply unit 8121a, a signal control unit 8121b, a light emitting unit 8121c, and a light emitting unit 8121d. The transmission unit 8122 includes a power supply unit 8122a, a signal control unit 8122b, a light emitting unit 8122c, and a light emitting unit 8122d.

[1569]

The signal change unit 8123 modulates a signal to be transmitted, to a signal indicating a luminance change pattern. The signal storage unit 8124 stores the signal indicating the luminance change pattern. The signal control unit 8121b in the transmission unit 121 reads the signal stored in the signal storage unit 8124, and causes the light emitting units 8121c and 8121d to change in luminance according to the signal.

[1570]

The synchronous signal input unit 8125 obtains a synchronous signal according to control by the centralized control unit 8118. The synchronous control unit 8126 synchronizes the luminance changes of the transmission units 8121 and 8122, when the synchronous

signal is obtained. That is, the synchronous control unit 8126 controls the signal control units 8121b and 8122b, to synchronize the luminance changes of the transmission units 8121 and 8122. Here, the light receiving unit 8127 detects light emission from the transmission units 8121 and 8122. The synchronous control unit 8126 feedback-controls the signal control units 8121b and 8122b, according to the light detected by the light receiving unit 8127.

[1571]

FIG. 386 is a block diagram illustrating another example of a transmitter in Embodiment 15.

[1572]

A transmitter 8130 includes a transmission unit 8131 that transmits a signal by changing in luminance, and a non-transmission unit 8132 that emits light without transmitting a signal.

[1573]

The transmission unit 8131 has the same structure as the transmitter 8115 illustrated in FIG. 384A, and includes a power supply unit 8131a, a signal control unit 8131b, and light emitting units 8131c to 8131f. The non-transmission unit 8132 includes a power supply unit 8132a and light emitting units 8132c to 8132f, but does not include a signal control unit. In other words, in the case where there are a plurality of units each including a power supply and luminance change synchronous control cannot be performed between the plurality of units, a signal control unit is provided in only one of the plurality of units to cause the unit to change in luminance, as in the structure illustrated in FIG. 386.

[1574]

In the transmitter 8130, the light emitting units 8131c to 8131f in the transmission unit 8131 are continuously arranged in a line. That is, none of the light emitting units 8132c to 8132f in the non-transmission unit 8132 is mixed in the set of the light emitting units 8131c to 8131f. This makes the light emitter that changes in luminance larger in size, so that the receiver can easily receive the signal transmitted using the change in luminance.

[1575]

FIG. 387A is a diagram illustrating an example of a transmitter in Embodiment 15.

[1576]

A transmitter 8134 such as a signage includes three light emitting units (light emitting areas) 8134a to 8134c. Light from these light emitting units 8134a to 8134c do not interfere with each other. In the case where only one of the light emitting units 8134a to 8134c can be changed in luminance to transmit a signal, it is desirable to change in luminance the light emitting unit 8134b at the center, as illustrated in (a) in FIG. 387A. In the case where two of the light emitting units 8134a to 8134c can be changed in luminance, it is desirable to change in luminance the light emitting unit 8134b at the center and the light emitting unit 8134a or 8134c at either edge, as illustrated in (b) in FIG. 387A. Changing in luminance the light emitting units at such positions enables the receiver to appropriately receive the signal transmitted using the change in luminance.

[1577]

FIG. 387B is a diagram illustrating an example of a transmitter in Embodiment 15.

[1578]

A transmitter 8135 such as a signage includes three light emitting units 8135a to 8135c. Light from adjacent light emitting units of these light emitting units 8135a to 8135c interferes with each other. In the case where only one of the light emitting units 8135a to 8135c can be changed in luminance to transmit a signal, it is desirable to change in luminance the light emitting unit 8135a or 8135c at either edge, as illustrated in (a) in FIG. 387B. This prevents light from another light emitting unit from interfering with the luminance change for signal transmission. In the case where two of the light emitting units 8135a to 8135c can be changed in luminance, it is desirable to change in luminance the light emitting unit 8135b at the center and the light emitting unit 8135a or 8135c at either edge, as illustrated in (b) in FIG. 387B. Changing in luminance the light emitting units at such positions contributes to a larger luminance change area, and so enables the receiver to

appropriately receive the signal transmitted using the change in luminance.

[1579]

FIG. 387C is a diagram illustrating an example of a transmitter in Embodiment 15.

[1580]

In the case where two of the light emitting units 8134a to 8134c can be changed in luminance in the transmitter 8134, the light emitting units 8134a and 8134c at both edges may be changed in luminance, as illustrated in FIG. 378C. In this case, the imaging range in which the luminance change part is shown can be widened in the image capture by the receiver.

[1581]

FIG. 388A is a diagram illustrating an example of a transmitter in Embodiment 15.

[1582]

A transmitter 8137 such as a signage transmits a signal by a character part "A Shop" and a light emitting unit 8137a changing in luminance. For example, the light emitting unit 8137a is formed like a horizontally long rectangle, and uniformly changes in luminance. The uniform change in luminance of the light emitting unit 8137a enables the receiver to appropriately receive the signal transmitted using the change in luminance.

[1583]

FIG. 388B is a diagram illustrating an example of a transmitter in Embodiment 15.

[1584]

A transmitter 8138 such as a signage transmits a signal by a character part "A Shop" and a light emitting unit 8138a changing in luminance. For example, the light emitting unit 8138a is formed like a frame along the edges of the signage, and uniformly changes in luminance. That is, the light emitting unit 8138a is formed so that, when the light emitting unit is projected onto an arbitrary straight line, the length of the continuous projection part is at the maximum. The uniform change in luminance of the light emitting unit 8138a

enables the receiver to more appropriately receive the signal transmitted using the change in luminance.

[1585]

FIG. 389 is a diagram illustrating an example of processing operation of a receiver, a transmitter, and a server in Embodiment 15.

[1586]

A receiver 8142 such as a smartphone obtains position information indicating the position of the receiver 8142, and transmits the position information to a server 8141. For example, the receiver 8142 obtains the position information when using a GPS or the like or receiving another signal. The server 8141 transmits an ID list associated with the position indicated by the position information, to the receiver 8142. The ID list includes each ID such as "abcd" and information associated with the ID.

[1587]

The receiver 8142 receives a signal from a transmitter 8143 such as a lighting device. Here, the receiver 8142 may be able to receive only a part (e.g. "b") of an ID as the above-mentioned signal. In such a case, the receiver 8142 searches the ID list for the ID including the part. In the case where the unique ID is not found, the receiver 8142 further receives a signal including another part of the ID, from the transmitter 8143. The receiver 8142 thus obtains a larger part (e.g. "bc") of the ID. The receiver 8142 again searches the ID list for the ID including the part (e.g. "bc"). Through such search, the receiver 8142 can specify the whole ID even in the case where the ID can be obtained only partially. Note that, when receiving the signal from the transmitter 8143, the receiver 8142 receives not only the part of the ID but also a check portion such as a CRC (Cyclic Redundancy Check).

[1588]

FIG. 390 is a diagram illustrating an example of processing operation of a receiver, a transmitter, and a server in Embodiment 15.

[1589]

A receiver 8152 such as a smartphone obtains position information indicating the position of the receiver 8152. For

example, the receiver 8152 obtains the position information when using a GPS or the like or receiving another signal. The receiver 8152 also receives a signal from a transmitter 8153 such as a lighting device. The signal includes only a part (e.g. "b") of an ID. The receiver 8152 transmits the position information and the part of the ID to a server 8151.

[1590]

The server 8151 searches an ID list associated with the position indicated by the position information, for the ID including the part. In the case where the unique ID is not found, the server 8151 notifies the receiver 8152 that the specification of the ID has failed.

[1591]

Following this, the receiver 8152 receives a signal including another part of the ID, from the transmitter 8153. The receiver 8152 thus obtains a large part (e.g. "be") of the ID. The receiver 8152 transmits the part (e.g. "be") of the ID and the position information to the server 8151.

[1592]

The server 8151 searches the ID list associated with the position indicated by the position information, for the ID including the part. When the unique ID is found, the server 8151 notifies the receiver 8152 that the ID (e.g. "abef") has been specified, and transmits information associated with the ID to the receiver 8152.

[1593]

FIG. 391 is a diagram illustrating an example of processing operation of a receiver, a transmitter, and a server in Embodiment 15.

[1594]

The receiver 8152 may transmit not the part of the ID but the whole ID to the server 8151, together with the position information. In the case where the complete ID (e.g. "wxyz") is not included in the ID list, the server 8151 notifies the receiver 8152 of an error.

[1595]

FIG. 392A is a diagram for describing synchronization between a plurality of transmitters in Embodiment 15.

[1596]

Transmitters 8155a and 8155b transmit a signal by changing in luminance. Here, the transmitter 8155a transmits a synchronous signal to the transmitter 8155b, thereby changing in luminance synchronously with the transmitter 8155b. Further, the transmitters 8155a and 8155b each obtain a signal from a source, and change in luminance according to the signal. There is a possibility that the time (first delay time) taken for the signal transmission from the source to the transmitter 8155a and the time (second delay time) taken for the signal transmission from the source to the transmitter 8155b are different. In view of this, the signal round-trip time between each of the transmitters 8155a and 8155b and the source is measured, and 1/2 of the round-trip time is specified as the first or second delay time. The transmitter 8155a transmits the synchronous signal so as to cancel out the difference between the first and second delay times, thereby changing in luminance synchronously with the transmitter 8155b.

[1597]

FIG. 392B is a diagram for describing synchronization between a plurality of transmitters in Embodiment 15.

[1598]

A light receiving sensor 8156 detects light from the transmitters 8155a and 8155b, and outputs the result to the transmitters 8155a and 8155b as a detection signal. Having received the detection signal from the light receiving sensor 8156, the transmitters 8155a and 8155b change in luminance synchronously or adjust the signal strength based on the detection signal.

[1599]

FIG. 393 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1600]

A transmitter 8165 such as a television obtains an image and an ID (ID 1000) associated with the image, from a control unit 8166. The transmitter 8165 displays the image, and also transmits the ID

(ID 1000) to a receiver 8167 by changing in luminance. The receiver 8167 captures the transmitter 8165 to receive the ID (ID 1000), and displays information associated with the ID (ID 1000). The control unit 8166 then changes the image output to the transmitter 8165, to another image. The control unit 8166 also changes the ID output to the transmitter 8165. That is, the control unit 8166 outputs the other image and the other ID (ID 1001) associated with the other image, to the transmitter 8165. The transmitter 8165 displays the other image, and transmits the other ID (ID 1001) to the receiver 8167 by changing in luminance. The receiver 8167 captures the transmitter 8165 to receive the other ID (ID 1001), and displays information associated with the other ID (ID 1001).

[1601]

FIG. 394 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1602]

A transmitter 8170 such as a signage displays images by switching between them. When displaying an image, the transmitter 8170 transmits, to a receiver 8171, ID time information indicating the ID corresponding to the displayed image and the time at which the image is displayed, by changing in luminance. For example, at time t1, the transmitter 8170 displays an image showing a circle, and transmits ID time information indicating the ID (ID: 1000) corresponding to the image and the time (TIME: t1) at which the image is displayed.

[1603]

Here, the transmitter 8170 transmits not only the ID time information corresponding to the currently displayed image but also ID time information corresponding to at least one previously displayed image. For example, at time t2, the transmitter 8170 displays an image showing a square, and transmits ID time information indicating the ID (ID: 1001) corresponding to the image and the time (TIME: t2) at which the image is displayed. At this time, the transmitter 8170 also transmits the ID time information

indicating the ID (ID: 1000) corresponding to the image showing the circle and the time (TIME: t1) at which the image is displayed. Likewise, at time t3, the transmitter 8170 displays an image showing a triangle, and transmits ID time information indicating the ID (ID: 1002) corresponding to the image and the time (TIME: t3) at which the image is displayed. At this time, the transmitter 8170 also transmits the ID time information indicating the ID (ID: 1001) corresponding to the image showing the square and the time (TIME: t2) at which the image is displayed. Thus, the transmitter 8170 transmits a plurality of sets of ID time information at the same time.

[1604]

Suppose, to obtain information related to the image showing the square, the user points an image sensor of the receiver 8171 at the transmitter 8170 and starts image capture by the receiver 8171, at the time t2 at which the image showing the square is displayed.

[1605]

Even when the receiver 8171 starts capturing at time t2, the receiver 8171 may not be able to obtain the ID time information corresponding to the image showing the square while the image is displayed on the transmitter 8170. Even in such a case, since the ID time information corresponding to the previously displayed image is also transmitted from the transmitter 8170 as mentioned above, at time t3 the receiver 8171 can obtain not only the ID time information (ID: 1002, TIME: t3) corresponding to the image showing the triangle but also the ID time information (ID: 1001, TIME: t2) corresponding to the image showing the square. The receiver 8171 selects, from these ID time information, the ID time information (ID: 1001, TIME: t2) indicating the time (t2) at which the receiver 8171 is pointed at the transmitter 8170, and specifies the ID (ID: 1001) indicated by the ID time information. As a result, at time t3, the receiver 8171 can obtain, from a server or the like, information related to the image showing the square based on the specified ID (ID: 1001).

[1606]

The above-mentioned time is not limited to an absolute time,

and may be a time (relative time) between the time at which the receiver 8171 is pointed at the transmitter 8170 and the time at which the receiver 8171 receives the ID time information. Moreover, though the transmitter 8170 transmits the ID time information corresponding to the previously displayed image together with the ID time information corresponding to the currently displayed image, the transmitter 8170 may transmit ID time information corresponding to an image to be displayed in the future. Furthermore, in a situation where the reception by the receiver 8171 is difficult, the transmitter 8170 may transmit more sets of previous or future ID time information.

[1607]

In the case where the transmitter 8170 is not a signage but a television, the transmitter 8170 may transmit information indicating a channel corresponding to a displayed image, instead of ID time information. In detail, in the case where an image of a television program being broadcasted is displayed on the transmitter 8170 in real time, the display time of the image displayed on the transmitter 8170 can be uniquely specified for each channel. Accordingly, the receiver 8171 can specify the time at which the receiver 8171 is pointed at the transmitter 8170, i.e. the time at which the receiver 8171 starts capturing, based on the captured image and the channel. The receiver 8171 can then obtain, from a server or the like, information related to the captured image based on the channel and the time. Here, the transmitter 8170 may transmit information indicating the display time of the displayed image, instead of ID time information. In such a case, the receiver 8171 searches all television programs being broadcasted, for a television program including the captured image. The receiver 8171 can then obtain, from a server or the like, information related to the image based on the channel and display time of the television program.

[1608]

FIG. 395 is a diagram illustrating an example of operation of a transmitter, a receiver, and a server in Embodiment 15.

[1609]

As illustrated in (a) in FIG. 395, a receiver 8176 captures a transmitter 8175 to obtain an image including a bright line, and specifies (obtains) the ID of the transmitter 8175 from the image. The receiver 8176 transmits the ID to a server 8177, and obtains information associated with the ID from the server 8177.

[1610]

On the other hand, as illustrated in (b) in FIG. 395, the receiver 8176 may capture the transmitter 8175 to obtain the image including the bright line, and transmit the image to the server 8177 as captured data. The receiver 8176 may also perform, on the image including the bright line, such preprocessing that reduces the amount of information of the image, and transmit the preprocessed image to the server 8177 as captured data. The preprocessing is, for instance, image binarization. Having received the captured data, the server 8177 specifies (obtains) the ID of the transmitter 8175 from the image indicated by the captured data. The server 8177 then transmits the information associated with the ID to the receiver 8176.

[1611]

FIG. 396 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1612]

When the user is located at position A, a receiver 8183 specifies the position of the receiver 8183, by obtaining a signal transmitted from a transmitter 8181 that changes in luminance. The receiver 8183 displays a point 8183b indicating the specified position, together with an error range 8183a of the position.

[1613]

Next, when the user moves from position A to position B, the receiver 8183 cannot obtain a signal from the transmitter 8181. The receiver 8183 accordingly estimates the position of the receiver 8183, using a 9-axis sensor and the like included in the receiver 8183. The receiver 8183 displays the point 8183b indicating the estimated position, together with the error range 8183a of the position. Since this position is estimated by the 9-axis sensor, a larger error range

8183a is displayed.

[1614]

Next, when the user moves from position B to position C, the receiver 8183 specifies the position of the receiver 8183, by obtaining a signal transmitted from another transmitter 8182 that changes in luminance. The receiver 8183 displays the point 8183b indicating the specified position, together with the error range 8183a of the position. Here, the receiver 8183 does not instantly switch the display from the point 8183b indicating the position estimated using the 9-axis sensor and its error range 8183a to the position specified as mentioned above and its error range, but smoothly switches the display with movement. The error range 8183a becomes smaller as a result.

[1615]

FIG. 397 is a diagram illustrating an example of appearance of a receiver in Embodiment 15.

[1616]

The receiver 8183 such as a smartphone (advanced mobile phone) includes an image sensor 8183c, an illuminance sensor 8183d, and a display 8183e on its front surface, as illustrated in (a) in FIG. 397. The image sensor 8183c obtains an image including a bright line by capturing a subject that changes in luminance as mentioned above. The illuminance sensor 8183d detects the change in luminance of the subject. Hence, the illuminance sensor 8183d can be used in place of the image sensor 8183c, depending on the state or situation of the subject. The display 8183e displays an image and the like. The receiver 8183 may also have a function as a subject that changes in luminance. In this case, the receiver 8183 transmits a signal by causing the display 8183e to change in luminance.

[1617]

The receiver 8183 also includes an image sensor 8183f, an illuminance sensor 8183g, and a flash light emitting unit 8183h on its back surface, as illustrated in (b) in FIG. 397. The image sensor 8183f is the same as the above-mentioned image sensor 8183c, and

obtains an image including a bright line by capturing a subject that changes in luminance as mentioned above. The illuminance sensor 8183g is the same as the above-mentioned illuminance sensor 8183d, and detects the change in luminance of the subject. Hence, the illuminance sensor 8183g can be used in place of the image sensor 8183f, depending on the state or situation of the subject. The flash light emitting unit 8183h emits a flash for imaging. The receiver 8183 may also have a function as a subject that changes in luminance. In this case, the receiver 8183 transmits a signal by causing the flash light emitting unit 8183h to change in luminance.

[1618]

FIG. 398 is a diagram illustrating an example of operation of a transmitter, a receiver, and a server in Embodiment 15.

[1619]

A transmitter 8185 such as a smartphone transmits information indicating "Coupon 100 yen off" as an example, by causing a part of a display 8185a except a barcode part 8185b to change in luminance, i.e. by visible light communication. The transmitter 8185 also causes the barcode part 8185b to display a barcode without changing in luminance. The barcode indicates the same information as the above-mentioned information transmitted by visible light communication. The transmitter 8185 further causes the part of the display 8185a except the barcode part 8185b to display the characters or pictures, e.g. the characters "Coupon 100 yen off", indicating the information transmitted by visible light communication. Displaying such characters or pictures allows the user of the transmitter 8185 to easily recognize what kind of information is being transmitted.

[1620]

A receiver 8186 performs image capture to obtain the information transmitted by visible light communication and the information indicated by the barcode, and transmits these information to a server 8187. The server 8187 determines whether or not these information match or relate to each other. In the case of determining that these information match or relate to each other,

the server 8187 executes a process according to these information. Alternatively, the server 8187 transmits the determination result to the receiver 8186 so that the receiver 8186 executes the process according to these information.

[1621]

The transmitter 8185 may transmit a part of the information indicated by the barcode, by visible light communication. Moreover, the URL of the server 8187 may be indicated in the barcode. Furthermore, the transmitter 8185 may obtain an ID as a receiver, and transmit the ID to the server 8187 to thereby obtain information associated with the ID. The information associated with the ID is the same as the information transmitted by visible light communication or the information indicated by the barcode. The server 8187 may transmit an ID associated with information (visible light communication information or barcode information) transmitted from the transmitter 8185 via the receiver 8186, to the transmitter 8185.

[1622]

FIG. 399 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1623]

The transmitter 8185 such as a smartphone transmits a signal by causing the display 8185a to change in luminance. A receiver 8188 includes a light-resistant cone-shaped container 8188b and an illuminance sensor 8188a. The illuminance sensor 8188a is contained in the container 8188b, and located near the tip of the container 8188b. When the signal is transmitted from the transmitter 8185 by visible light communication, the opening (bottom) of the container 8188b in the receiver 8188 is directed to the display 8185a. Since no light other than the light from the display 8185a enters the container 8188b, the illuminance sensor 8188a in the receiver 8188 can appropriately receive the light from the display 8185a without being affected by any light which is noise. As a result, the receiver 8188 can appropriately receive the signal from the transmitter 8185.

[1624]

FIG. 400 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1625]

A transmitter 8190 such as a bus stop sign transmits operation information indicating a bus operation state and the like to the receiver 8183, by changing in luminance. For instance, the operation information indicating the destination of a bus, the arrival time of the bus at the bus stop, the current position of the bus, and the like is transmitted to the receiver 8183. Having received the operation information, the receiver 8183 displays the contents of the operation information on its display.

[1626]

For example, suppose buses with different destinations stop at the bus stop. The transmitter 8190 transmits operation information about these buses with the different destinations. Having received these operation information, the receiver 8183 selects operation information of a bus with a destination that is frequently used by the user, and displays the contents of the selected operation information on the display. In detail, the receiver 8183 specifies the destination of each bus used by the user through a GPS or the like, and records a history of destinations. With reference to this history, the receiver 8183 selects operation information of a bus with a destination frequently used by the user. As an alternative, the receiver 8183 may display the contents of operation information selected by the user from these operation information, on the display. As another alternative, the receiver 8183 may display, with priority, operation information of a bus with a destination frequently selected by the user.

[1627]

FIG. 401 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1628]

A transmitter 8191 such as a signage transmits information of a plurality of shops to the receiver 8183, by changing in luminance.

This information summarizes information about the plurality of shops, and is not information unique to each shop. Accordingly, having received the information by image capture, the receiver 8183 can display information about not only one shop but the plurality of shops. The receiver 8183 selects information about a shop (e.g. "B shop") within the imaging range from the information about the plurality of shops, and displays the selected information. When displaying the information, the receiver 8183 translates the language for expressing the information to a language registered beforehand, and displays the information in the translated language. Moreover, a message prompting for image capture by an image sensor (camera) of the receiver 8183 may be displayed on the transmitter 8191 using characters or the like. In detail, a special application program is started to display, on the transmitter 8191, a message (e.g. "Get information with camera") informing that information can be provided if the transmitter 8191 is captured by camera.

[1629]

FIG. 402 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 15.

[1630]

For example, the receiver 8183 captures a subject including a plurality of persons 8197 and a street lighting 8195. The street lighting 8195 includes a transmitter 8195a that transmits information by changing in luminance. By capturing the subject, the receiver 8183 obtains an image in which the image of the transmitter 8195a appears as the above-mentioned bright line pattern. The receiver 8183 obtains an AR object 8196a associated with an ID indicated by the bright line pattern, from a server or the like. The receiver 8183 superimposes the AR object 8196a on a normal captured image 8196 obtained by normal imaging, and displays the normal captured image 8196 on which the AR object 8196a is superimposed.

[1631]

FIG. 403A is a diagram illustrating an example of a structure of information transmitted by a transmitter in Embodiment 15.

[1632]

For example, information transmitted by a transmitter is made up of a preamble unit, a data unit of fixed length, and a check unit. A receiver checks the data unit using the check unit, thus successfully receiving the information made up of these units. When the receiver receives the preamble unit and the data unit but cannot receive the check unit, the receiver omits the check using the check unit. Even in such a case where the check is omitted, the receiver can successfully receive the information made up of these units.

[1633]

FIG. 403B is a diagram illustrating another example of a structure of information transmitted by a transmitter in Embodiment 15.

[1634]

For example, information transmitted by a transmitter is made up of a preamble unit, a check unit, and a data unit of variable length. The next information transmitted by the transmitter is equally made up of the preamble unit, the check unit, and the data unit of variable length. When a receiver receives one preamble unit and the next preamble unit, the receiver recognizes information from the preamble unit to immediately before the next preamble unit, as one set of significant information. The receiver may also use the check unit, to specify the end of the data unit received following the check unit. In this case, even when the receiver cannot receive the above-mentioned next preamble unit (all or part of the preamble unit), the receiver can appropriately receive one set of significant information transmitted immediately before.

[1635]

FIG. 404 is a diagram illustrating an example of a 4-value PPM modulation scheme by a transmitter in Embodiment 15.

[1636]

A transmitter modulates a transmission signal (signal to be transmitted) to a luminance change pattern by a 4-value PPM modulation scheme. When doing so, the transmitter can maintain

the brightness of light that changes in luminance constant, regardless of the transmission signal.

[1637]

For instance, in the case of maintaining the brightness at 75%, the transmitter modulates each of the transmission signals "00", "01", "10", and "11" to a luminance change pattern in which luminance L (Low) is represented in one of four consecutive slots and luminance H (High) is represented in the other three slots. In detail, the transmitter modulates the transmission signal "00" to a luminance change pattern (L, H, H, H) in which luminance L is represented in the first slot and luminance H is represented in the second to fourth slots. In this luminance change, the luminance rises between the first and second slots. Likewise, the transmitter modulates the transmission signal "01" to a luminance change pattern (H, L, H, H) in which luminance L is represented in the second slot and luminance H is represented in the first, third, and fourth slots. In this luminance change, the luminance rises between the second and third slots.

[1638]

In the case of maintaining the brightness at 50%, the transmitter modulates each of the transmission signals "00", "01", "10", and "11" to a luminance change pattern in which luminance L (Low) is represented in two of the four slots and luminance H (High) is represented in the other two slots. In detail, the transmitter modulates the transmission signal "00" to a luminance change pattern (L, H, H, L) in which luminance L is represented in the first and fourth slots and luminance H is represented in the second and third slots. In this luminance change, the luminance rises between the first and second slots. Likewise, the transmitter modulates the transmission signal "01" to a luminance change pattern (L, L, H, H) in which luminance L is represented in the first and second slots and luminance H is represented in the third and fourth slots. Alternatively, the transmitter modulates the transmission signal "01" to a luminance change pattern (H, L, H, L) in which luminance L is represented in the second and fourth slots and luminance H is represented in the first and third slots. In this luminance change,

the luminance rises between the second and third slots.

[1639]

In the case of maintaining the brightness at 25%, the transmitter modulates each of the transmission signals "00", "01", "10", and "11" to a luminance change pattern in which luminance L (Low) is represented in three of the four slots and luminance H (High) is represented in the other slot. In detail, the transmitter modulates the transmission signal "00" to a luminance change pattern (L, H, L, L) in which luminance L is represented in the first, third, and fourth slots and luminance H is represented in the second slot. In this luminance change, the luminance rises between the first and second slots. Likewise, the transmitter modulates the transmission signal "01" to a luminance change pattern (L, L, H, L) in which luminance L is represented in the first, second, and fourth slots and luminance H is represented in the third slot. In this luminance change, the luminance rises between the second and third slots.

[1640]

By the above-mentioned 4-value PPM modulation scheme, the transmitter can suppress flicker, and also easily adjust the brightness in levels. Moreover, a receiver can appropriately demodulate the luminance change pattern by specifying the position at which the luminance rises. Here, the receiver does not use but ignores whether or not the luminance rises at the boundary between one slot group made up of four slots and the next slot group, when demodulating the luminance change pattern.

[1641]

FIG. 405 is a diagram illustrating an example of a PPM modulation scheme by a transmitter in Embodiment 15.

[1642]

A transmitter modulates a transmission signal to a luminance change pattern, as in the 4-value PPM modulation scheme illustrated in FIG. 404. Here, the transmitter may perform PPM modulation without switching the luminance between L and H per slot. In detail, the transmitter performs PPM modulation by switching the position at which the luminance rises in the duration (time width) (hereafter

referred to as "unit duration") of four consecutive slots illustrated in FIG. 404, depending on the transmission signal. For example, the transmitter modulates the transmission signal "00" to a luminance change pattern in which the luminance rises at the position of 25% in the unit duration, as illustrated in FIG. 405. Likewise, the transmitter modulates the transmission signal "01" to a luminance change pattern in which the luminance rises at the position of 50% of the unit duration, as illustrated in FIG. 405.

[1643]

In the case of maintaining the brightness at 75%, the transmitter modulates the transmission signal "00" to a luminance change pattern in which luminance L is represented in the position of 0 to 25% and luminance H is represented in the position of 25 to 100% in the unit duration. In the case of maintaining the brightness at 99%, the transmitter modulates the transmission signal "00" to a luminance change pattern in which luminance L is represented in the position of 24 to 25% and luminance H is represented in the position of 0 to 24% and the position of 25 to 100% in the unit duration. Likewise, in the case of maintaining the brightness at 1%, the transmitter modulates the transmission signal "00" to a luminance change pattern in which luminance L is represented in the position of 0 to 25% and the position of 26 to 100% and luminance H is represented in the position of 25 to 26% in the unit duration.

[1644]

By such switching the luminance between L and H at an arbitrary position in the unit duration without switching the luminance between L and H per slot, it is possible to adjust the brightness continuously.

[1645]

FIG. 406 is a diagram illustrating an example of a PPM modulation scheme by a transmitter in Embodiment 15.

[1646]

A transmitter performs modulation in the same way as in the PPM modulation scheme illustrated in FIG. 405. Here, regardless of the transmission signal, the transmitter modulates the signal to a

luminance change pattern in which luminance H is represented at the start of the unit duration and luminance L is represented at the end of the unit duration. Since the luminance rises at the boundary between one unit duration and the next unit duration, a receiver can appropriately specify the boundary. Therefore, the receiver and the transmitter can correct clock discrepancies.

[1647]

FIG. 407A is a diagram illustrating an example of a luminance change pattern corresponding to a header (preamble unit) in Embodiment 15.

[1648]

For example, in the case of transmitting the header (preamble unit) illustrated in FIGS. 403A and 403B, a transmitter changes in luminance according to a pattern illustrated in FIG. 407A. In detail, in the case where the header is made up of 7 slots, the transmitter changes in luminance according to the pattern "L, H, L, H, L, H, H". In the case where the header is made up of 8 slots, the transmitter changes in luminance according to the pattern "H, L, H, L, H, L, H, H". These patterns are distinguishable from the luminance change patterns illustrated in FIG. 404, with it being possible to clearly inform a receiver that the signal indicated by any of these patterns is the header.

[1649]

FIG. 407B is a diagram illustrating an example of a luminance change pattern in Embodiment 15.

[1650]

In the 4-value PPM modulation scheme, in the case of modulating the transmission signal "01" included in the data unit while maintaining the brightness at 50%, the transmitter modulates the signal to one of the two patterns, as illustrated in FIG. 404. In detail, the transmitter modulates the signal to the first pattern "L, L, H, H" or the second pattern "H, L, H, L".

[1651]

Here, suppose the luminance change pattern corresponding to the header is such a pattern as illustrated in FIG. 407A. In this case,

it is desirable that the transmitter modulates the transmission signal "01" to the first pattern "L, L, H, H". For instance, in the case of using the first pattern, the transmission signal "11, 01, 11" included in the data unit is modulated to the pattern "H, H, L, L, L, L, H, H, H, H, L, L". In the case of using the second pattern, on the other hand, the transmission signal "11, 01, 11" included in the data unit is modulated to the pattern "H, H, L, L, H, L, H, L, H, H, L, L". The pattern "H, H, L, L, H, L, H, L, H, H, L, L" includes the same pattern as the pattern of the header made up of 7 slots illustrated in FIG. 407A. For clear distinction between the header and the data unit, it is desirable to modulate the transmission signal "01" to the first pattern.

[1652]

FIG. 408A is a diagram illustrating an example of a luminance change pattern in Embodiment 15.

[1653]

In the 4-value PPM modulation scheme, in the case of modulating the transmission signal "11", the transmitter modulates the signal to the pattern "H, H, H, L", the pattern "H, H, L, L", or the pattern "H, L, L, L" so as not to cause a rise in luminance, as illustrated in FIG. 404. However, the transmitter may modulate the transmission signal "11" to the pattern "H, H, H, H" or the pattern "L, L, L, L" in order to adjust the brightness, as illustrated in FIG. 408A.

[1654]

FIG. 408B is a diagram illustrating an example of a luminance change pattern in Embodiment 15.

[1655]

In the 4-value PPM modulation scheme, in the case of modulating the transmission signal "11, 00" while maintaining the brightness at 75%, the transmitter modulates the signal to the pattern "H, H, H, L, L, H, H, H", as illustrated in FIG. 404. However, if luminance L is consecutive, each of the consecutive values of luminance L other than the last value may be changed to H so that luminance L is not consecutive. That is, the transmitter modulates the signal "11, 00" to the pattern "H, H, H, H, L, H, H, H".

[1656]

Since luminance L is not consecutive, the load on the transmitter can be reduced. Moreover, the capacitance of the capacitor included in the transmitter can be reduced, enabling a reduction in control circuit capacity. Furthermore, a lighter load on the light source of the transmitter facilitates the production of the light source. The power efficiency of the transmitter can also be enhanced. Besides, since it is ensured that luminance L is not consecutive, the receiver can easily demodulate the luminance change pattern.

[1657]

(Summary of this embodiment)

An information communication method in this embodiment is an information communication method of transmitting a signal using a change in luminance, the information communication method including: determining a pattern of the change in luminance by modulating the signal to be transmitted; and transmitting the signal by a light emitter changing in luminance according to the determined pattern, wherein the pattern of the change in luminance is a pattern in which one of two different luminance values occurs in each arbitrary position in a predetermined duration, and in the determining, the pattern of the change in luminance is determined so that, for each of different signals to be transmitted, a luminance change position in the duration is different and an integral of luminance of the light emitter in the duration is a same value corresponding to preset brightness, the luminance change position being a position at which the luminance rises or a position at which the luminance falls.

[1658]

In this way, the luminance change pattern is determined so that, for each of the different signals "00", "01", "10", and "11" to be transmitted, the position at which the luminance rises (luminance change position) is different and also the integral of luminance of the light emitter in the predetermined duration (unit duration) is the same value corresponding to the preset brightness (e.g. 99% or 1%),

for instance as illustrated in FIG. 405. Thus, the brightness of the light emitter can be maintained constant for each signal to be transmitted, with it being possible to suppress flicker. In addition, a receiver that captures the light emitter can appropriately demodulate the luminance change pattern based on the luminance change position. Furthermore, since the luminance change pattern is a pattern in which one of two different luminance values (luminance H (High) or luminance L (Low)) occurs in each arbitrary position in the unit duration, the brightness of the light emitter can be changed continuously.

[1659]

For example, the information communication method may include sequentially displaying a plurality of images by switching between the plurality of images, wherein in the determining, each time an image is displayed in the sequentially displaying, the pattern of the change in luminance for identification information corresponding to the displayed image is determined by modulating the identification information as the signal, and in the transmitting, each time the image is displayed in the sequentially displaying, the identification information corresponding to the displayed image is transmitted by the light emitter changing in luminance according to the pattern of the change in luminance determined for the identification information.

[1660]

In this way, each time an image is displayed, the identification information corresponding to the displayed image is transmitted, for instance as illustrated in FIG. 393. Based on the displayed image, the user can easily select the identification information to be received by the receiver.

[1661]

For example, in the transmitting, each time the image is displayed in the sequentially displaying, identification information corresponding to a previously displayed image may be further transmitted by the light emitter changing in luminance according to the pattern of the change in luminance determined for the

identification information.

[1662]

In this way, even in the case where, as a result of switching the displayed image, the receiver cannot receive the identification signal transmitted before the switching, the receiver can appropriately receive the identification information transmitted before the switching because the identification information corresponding to the previously displayed image is transmitted together with the identification information corresponding to the currently displayed image, for instance as illustrated in FIG. 394.

[1663]

For example, in the determining, each time the image is displayed in the sequentially displaying, the pattern of the change in luminance for the identification information corresponding to the displayed image and a time at which the image is displayed may be determined by modulating the identification information and the time as the signal, and in the transmitting, each time the image is displayed in the sequentially displaying, the identification information and the time corresponding to the displayed image may be transmitted by the light emitter changing in luminance according to the pattern of the change in luminance determined for the identification information and the time, and the identification information and a time corresponding to the previously displayed image may be further transmitted by the light emitter changing in luminance according to the pattern of the change in luminance determined for the identification information and the time.

[1664]

In this way, each time an image is displayed, a plurality of sets of ID time information (information made up of identification information and a time) are transmitted, for instance as illustrated in FIG. 394. The receiver can easily select, from the received plurality of sets of ID time information, a previously transmitted identification signal which the receiver cannot be received, based on the time included in each set of ID time information.

[1665]

For example, the light emitter may have a plurality of areas each of which emits light, and in the transmitting, in the case where light from adjacent areas of the plurality of areas interferes with each other and only one of the plurality of areas changes in luminance according to the determined pattern of the change in luminance, only an area located at an edge from among the plurality of areas may change in luminance according to the determined pattern of the change in luminance.

[1666]

In this way, only the area (light emitting unit) located at the edge changes in luminance, for instance as illustrated in (a) in FIG. 387B. The influence of light from another area on the luminance change can therefore be suppressed as compared with the case where only an area not located at the edge changes in luminance. As a result, the receiver can capture the luminance change pattern appropriately.

[1667]

For example, in the transmitting, in the case where only two of the plurality of areas change in luminance according to the determined pattern of the change in luminance, the area located at the edge and an area adjacent to the area located at the edge from among the plurality of areas may change in luminance according to the determined pattern of the change in luminance.

[1668]

In this way, the area (light emitting unit) located at the edge and the area (light emitting unit) adjacent to the area located at the edge change in luminance, for instance as illustrated in (b) in FIG. 387. The spatially continuous luminance change range has a wide area, as compared with the case where areas apart from each other change in luminance. As a result, the receiver can capture the luminance change pattern appropriately.

[1669]

An information communication method in this embodiment is an information communication method of obtaining information from a subject, the information communication method including:

transmitting position information indicating a position of an image sensor used to capture the subject; receiving an ID list that is associated with the position indicated by the position information and includes a plurality of sets of identification information; setting an exposure time of the image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image including the bright line, by capturing the subject that changes in luminance by the image sensor with the set exposure time; obtaining the information by demodulating data specified by a pattern of the bright line included in the obtained bright line image; and searching the ID list for identification information that includes the obtained information.

[1670]

In this way, since the ID list is received beforehand, even when the obtained information "bc" is only a part of identification information, the appropriate identification information "abcd" can be specified based on the ID list, for instance as illustrated in FIG. 389.

[1671]

For example, in the case where the identification information that includes the obtained information is not uniquely specified in the searching, the obtaining of a bright line image and the obtaining of the information may be repeated to obtain new information, and the information communication method may further include searching the ID list for the identification information that includes the obtained information and the new information.

[1672]

In this way, even in the case where the obtained information "b" is only a part of identification information and the identification information cannot be uniquely specified with this information alone, the new information "c" is obtained and so the appropriate identification information "abcd" can be specified based on the new information and the ID list, for instance as illustrated in FIG. 389.

[1673]

An information communication method in this embodiment is an information communication method of obtaining information from a subject, the information communication method including: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image including the bright line, by capturing the subject that changes in luminance by the image sensor with the set exposure time; obtaining identification information by demodulating data specified by a pattern of the bright line included in the obtained bright line image; transmitting the obtained identification information and position information indicating a position of the image sensor; and receiving error notification information for notifying an error, in the case where the obtained identification information is not included in an ID list that is associated with the position indicated by the position information and includes a plurality of sets of identification information.

[1674]

In this way, the error notification information is received in the case where the obtained identification information is not included in the ID list, for instance as illustrated in FIG. 391. Upon receiving the error notification information, the user of the receiver can easily recognize that information associated with the obtained identification information cannot be obtained.

[1675]

[Embodiment 16]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as a blink pattern of an LED, an organic EL device, or the like in Embodiments 1 to 15 described above, according to situation.

[1676]

(Situation: in front of store)

An example of application in a situation where a user carrying a receiver is in front of a store bearing an advertisement sign which

functions as a transmitter is described first, with reference to FIGS. 409 to 413.

[1677]

FIG. 409 is a diagram illustrating an example of operation of a receiver in the in-front-of-store situation.

[1678]

For example, when a user carrying a receiver 8300 (terminal device) such as a smartphone is walking, the user finds a sign 8301 of a store. The sign 8301 is a transmitter (subject) that transmits a signal using a change in luminance, like the transmitter in any of Embodiments 1 to 15 described above. The user is interested in the store and, upon determining that the sign 8301 is transmitting a signal by changing in luminance, operates the receiver 8300 to start visible light communication application software (hereafter referred to as "communication application") of the receiver 8300.

[1679]

FIG. 410 is a diagram illustrating another example of operation of the receiver 8300 in the in-front-of-store situation.

[1680]

The receiver 8300 may automatically start the communication application, without being operated by the user. For example, the receiver 8300 detects the current position of the receiver 8300 using a GPS, a 9-axis sensor, or the like, and determines whether or not the current position is in a predetermined specific area for the sign 8301. The specific area is an area near the sign 8301. In the case of determining that the current position of the receiver 8300 is in the specific area, the receiver 8300 starts the communication application. The receiver 8300 may also start the communication application upon detecting, through its 9-axis sensor or the like, the user sticking the receiver 8300 out or turning the receiver 8300. This saves the user operation, and provides ease of use.

[1681]

FIG. 411 is a diagram illustrating an example of next operation of the receiver 8300 in the in-front-of-store situation.

[1682]

After starting the communication application as described above, the receiver 8300 captures (visible light imaging) the sign 8301 that functions as a transmitter for transmitting a signal using a change in luminance. That is, the receiver 8300 performs visible light communication with the sign 8301.

[1683]

FIG. 412 is a diagram illustrating an example of next operation of the receiver 8300 in the in-front-of-store situation.

[1684]

The receiver 8300 obtains an image including a bright line, as a result of capturing the sign 8301. The receiver 8300 obtains a device ID of the sign 8301, by demodulating data specified by the pattern of the bright line. That is, the receiver 8300 obtains the device ID from the sign 8301, by visible light imaging or visible light communication in Embodiments 1 to 15. The receiver 8300 transmits the device ID to a server, and obtains advertisement information (service information) associated with the device ID from the server.

[1685]

The receiver 8300 may obtain the advertisement information associated with the device ID, from a plurality of sets of advertisement information held beforehand. In this case, when determining that the current position of the receiver 8300 is in the above-mentioned specific area, the receiver 8300 notifies the server of the specific area or the current position, and obtains all device IDs corresponding to the specific area and advertisement information associated with each of the device IDs from the server and holds (caches) them beforehand. By doing so, upon obtaining the device ID of the sign 8301 in the specific area, the receiver 8300 can promptly obtain the advertisement information associated with the device ID of the sign 8301 from the pre-stored advertisement information associated with each device ID, with no need to request the advertisement information associated with the device ID from the server.

[1686]

Upon obtaining the advertisement information associated with the device ID of the sign 8301, the receiver 8300 displays the advertisement information. For instance, the receiver 8300 displays a coupon and availability of the store shown by the sign 8301 and a barcode indicating the same contents.

[1687]

The receiver 8300 may obtain not only the device ID but also privilege data from the sign 8301 by visible light communication. For example, the privilege data indicates a random ID (random number), the time at which or period during which the privilege data is transmitted, or the like. In the case of receiving the privilege data, the receiver 8300 transmits the privilege data to the server together with the device ID. The receiver 8300 then obtains advertisement information associated with the device ID and the privilege data. The receiver 8300 can thus receive different advertisement information according to the privilege data. As an example, if the sign 8301 is captured early in the morning, the receiver 8300 can obtain and display advertisement information indicating an early bird discount coupon. In other words, the advertisement by the same sign can be varied according to the privilege data (e.g. hours). As a result, the user can be provided with a service suitable for hours and the like. In this embodiment, the presentation (display) of information such as service information to the user is referred to as "service provision".

[1688]

The receiver 8300 may also obtain, by visible light communication, 3D information indicating the spatial placement of the sign 8301 with high accuracy (within a tolerance of 1 m), from the sign 8301 together with the device ID. Alternatively, the receiver 8300 may obtain the 3D information associated with the device ID from the server. The receiver 8300 may obtain size information indicating the size of the sign 8301, instead of or together with the 3D information. In the case of receiving the size information, the receiver 8300 can calculate the distance from the receiver 8300 to the sign 8301, based on the difference between the

size of the sign 8301 indicated by the size information and the size of the sign 8301 shown in the captured image.

[1689]

Moreover, when transmitting the device ID obtained by visible light communication to the server, the receiver 8300 may transmit retention information (ancillary information) retained in the receiver 8300 to the server together with the device ID. For instance, the retention information is personal information (e.g. age, sex) or a user ID of the user of the receiver 8300. Having received the retention information together with the device ID, the server transmits advertisement information associated with the retention information (the personal information or user ID) from among one or more sets of advertisement information associated with the device ID, to the receiver 8300. The receiver 8300 can thus receive store advertisement information suitable for the personal information and the like, store advertisement information corresponding to the user ID, or the like. As a result, the user can be provided with a more valuable service.

[1690]

As an alternative, the retention information indicates a reception condition set in the receiver 8300 beforehand. For example, in the case where the store is a restaurant, the reception condition is the number of customers. Having received such retention information together with the device ID, the server transmits advertisement information associated with the reception condition (the number of customers) from among one or more sets of advertisement information associated with the device ID, to the receiver 8300. The receiver 8300 can thus receive store advertisement information suitable for the number of customers, such as availability information for the number of customers. The store can achieve customer attraction and profit optimization, by displaying advertisement information with a different discount rate according to the number of customers, the day of the week, or the time of day.

[1691]

As another alternative, the retention information indicates the current position detected by the receiver 8300 beforehand. Having received such retention information together with the device ID, the server transmits not only advertisement information associated with the device ID but also one or more other device IDs corresponding to the current position (the current position and its surroundings) indicated by the retention information and advertisement information associated with each of the other device IDs, to the receiver 8300. The receiver 8300 can cache the other device IDs and the advertisement information associated with each of the other device IDs. Accordingly, when the receiver 8300 performs visible light communication with another transmitter in the current position (the current position and its surroundings), the receiver 8300 can promptly obtain advertisement information associated with the device ID of this other transmitter, with no need to access the server.

[1692]

FIG. 413 is a diagram illustrating an example of next operation of the receiver 8300 in the in-front-of-store situation.

[1693]

Upon obtaining the advertisement information from the server as described above, the receiver 8300 displays, for example, the "Seats available" button as the availability indicated by the advertisement information. When the user performs an operation of touching the "Seats available" button with his or her finger, the receiver 8300 notifies the server of the operation. When notified of the operation, the server makes a provisional reservation at the store of the sign 8301, and notifies the receiver 8300 of the completion of the provisional reservation. The receiver 8300 receives the notification from the server, and displays the character string "Provisional reservation" indicating the completion of the provisional reservation, instead of the "Seats available" button. The receiver 8300 stores an image including: the coupon of the store shown by the sign 8301; the character string "Provisional reservation" proving the provisional reservation at the store; and a barcode indicating the same contents, in a memory as a prior

obtainment image.

[1694]

Here, the server can log information relating to visible light communication performed between the sign 8301 and the receiver 8300, by the operation described with reference to FIGS. 412 and 413. In detail, the server can log the device ID of the transmitter (sign) performing visible light communication, the location where visible light communication is performed (the current position of the receiver 8300), the privilege data indicating, for example, the time when visible light communication is performed, the personal information of the user of the receiver 8300 performing visible light communication, and so on. Through the use of at least one of these logged sets of information, the server can analyze the value of the sign 8301, i.e. the contribution of the sign 8301 to the advertisement of the store, as advertising effectiveness.

[1695]

(Situation: in store)

An example of application in a situation where the user carrying the receiver 8300 enters the store corresponding to the displayed advertisement information (service information) is described next, with reference to FIGS. 414 to 422.

[1696]

FIG. 414 is a diagram illustrating an example of operation of a display device in the in-store situation.

[1697]

For example, the user of the receiver 8300 that has performed visible light communication with the above-mentioned sign 8301 enters the store corresponding to the displayed advertisement information. At this time, the receiver 8300 detects the user entering the store corresponding to the advertisement information displayed using visible light communication (i.e. detects the entrance). For instance, after performing visible light communication with the sign 8301, the receiver 8300 obtains store information indicating the location of the store associated with the device ID of the sign 8301, from the server. The receiver 8300 then

determines whether or not the current position of the receiver 8300 obtained using the GPS, the 9-axis sensor, or the like enters the location of the store indicated by the store information. The receiver 8300 detects the above-mentioned entrance, by determining that the current position enters the location of the store.

[1698]

Upon detecting the entrance, the receiver 8300 notifies a display device 8300b of the entrance, via the server or the like. Alternatively, the receiver 8300 notifies the display device 8300b of the entrance by visible light communication or wireless communication. When notified of the entrance, the display device 8300b obtains product service information indicating, for example, a menu of products or services provided in the store, and displays the menu indicated by the product service information. The display device 8300b may be a mobile terminal carried by the user of the receiver 8300 or the store staff, or a device installed in the store.

[1699]

FIG. 415 is a diagram illustrating an example of next operation of the display device 8300b in the in-store situation.

[1700]

The user selects a desired product from the menu displayed on the display device 8300b. In detail, the user performs an operation of touching the part of the menu where the name of the desired product is displayed. The display device 8300b receives the product selection operation result.

[1701]

FIG. 416 is a diagram illustrating an example of next operation of the display device 8300b in the in-store situation.

[1702]

Upon receiving the product selection operation result, the display device 8300b displays an image representing the selected product and the price of the product. The display device 8300b thus prompts the user to confirm the selected product. The image representing the product, information indicating the price of the product, and the like are included, for example, in the

above-mentioned product service information.

[1703]

FIG. 417 is a diagram illustrating an example of next operation of the receiver 8300 in the in-store situation.

[1704]

When prompted to confirm the selected product, the user performs an operation for ordering the product. After the operation is performed, the receiver 8300 notifies payment information necessary for electronic payment to a POS (Point of Sale) system of the store via the display device 8300b or the server. The receiver 8300 also determines whether or not there is the above-mentioned prior obtainment image which is obtained using visible light communication with the sign 8301 of the store and stored. In the case of determining that there is the prior obtainment image, the receiver 8300 displays the prior obtainment image.

[1705]

Though the display device 8300b is used in this situation, the receiver 8300 may perform the processes by the display device 8300b instead, without using the display device 8300b. In this case, upon detecting the entrance, the receiver 8300 obtains, from the server, the product service information indicating, for example, the menu of products or services provided in the store, and displays the menu indicated by the product service information. Moreover, upon receiving the operation for ordering the product, the receiver 8300 notifies the ordered product and the payment information necessary for electronic payment, to the POS system of the store via the server.

[1706]

FIG. 418 is a diagram illustrating an example of next operation of the receiver 8300 in the in-store situation.

[1707]

The store staff applies a barcode scanner 8302 of the POS system to the barcode in the prior obtainment image displayed on the receiver 8300. The barcode scanner 8302 reads the barcode in the prior obtainment image. As a result, the POS system completes the electronic payment according to the coupon indicated by the barcode.

The barcode scanner 8302 of the POS system then transmits, to the receiver 8300, payment completion information indicating the completion of the electronic payment, by changing in luminance. Thus, the barcode scanner 8302 also has a function as a transmitter in visible light communication. The receiver 8300 receives the payment completion information by visible light communication, and displays the payment completion information. For example, the payment completion information indicates the message "Thank you for your purchase" and the amount paid. As a result of such electronic payment, the POS system, the server, and the receiver 8300 can determine that, in the store corresponding to the advertisement information (service information) displayed in front of the store, the user uses the service indicated by the advertisement information.

[1708]

As described above, the product in the store is ordered through the operation of the receiver 8300, the POS system, and the like as illustrated in FIGS. 414 to 418. Accordingly, the user who has entered the store can order the product from the menu of the store automatically displayed on the display device 8300b or the receiver 8300. In other words, there is no need for the store staff to show the menu to the user and directly receive the order for the product from the user. This significantly reduces the burden on the store staff. Though the barcode scanner 8302 reads the barcode in the above example, the barcode scanner 8302 may not be used. For instance, the receiver 8300 may transmit the information indicated by the barcode, to the POS system via the server. The receiver 8300 may then obtain the payment completion information from the POS system via the server. This further reduces the store staff's workload, and allows the user to order the product without the store staff. Alternatively, the display device 8300b and the receiver 8300 may transfer the order and charging data with each other by visible light communication, or transfer the data by wireless communication using a key exchanged by visible light communication.

[1709]

There is the case where the sign 8301 is displayed by one of a plurality of stores belonging to a chain. In such a case, the advertisement information obtained from the sign 8301 using visible light communication can be used in all stores of the chain. Here, the service provided to the user may be different between a store (advertisement store) displaying the sign 8301 and a store (non-advertisement store) not displaying the sign 8301, even though they belong to the same chain. For example, in the case where the user enters the non-advertisement store, the user receives the service of the discount rate (e.g. 20%) according to the coupon indicated by the prior obtainment image. In the case where the user enters the advertisement store, the user receives the service of a higher discount rate (e.g. 30%) than the discount rate of the coupon. In detail, in the case of detecting the entrance into the advertisement store, the receiver 8300 obtains additional service information indicating an additional discount of 10% from the server, and displays an image indicating a discount rate of 30% (20% + 10%) instead of the prior obtainment image illustrated in FIG. 417. Here, the receiver 8300 detects whether the user enters the advertisement store or the non-advertisement store, based on the above-mentioned store information obtained from the server. The store information indicates the location of each of the plurality of stores belonging to the chain, and whether the store is the advertisement store or the non-advertisement store.

[1710]

In the case where a plurality of non-advertisement stores are included in the chain, the service provided to the user may be different in each of the non-advertisement stores. For instance, the service according to the distance from the position of the sign 8301 or the current position of the receiver 8300 when performing visible light communication with the sign 8301 to the non-advertisement store is provided to the user entering the non-advertisement store. Alternatively, the service according to the difference (time difference) between the time at which the receiver 8300 and the sign 8301 perform visible light communication and the time at which the

user enters the non-advertisement store is provided to the user entering the non-advertisement store. That is, the receiver 8300 obtains, from the server, additional service information indicating an additional discount that differs depending on the above-mentioned distance (the position of the sign 8301) and time difference, and displays an image indicating a discount rate (e.g. 30%) on which the additional discount has been reflected, instead of the prior obtainment image illustrated in FIG. 417. Note that such a service is determined by the server or the POS system, or by cooperation between the server and the POS system. The service may be applied to every store belonging to the chain, regardless of whether the store is the advertisement store or the non-advertisement store.

[1711]

In the case where the user enters the non-advertisement store and makes the order using the advertisement information, the POS system of the non-advertisement store may pass part of the amount earned as a result of the order, to the POS system of the advertisement store.

[1712]

Each time the advertisement information is displayed, the server may determine whether or not the advertisement information is used. By collecting the determination results, the server can easily analyze the advertising effectiveness of the sign 8301. Moreover, by collecting at least one of: the position of the sign 8301; the time at which the advertisement information is displayed; the position of the store in which the advertisement information is used; the time at which the advertisement information is used; and the time at which the user enters the store, the server can improve the accuracy of analyzing the advertising effectiveness of the sign 8301, and find the position of the sign 8301 highest in advertising effectiveness.

[1713]

The receiver 8300 may also obtain, from the server, additional service information indicating an additional discount corresponding to the number of times the advertisement information is used to

order the product (the number of uses), and display an image indicating a discount rate (e.g. 30%) on which the additional discount corresponding to the number of uses has been reflected, instead of the prior obtainment image illustrated in FIG. 417. For example, the server may provide such a service that sets a higher discount rate when the number of uses is larger, in cooperation with the POS system.

[1714]

In the case where the receiver 8300 receives advertisement information associated with each of the device IDs of all signs 8301 displayed by the store (i.e. in the case where the obtainment of all advertisement information is completed), the server may provide a good-value service to the user entering the store of the sign 8301. Examples of the good-value service include a service of a very high discount rate and a service of offering a product other than the ordered product free of charge. When the receiver 8300 detects the entrance of the user into the store, the server determines whether or not the receiver 8300 has performed the process including visible light communication and the like on each of all signs associated with the store. In the case where the server determines that the receiver 8300 has performed the process, the receiver 8300 obtains additional service information indicating an additional discount from the server as the above-mentioned good-value service, and displays an image indicating a discount rate (e.g. 50%) on which the additional discount has been reflected, instead of the prior obtainment image illustrated in FIG. 417.

[1715]

The receiver 8300 may also obtain, from the server, additional service information indicating an additional discount that differs depending on the difference between the time at which the receiver 8300 performs visible light communication with the sign 8301 and displays the advertisement information and the time at which the user enters the store, and display an image indicating a discount rate (e.g. 30%) on which the additional discount has been reflected, instead of the prior obtainment image illustrated in FIG. 417. For

instance, the receiver 8300 obtains additional service information indicating a higher discount rate when the difference is smaller, from the server.

[1716]

FIG. 419 is a diagram illustrating an example of next operation of the receiver 8300 in the in-store situation.

[1717]

Having completed the order and the electronic payment, the receiver 8300 receives a signal transmitted from a transmitter such as a lighting device in the store by changing in luminance, and transmits the signal to the server, thus obtaining an in-store guide map indicating the seat position (e.g. black circle) of the user. The receiver 8300 also specifies the position of the receiver 8300 using the received signal, as in any of Embodiments 1 to 15 described above. The receiver 8300 displays the specified position (e.g. star) of the receiver 8300 in the guide map. This enables the user to easily find the way to his or her seat.

[1718]

While the user is moving, too, the receiver 8300 frequently specifies the position of the receiver 8300 by performing visible light communication with a nearby transmitter such as a lighting device in the store. Hence, the receiver 8300 sequentially updates the displayed position (e.g. start) of the receiver 8300. The user can be appropriately guided to the seat in this manner.

[1719]

FIG. 420 is a diagram illustrating an example of next operation of the receiver 8300 in the in-store situation.

[1720]

When the user is seated, the receiver 8300 specifies the position of the receiver 8300 by performing visible light communication with a transmitter 8303 such as a lighting device, and determines that the position is the seat position of the user. The receiver 8300 notifies, together with the user name or nickname, that the user is seated, to a terminal in the store via the server. This enables the store staff to recognize which seat the user is in.

[1721]

FIG. 421 is a diagram illustrating an example of next operation of the receiver 8300 in the in-store situation.

[1722]

The transmitter 8303 transmits a signal including a customer ID and a message informing that the ordered product is ready, by changing in luminance. Note that, for example when obtaining the product service information indicating the product menu and the like from the server, the receiver 8300 also obtains the customer ID from the server and holds it. The receiver 8300 receives the signal, by performing visible light imaging on the transmitter 8303. The receiver 8300 determines whether or not the customer ID included in the signal matches the customer ID held beforehand. In the case of determining that they match, the receiver 8300 displays the message (e.g. "Your order is ready") included in the signal.

[1723]

FIG. 422 is a diagram illustrating an example of next operation of the receiver 8300 in the in-store situation.

[1724]

The store staff, having delivered the ordered product to the user's seat, directs a handheld terminal 8302a to the receiver 8300 in order to prove that the ordered product has been delivered. The handheld terminal 8302a functions as a transmitter. The handheld terminal 8302a transmits, to the receiver 8300, a signal indicating the delivery of the ordered product by changing in luminance. The receiver 8300 captures the handheld terminal 8302a to receive the signal, and displays a message (e.g. "Please enjoy your meal") indicated by the signal.

[1725]

(Situation: store search)

An example of application in a situation where the user carrying the receiver 8300 is searching for a store of interest is described below, with reference to FIGS. 423 to 425.

[1726]

FIG. 423 is a diagram illustrating an example of operation of

the receiver 8300 in the store search situation.

[1727]

The user finds a signage 8304 showing restaurants of interest. Upon determining that the signage 8304 is transmitting a signal by changing in luminance, the user operates the receiver 8300 to start the communication application of the receiver 8300, as in the example illustrated in FIG. 409. Alternatively, the receiver 8300 may automatically start the communication application as in the example illustrated in FIG. 410.

[1728]

FIG. 424 is a diagram illustrating an example of next operation of the receiver 8300 in the store search situation.

[1729]

The receiver 8300 captures the entire signage 8304 or a part of the signage 8304 showing a restaurant of the user's interest, to receive an ID for identifying the signage 8304 or the restaurant.

[1730]

FIG. 425 is a diagram illustrating an example of next operation of the receiver 8300 in the store search situation.

[1731]

Upon receiving the ID mentioned above, the receiver 8300 transmits the ID to the server, and obtains advertisement information (service information) associated with the ID from the server and displays it. Here, the receiver 8300 may notify the number of people (ancillary information) who are about to enter the restaurant, to the server together with the ID. As a result, the receiver 8300 can obtain advertisement information corresponding to the number of people. For example, the receiver 8300 can obtain advertisement information indicating that seats are available in the restaurant for the notified number of people.

[1732]

(Situation: movie advertisement)

An example of application in a situation where the user carrying the receiver 8300 is in front of a signage including a movie advertisement of interest is described below, with reference to FIGS.

426 to 429.

[1733]

FIG. 426 is a diagram illustrating an example of operation of the receiver 8300 in the movie advertisement situation.

[1734]

The user finds a signage 8305 including a movie advertisement of interest, and a signage 8306 such as a liquid crystal display for displaying movie advertisement video. The signage 8305 includes, for example, a transparent film on which an image representing the movie advertisement is drawn, and a plurality of LEDs arranged on the back side of the film and lights the film. That is, the signage 8305 brightly displays the image drawn on the film by the light emission from the plurality of LEDs, as a still image. The signage 8305 is a transmitter for transmitting a signal by changing in luminance.

[1735]

Upon determining that the signage 8305 is transmitting a signal by changing in luminance, the user operates the receiver 8300 to start the communication application of the receiver 8300, as in the example illustrated in FIG. 409. Alternatively, the receiver 8300 may automatically start the communication application as in the example illustrated in FIG. 410.

[1736]

FIG. 427 is a diagram illustrating an example of next operation of the receiver 8300 in the movie advertisement situation.

[1737]

The receiver 8300 captures the signage 8305, to obtain the ID of the signage 8305. The receiver 8300 transmits the ID to the server, downloads movie advertisement video data associated with the ID from the server as service information, and reproduces the video.

[1738]

FIG. 428 is a diagram illustrating an example of next operation of the receiver 8300 in the movie advertisement situation.

[1739]

Video displayed by reproducing the downloaded video data as mentioned above is the same as the video displayed by the signage 8306 as an example. Accordingly, in the case where the user wants to watch the movie advertisement video, the user can watch the video in any location without stopping in front of the signage 8306.

[1740]

FIG. 429 is a diagram illustrating an example of next operation of the receiver 8300 in the movie advertisement situation.

[1741]

The receiver 8300 may download not only the video data but also showing information indicating the showtimes of the movie and the like together with the video data, as service information. The receiver 8300 can then display the showing information to inform the user, and also share the showing information with other terminals (e.g. other smartphones).

[1742]

(Situation: museum)

An example of application in a situation where the user carrying the receiver 8300 enters a museum to appreciate each exhibit in the museum is described below, with reference to FIGS. 430 to 435.

[1743]

FIG. 430 is a diagram illustrating an example of operation of the receiver 8300 in the museum situation.

[1744]

For example, when entering the museum, the user finds a signboard 8307 on the entrance of the museum. Upon determining that the signboard 8307 is transmitting a signal by changing in luminance, the user operates the receiver 8300 to start the communication application of the receiver 8300, as in the example illustrated in FIG. 409. Alternatively, the receiver 8300 may automatically start the communication application as in the example illustrated in FIG. 410.

[1745]

FIG. 431 is a diagram illustrating an example of next operation

of the receiver 8300 in the museum situation.

[1746]

The receiver 8300 captures the signboard 8307, to obtain the ID of the signboard 8307. The receiver 8300 transmits the ID to the server, downloads a guide application program of the museum (hereafter referred to as "museum application") from the server as service information associated with the ID, and starts the museum application.

[1747]

FIG. 432 is a diagram illustrating an example of next operation of the receiver 8300 in the museum situation.

[1748]

After the museum application starts, the receiver 8300 displays a museum guide map according to the museum application. The receiver 8300 also specifies the position of the receiver 8300 in the museum, as in any of Embodiments 1 to 15 described above. The receiver 8300 displays the specified position (e.g. star) of the receiver 8300 in the guide map.

[1749]

To specify the position as mentioned above, the receiver 8300 obtains form information indicating the size, shape, and the like of the signboard 8307 from the server, for example when downloading the museum application. The receiver 8300 specifies the relative position of the receiver 8300 to the signboard 8307 by triangulation or the like, based on the size and shape of the signboard 8307 indicated by the form information and the size and shape of the signboard 8307 shown in the captured image.

[1750]

FIG. 433 is a diagram illustrating an example of next operation of the receiver 8300 in the museum situation.

[1751]

When the user enters the museum, the receiver 8300 which has started the museum application as mentioned above frequently specifies the position of the receiver 8300 by performing visible light communication with a nearby transmitter such as a lighting device in

the museum. For example, the receiver 8300 captures a transmitter 8308 such as a lighting device, to obtain the ID of the transmitter 8308 from the transmitter 8308. The receiver 8300 then obtains position information indicating the position of the transmitter 8308 and form information indicating the size, shape, and the like of the transmitter 8308 which are associated with the ID, from the server. The receiver 8300 estimates the relative position of the receiver 8300 to the transmitter 8308 by triangulation or the like, based on the size and shape of the transmitter 8308 indicated by the form information and the size and shape of the transmitter 8308 shown in the captured image. The receiver 8300 also specifies the position of the receiver 8300 in the museum, based on the position of the transmitter 8308 indicated by the position information obtained from the server and the estimated relative position of the receiver 8300.

[1752]

Each time the position of the receiver 8300 is specified, the receiver 8300 moves the displayed star to the specified new position. The user who has entered the museum can easily know his or her position in the museum, from the guide map and the star displayed on the receiver 8300.

[1753]

FIG. 434 is a diagram illustrating an example of next operation of the receiver 8300 in the museum situation.

[1754]

The user who has entered the museum, upon finding an exhibit 8309 of interest, performs an operation of pointing the receiver 8300 at the exhibit 8309 so that the receiver 8300 can capture the exhibit 8309. Here, the exhibit 8309 is lit by light from a lighting device 8310. The lighting device 8310 is used exclusively for the exhibit 8309, and is a transmitter for transmitting a signal by changing in luminance. Accordingly, the exhibit 8309 which is lit by the light changing in luminance is indirectly transmitting the signal from the lighting device 8310.

[1755]

Upon detecting the operation of pointing the receiver 8300 at the exhibit 8309 based on the output from the internal 9-axis sensor or the like, the receiver 8300 captures the exhibit 8309 to receive the signal from the lighting device 8310. The signal indicates the ID of the exhibit 8309, as an example. The receiver 8300 then obtains introduction information (service information) of the exhibit 8309 associated with the ID, from the server. The introduction information indicates a figure for introducing the exhibit 8309, and text for introduction in the language of each country such as Japanese, English, and French.

[1756]

Having obtained the introduction information from the server, the receiver 8300 displays the figure and the text indicated by the introduction information. When displaying the text, the receiver 8300 extracts text of a language set by the user beforehand from among text of each language, and displays only the text of the language. The receiver 8300 may change the language according to a selection operation by the user.

[1757]

FIG. 435 is a diagram illustrating an example of next operation of the receiver 8300 in the museum situation.

[1758]

After the display of the figure and the text in the introduction information ends according to a user operation, the receiver 8300 again specifies the position of the receiver 8300 by performing visible light communication with a nearby transmitter such as a lighting device (e.g. a lighting device 8311). Upon specifying the new position of the receiver 8300, the receiver 8300 moves the displayed star to the specified new position. Hence, the user who has appreciated the exhibit 8309 can easily move to the next exhibit of interest, by referring to the guide map and the star displayed on the receiver 8300.

[1759]

(Situation: bus stop)

An example of application in a situation where the user

carrying the receiver 8300 is at a bus stop is described below, with reference to FIGS. 436 to 437.

[1760]

FIG. 436 is a diagram illustrating an example of operation of the receiver 8300 in the bus stop situation.

[1761]

For example, the user goes to the bus stop to ride a bus. Upon determining that a sign 8312 at the bus stop is transmitting a signal by changing in luminance, the user operates the receiver 8300 to start the communication application of the receiver 8300, as in the example illustrated in FIG. 409. Alternatively, the receiver 8300 may automatically start the communication application as in the example illustrated in FIG. 410.

[1762]

FIG. 437 is a diagram illustrating an example of next operation of the receiver 8300 in the bus stop situation.

[1763]

The receiver 8300 captures the sign 8312, to obtain the ID of the bus stop where the sign 8312 is placed. The receiver 8300 transmits the ID to the server, and obtains operation state information associated with the ID from the server. The operation state information indicates the traffic state, and is service information indicating a service provided to the user.

[1764]

Here, the server collects information from each bus operating in an area including the bus stop, to manage the operation state of each bus. Hence, upon obtaining the ID of the bus stop from the receiver 8300, the server estimates the time at which a bus arrives at the bus stop of the ID based on the managed operation state, and transmits the operation state information indicating the estimated time to the receiver 8300.

[1765]

Having obtained the operation state information, the receiver 8300 displays the time indicated by the operation state information in a form such as "Arriving in 10 minutes". This enables the user to

easily recognize the operation state of the bus.

[1766]

(Supplementary note)

In the case where the scan direction on the imaging side is the vertical direction (up-down direction) of a mobile terminal, when an LED lighting device is captured with a shorter exposure time, bright lines of a black and white pattern can be captured in the same direction as the scan direction for ON/OFF of the entire LED lighting device, as illustrated in (a) in FIG. 438. In (a) in FIG. 438, a vertically long LED lighting device is captured so that its longitudinal direction is perpendicular to the scan direction on the imaging side (the left-right direction of the mobile terminal), and therefore many bright lines of the black and white pattern can be captured in the same direction as the scan direction. In other words, a larger amount of information can be transmitted and received. On the other hand, in the case where the vertically long LED lighting device is captured so as to be parallel to the scan direction on the imaging side (the up-down direction of the mobile terminal) as illustrated in (b) in FIG. 438, the number of bright lines of the black and white pattern that can be captured decreases. In other words, the amount of information that can be transmitted decreases.

[1767]

Thus, depending on the direction of the LED lighting device with respect to the scan direction on the imaging side, many bright lines of the black and white pattern can be captured (in the case where the vertically long LED lighting device is captured so that its longitudinal direction is perpendicular to the scan direction on the imaging side) or only a few bright lines of the black and white pattern can be captured (in the case where the vertically long LED lighting device is captured so that its longitudinal direction is parallel to the scan direction on the imaging side).

[1768]

This embodiment describes a lighting device control method capable of capturing many bright lines even in the case where only a few bright lines of the black and white pattern can be captured.

[1769]

FIG. 439 illustrates an example of a lighting device having a plurality of LEDs in the vertical direction, and a drive signal for the lighting device. (a) in FIG. 439 illustrates the lighting device having the plurality of LEDs in the vertical direction. Suppose each LED element corresponds to a smallest unit of horizontal stripes obtained by coding a visible light communication signal, and corresponds to a coded ON/OFF signal. By generating the black and white pattern and turning each LED element ON or OFF for lighting in this way, the black and white pattern on an LED element basis can be captured even when the scan direction on the imaging side and the longitudinal direction of the vertically long LED lighting device are parallel to each other.

[1770]

(c) and (d) in FIG. 439 illustrate an example of generating the black and white pattern and turning each LED element ON or OFF for lighting. When the lighting device lights as the black and white pattern, the light may become not uniform even in a short time. In view of this, an example of generating a reverse phase pattern and performing lighting alternately between the two patterns is illustrated in (c) and (d) in FIG. 439. Each element that is ON in (c) in FIG. 439 is OFF in (d) in FIG. 439, whereas each element that is OFF in (c) in FIG. 439 is ON in (d) in FIG. 439. By lighting in the black and white pattern alternately between the normal phase pattern and the reverse phase pattern in this way, a lot of information can be transmitted and received in visible light communication, without causing the light to become not uniform and without being affected by the relation between the scan direction on the imaging side and the direction of the lighting device. The present invention is not limited to the case of alternately generating two types of patterns, i.e. the normal phase pattern and the reverse phase pattern, for lighting, as three or more types of patterns may be generated for lighting. FIG. 440 illustrates an example of lighting in four types of patterns in sequence.

[1771]

A structure in which usually the entire LED lighting blinks ((b) in FIG. 439) and, only for a predetermined time, the black and white pattern is generated to perform lighting on an LED element basis is also available. As an example, the entire LED lighting blinks for a transmission and reception time of a predetermined data unit, and subsequently lighting is performed in the black and white pattern on an LED element basis for a short time. The predetermined data unit is, for instance, a data unit from the first header to the next header. In this case, when the LED lighting is captured in the direction in (a) in FIG. 438, a signal is received from bright lines obtained by capturing the blink of the entire LED lighting. When the LED lighting is captured in the direction in (b) in FIG. 438, a signal is received from a light emission pattern on an LED element basis.

[1772]

This embodiment is not limited to an LED lighting device, and is applicable to any device whose ON/OFF can be controlled in units of small elements like LED elements. Moreover, this embodiment is not limited to a lighting device, and is applicable to other devices such as a television, a projector, and a signage.

[1773]

Though an example of lighting in the black and white pattern is described in this embodiment, colors may be used instead of the black and white pattern. As an example, in RGB, blink may be performed using only B, while R and G are constantly ON. The use of only B rather than R or G prevents recognition by humans, and therefore suppresses flicker. As another example, additive complementary colors (e.g. a red and cyan pattern, a green and magenta pattern, a yellow and blue pattern) may be used to display ON/OFF, instead of the black and white pattern. The use of additive complementary colors suppresses flicker.

[1774]

Though an example of one-dimensionally arranging LED elements is described in this embodiment, LED elements may be arranged not one-dimensionally but two-dimensionally so as to be displayed like a 2D barcode.

[1775]

(Summary of this embodiment)

A service provision method in this embodiment is a service provision method of providing, using a terminal device that includes an image sensor having a plurality of exposure lines, a service to a user of the terminal device, the service provision method including: obtaining image data, by starting exposure sequentially for the plurality of exposure lines in the image sensor each at a different time and capturing a subject with an exposure time less than or equal to 1/480 second so that an exposure time of each of the plurality of exposure lines partially overlaps an exposure time of an adjacent one of the plurality of exposure lines; obtaining identification information of the subject, by demodulating a bright line pattern that appears in the image data, the bright line pattern corresponding to the plurality of exposure lines; and presenting service information associated with the identification information of the subject, to the user.

[1776]

In this way, through the use of communication between the subject and the terminal device respectively as a transmitter and a receiver, the service information relating to the subject can be presented to the user of the terminal device. The user can thus be provided with information variable to the user in various forms, as a service. For example, in the presenting, at least one of: information indicating an advertisement, availability, or reservation status of a store relating to the subject; information indicating a discount rate of a product or a service; movie advertisement video; information indicating a showtime of a movie; information for guiding in a building; information for introducing an exhibit; and information indicating a traffic state may be presented as the service information.

[1777]

For example, the service provision method may further include: transmitting, by the terminal device, the identification information of the subject to a server; and obtaining, by the terminal device, the service information associated with the identification information of the subject from the server, wherein in the presenting,

the terminal device presents the obtained service information to the user.

[1778]

In this way, the service information can be managed in the server in association with the identification information of the subject, which contributes to ease of maintenance such as service information update.

[1779]

For example, in the transmitting, ancillary information may be transmitted to the server together with the identification information of the subject, and in the obtaining of the service information, the service information associated with the identification information of the subject and the ancillary information may be obtained.

[1780]

In this way, a more suitable service for the user can be provided according to the ancillary information. For example, in the transmitting, personal information of the user, identification information of the user, number information indicating the number of people of a group including the user, or position information indicating a position of the terminal device may be transmitted as the ancillary information, as in the operation described with reference to FIGS. 412 and 425.

[1781]

For example, the service provision method may further include: transmitting, by the terminal device, position information indicating a position of the terminal device to the server; and obtaining, by the terminal device, one or more sets of identification information of respective one or more devices located in a predetermined range including the position indicated by the position information and one or more sets of service information respectively associated with the one or more sets of identification information, from the server and holding the one or more sets of identification information and the one or more sets of service information, wherein in the presenting, the terminal device selects service information associated with the identification information of the subject from the

one or more sets of service information held in the obtaining of the identification information, and presents the service information to the user.

[1782]

In this way, when the terminal device obtains the identification information of the subject, the terminal device can obtain the service information associated with the identification information of the subject from the one or more sets of service information held beforehand and present the service information without communicating with the server or the like, as in the operation described with reference to FIG. 410 as an example. Faster service provision can therefore be achieved.

[1783]

For example, the service provision method may further include: determining whether or not the user enters a store corresponding to the service information presented in the presenting, by specifying a position of the user; and in the case of determining that the user enters the store, obtaining, by the terminal device, product service information relating to a product or a service of the store from the server, and presenting the product service information to the user.

[1784]

In this way, when the user enters the store, the menu of the store or the like can be automatically presented to the user as the product service information, as in the operation described with reference to FIGS. 414 to 418 as an example. This saves the need for the store staff to present the menu or the like to the user, and enables the user to make an order to the store in a simple manner.

[1785]

For example, the service provision method may further include: determining whether or not the user enters a store corresponding to the service information presented in the presenting, by specifying a position of the user; and in the case of determining that the user enters the store, presenting, by the terminal device, additional service information of the store to the user, the additional

service information being different depending on at least one of the position of the subject and a time at which the service information is presented.

[1786]

In this way, when the subject is closer to the store which the user enters or when the time at which the user enters the store and the time at which the service information is presented (or the time at which the subject is captured) are closer to each other, service information more valuable to the user can be presented to the user as the additional service information, as in the process described with reference to FIGS. 414 to 418 as an example. Suppose each of a plurality of stores belonging to a chain is a store corresponding to the presented service information, and a sign which is the subject is displayed by one (advertisement store) of the plurality of stores. In such a case, the advertisement store is usually closest to the subject (sign) from among the plurality of stores belonging to the chain. Accordingly, when the subject is closer to the store which the user enters or when the time at which the user enters the store and the time at which the service information is presented are closer to each other, there is a high possibility that the store which the user enters is the advertisement store. In the case where there is a high possibility that the user enters the advertisement store, service information more valuable to the user can be presented to the user as the additional service information.

[1787]

For example, the service provision method may further include: determining whether or not the user enters a store corresponding to the service information presented in the presenting, by specifying a position of the user; and in the case of determining that the user enters the store, presenting, by the terminal device, additional service information of the store to the user, the additional service information being different depending on the number of times the user uses a service indicated by the service information in the store.

[1788]

In this way, when the number of times the service is used is larger, service information more valuable to the user can be presented to the user as the additional service information, as in the operation described with reference to FIGS. 414 to 418 as an example. For instance, when the number of uses of service information indicating 20% product price discount exceeds a threshold, additional service information indicating additional 10% discount can be presented to the user.

[1789]

For example, the service provision method may further include: determining whether or not the user enters a store corresponding to the service information presented in the presenting, by specifying a position of the user; in the case of determining that the user enters the store, determining whether or not a process including the obtaining of image data, the obtaining of identification information, and the presenting is also performed for all subjects associated with the store other than the subject; and presenting, by the terminal device, additional service information of the store to the user in the case of determining that the process is performed.

[1790]

In this way, for instance in the case where the store displays several subjects as signs and the obtaining of image data, the obtaining of identification information, and the presenting have been performed for all of these signs, service information most valuable to the user can be presented to the user as the additional service information, as in the operation described with reference to FIGS. 414 to 418 as an example.

[1791]

For example, the service provision method may further include: determining whether or not the user enters a store corresponding to the service information presented in the presenting, by specifying a position of the user; and in the case of determining that the user enters the store, presenting, by the terminal device, additional service information of the store to the user, the additional service information being different depending on a difference

between a time at which the service information is presented and a time at which the user enters the store.

[1792]

In this way, when the difference between the time at which the service information is presented (or the time at which the subject is captured) and the time at which the user enters the store is smaller, service information more valuable to the user can be presented to the user as the additional service information, as in the operation described with reference to FIGS. 414 to 418 as an example. That is, the time from when the service information is presented to the user as a result of capturing the subject to when the user enters the store is shorter, the user is additionally provided with a more valuable service.

[1793]

For example, the service provision method may further include: determining whether or not the user uses a service indicated by the service information in a store corresponding to the service information presented in the presenting; and accumulating, each time the service information is presented, a determination result in the determining, and analyzing an advertising effect of the subject based on an accumulation result.

[1794]

In this way, in the case where the service information indicates a service such as 20% product price discount or the like, it is determined whether or not the service is used by electronic payment or the like, as in the operation described with reference to FIGS. 414 to 418 as an example. Thus, each time the service is provided to the user upon capturing the subject, whether or not the service is used is determined. As a result, the advertising effect of the subject is analyzed as high in the case where, for example, it is frequently determined that the service is used. Hence, the advertising effect of the subject can be appropriately analyzed based on the use result.

[1795]

For example, in the analyzing, at least one of a position of the

subject, a time at which the service information is presented, a position of the store, and a time at which the user enters the store may be accumulated together with the determination result in the determining, to analyze the advertising effect of the subject based on an accumulation result.

[1796]

In this way, the advertising effect of the subject can be analyzed in more detail. For instance, in the case where the position of the subject is changed, it is possible to compare the advertising effect between the original position and the changed position, as a result of which the subject can be displayed at a position with higher advertising effectiveness.

[1797]

For example, the service provision method may further include: determining whether or not the user uses a service indicated by the service information in a store corresponding to the service information presented in the presenting; in the case of determining that the user uses the service, determining whether or not a used store which is the store where the service is used is a specific store associated with the subject; and in the case of determining that the used store is not the specific store, returning at least a part of an amount paid for using the service in the store, to the specific store using electronic commerce.

[1798]

In this way, even in the case where the service is not used in the specific store (e.g. the advertisement store displaying the sign which is the subject), the specific store can earn a profit for the cost of installing the sign which is the subject, as in the operation described with reference to FIGS. 414 to 418 as an example.

[1799]

For example, in the presenting, the terminal device may present the service information for introducing the subject to the user in the case where the subject lit by light changing in luminance is captured in the obtaining of the image data, and the terminal device may present the service information for guiding in a building

in which the subject is placed in the case where a lighting device changing in luminance is captured as the subject in the obtaining of the image data.

[1800]

In this way, a guide service in a building such as a museum and an introduction service for an exhibit which is the subject can be appropriately provided to the user, as in the operation described with reference to FIGS. 433 and 434 as an example.

[1801]

An information communication method in this embodiment is an information communication method of obtaining information from a subject having a plurality of light emitting elements, the information communication method including: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a bright line corresponding to an exposure line included in the image sensor appears according to a change in luminance of the subject; obtaining a bright line image by capturing, by the image sensor with the set exposure time, the subject in which the plurality of light emitting elements all change in luminance in the same manner according to a pattern of the change in luminance for representing first information, the bright line image being an image including the bright line; obtaining the first information by demodulating data specified by a pattern of the bright line included in the obtained bright line image; and obtaining second information, by capturing the subject in which each of the plurality of light emitting elements emits light with one of two different luminance values and demodulating data specified by a light and dark sequence of luminance along a direction parallel to the exposure line, the light and dark sequence being shown in an image obtained by capturing the subject.

[1802]

Alternatively, an information communication method in this embodiment is an information communication method of transmitting a signal using a change in luminance, the information communication method including: determining a pattern of the

change in luminance, by modulating a first signal to be transmitted; transmitting the first signal, by all of a plurality of light emitting elements in a light emitter changing in luminance in the same manner according to the determined pattern of the change in luminance; and transmitting a second signal to be transmitted, by each of the plurality of light emitting elements emitting light with one of two different luminance values so that a light and dark sequence of luminance appears in a space where the light emitter is placed.

[1803]

In this way, even when a lighting device which is the subject or the light emitter has a long and thin shape including a plurality of LEDs arranged in a line, the receiver can appropriately obtain the information or signal from the lighting device regardless of the imaging direction, as in the operation described with reference to FIGS. 438 to 440 as an example. In detail, in the case where the exposure line (the operation direction on the imaging side) of the image sensor included in the receiver is not parallel to the arrangement direction of the plurality of LEDs, the receiver can appropriately obtain the information or signal from the luminance change of the entire lighting device. Even in the case where the exposure line is parallel to the arrangement direction, the receiver can appropriately obtain the information or signal from the light and dark sequence of luminance along the direction parallel to the exposure line. In other words, the dependence of information reception on the imaging direction can be reduced.

[1804]

[Embodiment 17]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as a blink pattern of an LED, an organic EL device, or the like in Embodiments 1 to 16 described above.

[1805]

FIG. 441 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1806]

Transmitters 8321, 8322, and 8323 each have the same function as the transmitter in any of Embodiments 1 to 16 described above, and is a lighting device that transmits a signal by changing in luminance (visible light communication). The transmitters 8321 to 8323 each transmit a signal by changing in luminance at a different frequency. For example, the transmitter 8321 transmits the ID "1000" of the transmitter 8321, by changing in luminance at frequency a (e.g. 9200 Hz). The transmitter 8322 transmits the ID "2000" of the transmitter 8322, by changing in luminance at frequency b (e.g. 9600 Hz). The transmitter 8323 transmits the ID "3000" of the transmitter 8322, by changing in luminance at frequency c (e.g. 10000 Hz).

[1807]

A receiver captures (visible light imaging) the transmitters 8321 to 8323 so that the transmitters 8321 to 8323 are all included in the angle of view, in the same way as in Embodiments 1 to 16. A bright line pattern corresponding to each transmitter appears in an image obtained as a result of image capture. It is possible to specify, from the bright line pattern, the luminance change frequency of the transmitter corresponding to the bright line pattern.

[1808]

Suppose the frequencies of the transmitters 8321 to 8323 are the same. In such a case, the same frequency is specified from the bright line pattern corresponding to each transmitter. In the case where these bright line patterns are adjacent to each other, it is difficult to distinguish between the bright line patterns because the frequency specified from each of the bright line patterns is the same.

[1809]

In view of this, the transmitters 8321 to 8323 each change in luminance at a different frequency, as mentioned above. As a result, the receiver can easily distinguish between the bright line patterns and, by demodulating data specified by each bright line pattern, appropriately obtain the ID of each of the transmitters 8321 to 8323. Thus, the receiver can appropriately distinguish between the signals from the transmitters 8321 to 8323.

[1810]

The frequency of each of the transmitters 8321 to 8323 may be set by a remote control, and may be set randomly. Each of the transmitters 8321 to 8323 may communicate with its adjacent transmitter, and automatically set the frequency of the transmitter so as to be different from the frequency of the adjacent transmitter.

[1811]

FIG. 442 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1812]

In the above example, each transmitter changes in luminance at a different frequency. In the case where there are at least five transmitters, however, each transmitter need not change in luminance at a different frequency. In detail, each of the at least five transmitters may change in luminance at any one of four types of frequencies.

[1813]

For example as illustrated in FIG. 442, even in a situation where the bright line patterns (rectangles in FIG. 442) respectively corresponding to the at least five transmitters are adjacent, the same number of types of frequencies as the number of transmitters are not needed. So long as there are four types (frequencies a, b, c, and d), it can be ensured that the frequencies of adjacent bright line patterns are different. This is reasoned by the four color theorem or the four color problem.

[1814]

In detail, in this embodiment, each of the plurality of transmitters changes in luminance at any one of at least four types of frequencies, and two or more light emitters of the plurality of transmitters change in luminance at the same frequency. Moreover, the plurality of transmitters each change in luminance so that the luminance change frequency is different between all transmitters (bright line patterns as transmitter images) which, in the case where the plurality of transmitters are projected on the light receiving surface of the image sensor of the receiver, are adjacent to each

other on the light receiving surface.

[1815]

FIG. 443 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1816]

A transmitter changes in luminance to output high-luminance light (H) or low-luminance light (L) per predetermined time unit (slot), thereby transmitting a signal. Here, the transmitter transmits a signal for each block made up of a header and a body. The header is expressed as (L, H, L, H, L, H, H) using seven slots, as illustrated in FIG. 407A as an example. The body is made up of a plurality of symbols (00, 01, 10, or 11), where each symbol is expressed using four slots (4-value PPM). The block is expressed using a predetermined number (19 in the example in FIG. 443) of slots. For instance, an ID is obtained by combining the body included in each of four blocks. The block may instead be expressed using 33 slots.

[1817]

A bright line pattern obtained by image capture by a receiver includes a pattern (header pattern) corresponding to the header and a pattern (data pattern) corresponding to the body. The data pattern does not include the same pattern as the header pattern. Accordingly, the receiver can easily find the header pattern from the bright line pattern, and measure the number of pixels between the header pattern and the next header pattern (the number of exposure lines corresponding to the block). Since the number of slots per block (19 in the example in FIG. 43) is set to a fixed number regardless of the frequency, the receiver can specify the frequency (the inverse of the duration of one slot) of the transmitter according to the measured number of pixels. That is, the receiver specifies a lower frequency when the number of pixels is larger, and a higher frequency when the number of pixels is smaller.

[1818]

Thus, by capturing the transmitter, the receiver can obtain the ID of the transmitter, and also specify the frequency of the

transmitter. Through the use of the specified frequency, the receiver can determine whether or not the obtained ID is correct, that is, perform error detection on the ID. In detail, the receiver calculates a hash value for the ID, and compares the hash value with the specified frequency. In the case where the hash value and the frequency match, the receiver determines that the obtained ID is correct. In the case where the hash value and the frequency do not match, the receiver determines that the obtained ID is incorrect (error). For instance, the receiver uses the remainder when dividing the ID by a predetermined divisor, as the hash value. Conversely, the transmitter transmits the ID, by changing in luminance at the frequency (the inverse of the duration of one slot) of the same value as the hash value for the ID.

[1819]

FIG. 444 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[1820]

The transmitter may change in luminance using an arbitrary frequency, instead of using the frequency of the same value as the hash value as mentioned above. In this case, the transmitter transmits a signal indicating a value different from the ID of the transmitter. For example, in the case where the ID of the transmitter is "100" and the transmitter uses 2 kHz as an arbitrary frequency, the transmitter transmits the signal "1002" that combines the ID and the frequency. Likewise, in the case where the ID of another transmitter is "110" and this other transmitter uses 1 kHz as an arbitrary frequency, the other transmitter transmits the signal "1101" that combines the ID and the frequency.

[1821]

In such a case, the receiver uses the value of the last digit of the signal obtained from the transmitter for error detection, and extracts the value of the other digits as the ID of the transmitter. The receiver compares the frequency specified from the luminance pattern and the value of the last digit of the obtained signal. In the case where the value of the last digit and the frequency match, the

receiver determines that the extracted ID is correct. In the case where the value of the last digit and the frequency do not match, the receiver determines that the extracted ID is incorrect (error).

[1822]

In this way, the degree of freedom in setting the luminance change frequency in the transmitter can be increased, while enabling error detection in the receiver.

[1823]

FIG. 445 is a diagram illustrating an example of operation of a receiver in Embodiment 17.

[1824]

As illustrated in FIG. 445, there is the case where, in an image obtained by image capture (visible light imaging) by the receiver, a part of a bright line pattern 8327a and a part of a bright line pattern 8327b overlap each other. In such a case, the receiver does not demodulate data from an overlapping part 8327c of the bright line patterns 8327a and 8327b, and demodulates data from the parts of the bright line patterns 8327a and 8327b other than the part 8327c. By doing so, the receiver can obtain an appropriate ID from each of the bright line patterns 8327a and 8327b.

[1825]

FIG. 446 is a diagram illustrating an example of operation of a receiver in Embodiment 17.

[1826]

The transmitter switches, for each block as an example, the luminance change frequency for transmitting the block, as illustrated in (a) in FIG. 433. This enables the receiver to detect the block boundary more easily.

[1827]

Moreover, the transmitter uses different frequencies as the luminance change frequency for transmitting the header of the block and the luminance change frequency for transmitting the body of the block as an example, as illustrated in (b) in FIG. 433. This prevents the same pattern as the header from occurring in the body. As a result, the receiver can distinguish between the header and the body

more appropriately.

[1828]

FIG. 447 is a diagram illustrating an example of operation of a system including a transmitter, a receiver, and a server in Embodiment 17.

[1829]

The system in this embodiment includes a transmitter 8331, a receiver 8332, and a server 8333. The transmitter 8331 has the same function as the transmitter in any of Embodiments 1 to 16 described above, and is a lighting device that transmits the ID of the transmitter 8331 by changing in luminance (visible light communication). The receiver 8332 has the same function as the receiver in any of Embodiments 1 to 16 described above, and obtains the ID of the transmitter 8331 from the transmitter 8331 by capturing the transmitter 8331 (visible light imaging). The server 8333 communicates with the transmitter 8331 and the receiver 8332 via a network such as the Internet.

[1830]

Note that, in this embodiment, the ID of the transmitter 8331 is fixed without a change. Meanwhile, the frequency used for the luminance change (visible light communication) of the transmitter 8331 can be arbitrarily changed by setting.

[1831]

In such a system, first the transmitter 8331 registers the frequency used for the luminance change (visible light communication), in the server 8333. In detail, the transmitter 8331 transmits the ID of the transmitter 8331, registered frequency information indicating the frequency of the transmitter 8331, and related information relating to the transmitter 8331, to the server 8333. Upon receiving the ID, registered frequency information, and related information of the transmitter 8331, the server 8333 records them in association with each other. That is, the ID of the transmitter 8331, the frequency used for the luminance change of the transmitter 8331, and the related information are recorded in association with each other. The frequency used for the luminance

change of the transmitter 8331 is registered in this way.

[1832]

Next, the transmitter 8331 transmits the ID of the transmitter 8331, by changing in luminance at the registered frequency. The receiver 8332 captures the transmitter 8331 to obtain the ID of the transmitter 8331, and specifies the luminance change frequency of the transmitter 8331 as mentioned above.

[1833]

The receiver 8332 then transmits the obtained ID and specified frequency information indicating the specified frequency, to the server 8333. Upon receiving the ID and the specified frequency information transmitted from the receiver 8332, the server 8333 searches for the frequency (the frequency indicated by the registered frequency information) recorded in association with the ID, and determines whether or not the recorded frequency and the frequency indicated by the specified frequency information match. In the case of determining that the frequencies match, the server 8333 transmits the related information (data) recorded in association with the ID and the frequency, to the receiver 8332.

[1834]

If the frequency specified by the receiver 8332 does not match the frequency registered in the server 8333, the related information is not transmitted from the server 8333 to the receiver 8332. Therefore, by changing the frequency registered in the server 8333 according to need, it is possible to prevent a situation where, once the receiver 8332 has obtained the ID from the transmitter 8331, the receiver 8332 can receive the related information from the server 8333 at any time. In detail, by changing the frequency registered in the server 8333 (i.e. the frequency used for the luminance change), the transmitter 8331 can prohibit the receiver 8332 that has obtained the ID before the change, from obtaining the related information. In other words, by changing the frequency, it is possible to set a time limit for the obtainment of the related information. As an example, in the case where the user of the receiver 8332 stays at a hotel in which the transmitter 8331 is

installed, an administrator in the hotel changes the frequency after the stay. Hence, the receiver 8332 can obtain the related information only on the date when the user stays at the hotel, and is prohibited from obtaining the related information after the stay.

[1835]

The server 8333 may register a plurality of frequencies in association with one ID. For instance, each time the server 8333 receives the registered frequency information from the receiver 8332, the server 8333 registers the frequencies indicated by four latest sets of registered frequency information, in association with the ID. This allows even the receiver 8332 which obtained the ID in the past, to obtain the related information from the server 8333 until the frequency is changed three times. The server 8333 may also manage, for each registered frequency, the time at which or period during which the frequency is set in the transmitter 8331. In such a case, upon receiving the ID and the specified frequency information from the receiver 8332, the server 8333 can specify the period during which the receiver 8332 obtains the ID, by referring to the time period and the like managed for the frequency indicated by the specified frequency information.

[1836]

FIG. 448 is a block diagram illustrating a structure of a transmitter in Embodiment 17.

[1837]

A transmitter 8334 has the same function as the transmitter in any of Embodiments 1 to 16 described above, and includes a frequency storage unit 8335, an ID storage unit 8336, a check value storage unit 8337, a check value comparison unit 8338, a check value calculation unit 8339, a frequency calculation unit 8340, a frequency comparison unit 8341, a transmission unit 8342, and an error reporting unit 8343.

[1838]

The frequency storage unit 8335 stores the frequency used for the luminance change (visible light communication). The ID storage unit 8336 stores the ID of the transmitter 8334. The check value

storage unit 8337 stores a check value for determining whether or not the ID stored in the ID storage unit 8336 is correct.

[1839]

The check value calculation unit 8339 reads the ID stored in the ID storage unit 8336, and applies a predetermined function to the ID to calculate a check value (calculated check value) for the ID. The check value comparison unit 8338 reads the check value stored in the check value storage unit 8337, and compares the check value with the calculated check value calculated by the check value calculation unit 8339. In the case of determining that the calculated check value is different from the check value, the check value comparison unit 8338 notifies an error to the error reporting unit 8343. For example, the check value storage unit 8337 stores the value "0" indicating that the ID stored in the ID storage unit 8336 is an even number, as the check value. The check value calculation unit 8339 reads the ID stored in the ID storage unit 8336, and divides it by the value "2" to calculate the remainder as the calculated check value. The check value comparison unit 8338 compares the check value "0" and the calculated check value which is the remainder of the division mentioned above.

[1840]

The frequency calculation unit 8340 reads the ID stored in the ID storage unit 8336 via the check value calculation unit 8339, and calculates the frequency (calculated frequency) from the ID. For instance, the frequency calculation unit 8340 divides the ID by a predetermined value, to calculate the remainder as the frequency. The frequency comparison unit 8341 compares the frequency (stored frequency) stored in the frequency storage unit 8335 and the calculated frequency. In the case of determining that the calculated frequency is different from the stored frequency, the frequency comparison unit 8341 notifies an error to the error reporting unit 8343.

[1841]

The transmission unit 8342 transmits the ID stored in the ID storage unit 8336, by changing in luminance at the calculated

frequency calculated by the frequency calculation unit 8340.

[1842]

The error reporting unit 8343, when notified of the error from at least one of the check value comparison unit 8338 and the frequency comparison unit 8341, reports the error by buzzer sound, blink, or lighting. In detail, the error reporting unit 8343 includes a lamp for error reporting, and reports the error by lighting or blinking the lamp. Alternatively, when the power switch of the transmitter 8334 is turned on, the error reporting unit 8343 reports the error by blinking, at a frequency perceivable by humans, a light source that changes in luminance to transmit a signal such as an ID, for a predetermined period (e.g. 10 seconds).

[1843]

Thus, whether or not the ID stored in the ID storage unit 8336 and the frequency calculated from the ID are correct is checked, with it being possible to prevent erroneous ID transmission and luminance change at an erroneous frequency.

[1844]

FIG. 449 is a block diagram illustrating a structure of a receiver in Embodiment 17.

[1845]

A receiver 8344 has the same function as the receiver in any of Embodiments 1 to 16 described above, and includes a light receiving unit 8345, a frequency detection unit 8346, an ID detection unit 8347, a frequency comparison unit 3848, and a frequency calculation unit 8349.

[1846]

The light receiving unit 8345 includes an image sensor as an example, and captures (visible light imaging) a transmitter that changes in luminance to obtain an image including a bright line pattern. The ID detection unit 8347 detects the ID of the transmitter from the image. That is, the ID detection unit 8347 obtains the ID of the transmitter, by demodulating data specified by the bright line pattern included in the image. The frequency detection unit 8346 detects the luminance change frequency of the

transmitter, from the image. That is, the frequency detection unit 8346 specifies the frequency of the transmitter from the bright line pattern included in the image, as in the example described with reference to FIG. 443.

[1847]

The frequency calculation unit 8349 calculates the frequency of the transmitter from the ID detected by the ID detection unit 8347, for example by dividing the ID as mentioned above. The frequency comparison unit 8348 compares the frequency detected by the frequency detection unit 8346 and the frequency calculated by the frequency calculation unit 8349. In the case where these frequencies are different, the frequency comparison unit 8348 determines that the detected ID is an error, and causes the ID detection unit 8347 to detect the ID again. Obtainment of an erroneous ID can be prevented in this way.

[1848]

FIG. 450 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1849]

The transmitter may transmit each of the symbols "00, 01, 10, 10" separately, by making the luminance change position in a predetermined time unit different.

[1850]

For example, when transmitting the symbol "00", the transmitter transmits the symbol "00" by changing in luminance only for a first section which is the first section in the time unit. When transmitting the symbol "01", the transmitter transmits the symbol "01" by changing in luminance only for a second section which is the second section in the time unit. Likewise, when transmitting the symbol "10", the transmitter transmits the symbol "10" by changing in luminance only for a third section which is the third section in the time unit. When transmitting the symbol "11", the transmitter transmits the symbol "11" by changing in luminance only for a fourth section which is the fourth section in the time unit.

[1851]

Thus, in this embodiment, the luminance changes in one section regardless of which symbol is transmitted, so that flicker can be suppressed as compared with the above-mentioned transmitter that causes one entire section (slot) to be low in luminance.

[1852]

FIG. 451 is a diagram illustrating an example of a transmitter in Embodiment 17.

[1853]

The transmitter may transmit each of the symbols "0, 1" separately, by making whether or not the luminance changes in a predetermined time unit different. For example, when transmitting the symbol "0", the transmitter transmits the symbol "0" by not changing in luminance in the time unit. When transmitting the symbol "1", the transmitter transmits the symbol "1" by changing in luminance in the time unit.

[1854]

FIG. 452 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1855]

The transmitter may transmit each of the symbols "00, 01, 10, 10" separately, by making the luminance change frequency in a predetermined time unit different. For example, when transmitting the symbol "00", the transmitter transmits the symbol "00" by not changing in luminance in the time unit. When transmitting the symbol "01", the transmitter transmits the symbol "01" by changing in luminance (changing in luminance at a low frequency) in the time unit. When transmitting the symbol "10", the transmitter transmits the symbol "10" by changing in luminance sharply (changing in luminance at a high frequency) in the time unit. When transmitting the symbol "11", the transmitter transmits the symbol "11" by changing in luminance more sharply (changing in luminance at a higher frequency) in the time unit.

[1856]

FIG. 453 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1857]

The transmitter may transmit each of the symbols "0, 1" separately, by making the phase of the luminance change in a predetermined time unit different. For example, when transmitting the symbol "0", the transmitter transmits the symbol "0" by changing in luminance in a predetermined phase in the time unit. When transmitting the symbol "1", the transmitter transmits the symbol "1" by changing in luminance in the reverse phase of the above-mentioned phase in the time unit.

[1858]

FIG. 454 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1859]

When transmitting a signal such as an ID, the transmitter changes in luminance according to color such as red, green and blue. The transmitter can therefore transmit a signal of a larger amount of information, to a receiver capable of recognizing the luminance change according to color. The luminance change of any of the colors may be used for clock synchronization. For example, the luminance change of red color may be used for clock synchronization. In this case, the luminance change of red color serves as a header. Since there is no need to use a header for the luminance change of each color (green and blue) other than red, redundant data transmission can be avoided.

[1860]

FIG. 455 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1861]

The transmitter may express the luminance of synthetic color (e.g. white) by synthesizing a plurality of colors such as red, green, and blue. In other words, the transmitter expresses the luminance change of synthetic color, by changing in luminance according to color such as red, green, and blue. A signal is transmitted using this luminance change of synthetic color, as in the above-mentioned visible light communication. Here, the luminance of one or more

colors of red, green, and blue may be used for adjustment when expressing predetermined luminance of synthetic color. This enables the signal to be transmitted using the luminance change of synthetic color, and also enables the signal to be transmitted using the luminance change of any two colors of red, green, and blue. The transmitter can therefore transmit a signal even to a receiver capable of recognizing only the luminance change of the above-mentioned synthetic color (e.g. white), and also transmit more signals as ancillary information to a receiver capable of recognizing each color such as red, green, and blue.

[1862]

FIG. 456 is a diagram illustrating an example of operation of a transmitter in Embodiment 17.

[1863]

The transmitter includes four light sources. The four light sources (e.g. LED lights) emit light of the colors expressed by different positions 8351a, 8351b, 8352a, and 8352b in a CIExy chromaticity diagram illustrated in FIG. 456.

[1864]

The transmitter transmits each signal by switching between first lighting transmission and second lighting transmission. The first lighting transmission is a process of transmitting the signal "0" by turning on the light source for emitting light of the color of the position 8351a and the light source for emitting the light of the color of the position 8351b from among the four light sources. The second lighting transmission is a process of transmitting the signal "1" by turning on the light source for emitting light of the color of the position 8352a and the light source for emitting the light of the color of the position 8352b. The image sensor in the receiver can identify the color expressed by each of the positions 8351a, 8351b, 8352a, and 8352b, and so the receiver can appropriately receive the signal "0" and the signal "1".

[1865]

During the first lighting transmission, the color expressed by the intermediate position between the positions 8351a and 8351b in

the CIExy chromaticity diagram is seen by the human eye. Likewise, during the second lighting transmission, the color expressed by the intermediate position between the positions 8352a and 8352b in the CIExy chromaticity diagram is seen by the human eye. Therefore, by appropriately adjusting the color and luminance of each of the four light sources, it is possible to match the intermediate position between the positions 8351a and 8351b and the intermediate position between the positions 8352a and 8352b to each other (to a position 8353). As a result, even when the transmitter switches between the first lighting transmission and the second lighting transmission, to the human eye the light emission color of the transmitter appears to be fixed. Flicker perceived by humans can thus be suppressed.

[1866]

FIG. 457 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[1867]

The transmitter includes an ID storage unit 8361, a random number generation unit 8362, an addition unit 8363, an encryption unit 8364, and a transmission unit 8365. The ID storage unit 8361 stores the ID of the transmitter. The random number generation unit 8362 generates a different random number at regular time intervals. The addition unit 8363 combines the ID stored in the ID storage unit 8361 with the latest random number generated by the random number generation unit 8362, and outputs the result as an edited ID. The encryption unit 8364 encrypts the edited ID to generate an encrypted edited ID. The transmission unit 8365 transmits the encrypted edited ID to the receiver by changing in luminance.

[1868]

The receiver includes a reception unit 8366, a decryption unit 8367, and an ID obtainment unit 8368. The reception unit 8366 receives the encrypted edited ID from the transmitter, by capturing the transmitter (visible light imaging). The decryption unit 8367 decrypts the received encrypted edited ID to restore the edited ID.

The ID obtainment unit 8368 extracts the ID from the edited ID, thus obtaining the ID.

[1869]

For instance, the ID storage unit 8361 stores the ID "100", and the random number generation unit 8362 generates a new random number "817" (example 1). In this case, the addition unit 8363 combines the ID "100" with the random number "817" to generate the edited ID "100817", and outputs it. The encryption unit 8364 encrypts the edited ID "100817" to generate the encrypted edited ID "abced". The decryption unit 8367 in the receiver decrypts the encrypted edited ID "abced" to restore the edited ID "100817". The ID obtainment unit 8368 extracts the ID "100" from the restored edited ID "100817". In other words, the ID obtainment unit 8368 obtains the ID "100" by deleting the last three digits of the edited ID.

[1870]

Next, the random number generation unit 8362 generates a new random number "619" (example 2). In this case, the addition unit 8363 combines the ID "100" with the random number "619" to generate the edited ID "100619", and outputs it. The encryption unit 8364 encrypts the edited ID "100619" to generate the encrypted edited ID "difia". The decryption unit 8367 in the receiver decrypts the encrypted edited ID "difia" to restore the edited ID "100619". The ID obtainment unit 8368 extracts the ID "100" from the restored edited ID "100619". In other words, the ID obtainment unit 8368 obtains the ID "100" by deleting the last three digits of the edited ID.

[1871]

Thus, the transmitter does not simply encrypt the ID but encrypts its combination with the random number changed at regular time intervals, with it being possible to prevent the ID from being easily cracked from the signal transmitted from the transmission unit 8365. That is, in the case where the simply encrypted ID is transmitted from the transmitter to the receiver a plurality of times, even though the ID is encrypted, the signal transmitted from the transmitter to the receiver is the same if the ID is the same, so that there is a possibility of the ID being cracked. In the example

illustrated in FIG. 457, however, the ID is combined with the random number changed at regular time intervals, and the ID combined with the random number is encrypted. Therefore, even in the case where the same ID is transmitted to the receiver a plurality of times, if the time of transmitting the ID is different, the signal transmitted from the transmitter to the receiver is different. This protects the ID from being cracked easily.

[1872]

FIG. 458 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[1873]

The transmitter includes an ID storage unit 8371, a timer unit 8372, an addition unit 8373, an encryption unit 8374, and a transmission unit 8375. The ID storage unit 8371 stores the ID of the transmitter. The timer unit 8372 counts time, and outputs the current date and time (the current year, month, day, and time). The addition unit 8373 combines the ID stored in the ID storage unit 8371 with the current date and time output from the timer unit 8372 as a transmission date and time, and outputs the result as an edited ID. The encryption unit 8374 encrypts the edited ID to generate an encrypted edited ID. The transmission unit 8375 transmits the encrypted edited ID to the receiver by changing in luminance.

[1874]

The receiver includes a reception unit 8376, a decryption unit 8377, a validity determination unit 8378, and a timer unit 8379. The reception unit 8376 receives the encrypted edited ID from the transmitter, by capturing the transmitter (visible light imaging). The decryption unit 8377 decrypts the received encrypted edited ID to restore the edited ID. The timer unit 8379 counts time, and outputs the current date and time (the current year, month, day, and time). The validity determination unit 8378 extracts the ID from the restored edited ID, thus obtaining the ID. The validity determination unit 8378 also extracts the transmission date and time from the restored edited ID, and compares the transmission date and time with the current date and time output from the timer unit 8379

to determine the validity of the ID. For example, in the case where the difference between the transmission date and time and the current date and time is longer than a predetermined time or in the case where the transmission date and time is later than the current date and time, the validity determination unit 8378 determines that the ID is invalid.

[1875]

For instance, the ID storage unit 8371 stores the ID "100", and the timer unit 8372 outputs the current date and time "201305011200" (2013/5/1 12:00) as the transmission date and time (example 1). In this case, the addition unit 8373 combines the ID "100" with the transmission date and time "201305011200" to generate the edited ID "100201305011200", and outputs it. The encryption unit 8374 encrypts the edited ID "100201305011200" to generate the encrypted edited ID "ei39ks". The decryption unit 8377 in the receiver decrypts the encrypted edited ID "ei39ks" to restore the edited ID "100201305011200". The validity determination unit 8378 extracts the ID "100" from the restored edited ID "100201305011200". In other words, the validity determination unit 8378 obtains the ID "100" by deleting the last 12 digits of the edited ID. The validity determination unit 8378 also extracts the transmission date and time "201305011200" from the restored edited ID "100201305011200". If the transmission date and time "201305011200" is earlier than the current date and time output from the timer unit 8379 and the difference between the transmission date and time and the current date and time is within, for example, 10 minutes, the validity determination unit 8378 determines that the ID "100" is valid.

[1876]

On the other hand, the ID storage unit 8371 stores the ID "100", and the timer unit 8372 outputs the current date and time "201401011730" (2014/1/1 17:30) as the transmission date and time (example 2). In this case, the addition unit 8373 combines the ID "100" with the transmission date and time "201401011730" to generate the edited ID "100201401011730", and outputs it. The

encryption unit 8374 encrypts the edited ID "100201401011730" to generate the encrypted edited ID "002jflk". The decryption unit 8377 in the receiver decrypts the encrypted edited ID "002jflk" to restore the edited ID "100201401011730". The validity determination unit 8378 extracts the ID "100" from the restored edited ID "100201401011730". In other words, the validity determination unit 8378 obtains the ID "100" by deleting the last 12 digits of the edited ID. The validity determination unit 8378 also extracts the transmission date and time "201401011730" from the restored edited ID "100201401011730". If the transmission date and time "201401011730" is later than the current date and time output from the timer unit 8379, the validity determination unit 8378 determines that the ID "100" is invalid.

[1877]

Thus, the transmitter does not simply encrypt the ID but encrypts its combination with the current date and time changed at regular time intervals, with it being possible to prevent the ID from being easily cracked from the signal transmitted from the transmission unit 8375. That is, in the case where the simply encrypted ID is transmitted from the transmitter to the receiver a plurality of times, even though the ID is encrypted, the signal transmitted from the transmitter to the receiver is the same if the ID is the same, so that there is a possibility of the ID being cracked. In the example illustrated in FIG. 458, however, the ID is combined with the current date and time changed at regular time intervals, and the ID combined with the current date and time is encrypted. Therefore, even in the case where the same ID is transmitted to the receiver a plurality of times, if the time of transmitting the ID is different, the signal transmitted from the transmitter to the receiver is different. This protects the ID from being cracked easily.

[1878]

Moreover, whether or not the obtained ID is valid is determined by comparing the transmission date and time of the encrypted edited ID and the current date and time. Thus, the validity of the ID can be managed based on the

transmission/reception time.

[1879]

Note that the receiver illustrated in each of FIGS. 457 and 458 may, upon obtaining the encrypted edited ID, transmit the encrypted edited ID to the server, and obtain the ID from the server.

[1880]

(Station guide)

FIG. 459 is a diagram illustrating an example of use according to the present invention on a train platform. A user points a mobile terminal at an electronic display board or a lighting, and obtains information displayed on the electronic display board or train information or station information of a station where the electronic display board is installed, by visible light communication. Here, the information displayed on the electronic display board may be directly transmitted to the mobile terminal by visible light communication, or ID information corresponding to the electronic display board may be transmitted to the mobile terminal so that the mobile terminal inquires of a server using the obtained ID information to obtain the information displayed on the electronic display board. In the case where the ID information is transmitted from the mobile terminal, the server transmits the information displayed on the electronic display board to the mobile terminal, based on the ID information. Train ticket information stored in a memory of the mobile terminal is compared with the information displayed on the electronic display board and, in the case where ticket information corresponding to the ticket of the user is displayed on the electronic display board, an arrow indicating the way to the platform at which the train the user is going to ride arrives is displayed on a display of the mobile terminal. An exit or a path to a train car near a transfer route may be displayed when the user gets off a train. When a seat is reserved, a path to the seat may be displayed. When displaying the arrow, the same color as the train line in a map or train guide information may be used to display the arrow, to facilitate understanding. Reservation information (platform number, car number, departure time, seat number) of the user may be displayed together with the

arrow. A recognition error can be prevented by also displaying the reservation information of the user. In the case where the ticket is stored in a server, the mobile terminal inquires of the server to obtain the ticket information and compares it with the information displayed on the electronic display board, or the server compares the ticket information with the information displayed on the electronic display board. Information relating to the ticket information can be obtained in this way. The intended train line may be estimated from a history of transfer search made by the user, to display the route. Not only the information displayed on the electronic display board but also the train information or station information of the station where the electronic display board is installed may be obtained and used for comparison. Information relating to the user in the electronic display board displayed on the display may be highlighted or modified. In the case where the train ride schedule of the user is unknown, a guide arrow to each train line platform may be displayed. When the station information is obtained, a guide arrow to souvenir shops and toilets may be displayed on the display. The behavior characteristics of the user may be managed in the server so that, in the case where the user frequently goes to souvenir shops or toilets in a train station, the guide arrow to souvenir shops and toilets is displayed on the display. By displaying the guide arrow to souvenir shops and toilets only to each user having the behavior characteristics of going to souvenir shops or toilets while not displaying the guide arrow to other users, it is possible to reduce processing. The guide arrow to souvenir shops and toilets may be displayed in a different color from the guide arrow to the platform. When displaying both arrows simultaneously, a recognition error can be prevented by displaying them in different colors. Though a train example is illustrated in FIG. 459, the same structure is applicable to display for planes, buses, and so on.

[1881]

(Guide sign translation)

FIG. 460 is a diagram illustrating an example of obtaining information from an electronic guidance display board installed in an

airport, a train station, a hospital, or the like by visible light communication. Information displayed on the electronic guidance display board is obtained by visible light communication and, after the displayed information is translated into language information set in a mobile terminal, the information is displayed on a display of the mobile terminal. Since the displayed information has been translated into the language of the user, the user can easily understand the information. The language translation may be performed in the mobile terminal or in a server. In the case of performing the translation in the server, the mobile terminal may transmit the displayed information obtained by visible light communication and the language information of the mobile terminal to the server. The server then performs the translation and transmits the translated information to the mobile terminal, and the mobile terminal displays the information on the display. In the case of obtaining ID information from the electronic guidance display board, the mobile terminal may transmit ID information to the server, and obtain display information corresponding to the ID information from the server. Furthermore, a guide arrow indicating where the user should go next may be displayed based on nationality information, ticket information, or baggage check information stored in the mobile terminal.

[1882]

(Coupon popup)

FIG. 461 is a diagram illustrating an example of displaying, on a display of a mobile terminal, coupon information obtained by visible light communication or a popup when a user comes close to a store. The user obtains the coupon information of the store from an electronic display board or the like by visible light communication, using his or her mobile terminal. After this, when the user enters a predetermined range from the store, the coupon information of the store or a popup is displayed. Whether or not the user enters the predetermined range from the store is determined using GPS information of the mobile terminal and store information included in the coupon information. The information is not limited to coupon

information, and may be ticket information. Since the user is automatically alerted when coming close to a store where a coupon or a ticket can be used, the user can use the coupon or the ticket effectively.

[1883]

FIG. 462 is a diagram illustrating an example of displaying coupon information, ticket information, or a popup on a display of a mobile terminal at a cash register, a ticket gate, or the like. Position information is obtained from a lighting installed at the cash register or the ticket gate, by visible light communication. In the case where the obtained position information matches information included in the coupon information or the ticket information, the display is performed. A barcode reader may include a light emitting unit so that the position information is obtained by performing visible light communication with the light emitting unit. Alternatively, the position information may be obtained from the GPS of the mobile terminal. A transmitter may be installed near the cash register so that, when the user points the receiver at the transmitter, the coupon or payment information is displayed on the display of the receiver. The receiver may also perform the payment process by communicating with the server. The coupon information or the ticket information may include Wi-Fi information installed in a store or the like so that, in the case where the mobile terminal of the user obtains the same information as the W-Fi information included in the coupon information or the ticket information, the display is performed.

[1884]

(Start of operation application)

FIG. 463 is a diagram illustrating an example where a user obtains information from a home appliance by visible light communication using a mobile terminal. In the case where ID information or information related to the home appliance is obtained from the home appliance by visible light communication, an application for operating the home appliance starts automatically. FIG. 463 illustrates an example of using a TV. Thus, merely pointing

the mobile terminal at the home appliance enables the application for operating the home appliance to start.

[1885]

(Stopping transmission during operation of barcode reader)

FIG. 464 is a diagram illustrating an example of stopping, when a barcode reader 8405a reads a barcode of a product, data communication for visible light communication is stopped near the barcode reader 8405a. By stopping visible light communication during barcode read, the barcode reader 8405a can be kept from erroneously recognizing the barcode. When a barcode read button is pressed, the barcode reader 8405a transmits a transmission stop signal to a visible light signal transmitter 8405b. When the finger is released from the button or when a predetermined time has elapsed after the release, the barcode reader 8405a transmits a transmission restart signal to the visible light signal transmitter 8405b. The transmission stop signal or the transmission restart signal is transmitted by wired/wireless communication, infrared communication, or sound wave communication. The barcode reader 8405a may transmit the transmission stop signal upon estimating that the barcode reader 8405a is moved, and transmit the transmission restart signal upon estimating that the barcode reader 8405a is not moved for a predetermined time, based on the measurement of an accelerometer included in the barcode reader 8405a. The barcode reader 8405a may transmit the transmission stop signal upon estimating that the barcode reader 8405a is grasped, and transmit the transmission restart signal upon estimating that the hand is released from the barcode reader 8405a, based on the measurement of an electrostatic sensor or an illuminance sensor included in the barcode reader 8405a. The barcode reader 8405a may transmit the transmission stop signal upon detecting that the barcode reader 8405a is lifted on the ground that a switch on the supporting surface of the barcode reader 8405a is released form the pressed state, and transmit the transmission restart signal upon detecting that the barcode reader 8405a is placed on the ground that the button is pressed. The barcode reader 8405a may transmit the

transmission stop signal upon detecting that the barcode reader 8405a is lifted, and transmit the transmission restart signal upon detecting that the barcode reader 8405a is placed again, based on the measurement of a switch or an infrared sensor of a barcode reader receptacle. A cash register 8405c may transmit the transmission stop signal when operation is started, and transmit the transmission restart signal when settlement is completed.

[1886]

Upon receiving the transmission stop signal, the transmitter 8405b such as a lighting stops signal transmission, or operates so that the ripple (luminance change) from 100 Hz to 100 kHz is smaller. As an alternative, the transmitter 8405b continues signal transmission while reducing the luminance change of the signal pattern. As another alternative, the transmitter 8405b makes the carrier wave period longer than the barcode read time of the barcode reader 8405a, or makes the carrier wave period shorter than the exposure time of the barcode reader 8405a. Malfunction of the barcode reader 8405a can be prevented in this way.

[1887]

As illustrated in FIG. 465, a transmitter 8406b such as a lighting detects, by a motion sensor or a camera, that there is a person near a barcode reader 8406a, and stops signal transmission. As an alternative, the transmitter 8406b performs the same operation as the transmitter 8405b when receiving the transmission stop signal. The transmitter 8406b restarts signal transmission, upon detecting that no one is present near the barcode reader 8406a any longer. The transmitter 8406b may detect the operation sound of the barcode reader 8406a, and stop signal transmission for a predetermined time.

[1888]

(Information transmission from personal computer)

FIG. 466 is a diagram illustrating an example of use according to the present invention.

[1889]

A transmitter 8407a such as a personal computer transmits a

visible light signal, through a display device such as a display included in the transmitter 8407a, a display connected to the transmitter 8407a, or a projector. The transmitter 8407a transmits an URL of a website displayed by a browser, information of a clipboard, or information defined by a focused application. For example, the transmitter 8407a transmits coupon information obtained in a website.

[1890]

(Database)

FIG. 467 is a diagram illustrating an example of a structure of a database held in a server that manages an ID transmitted from a transmitter.

[1891]

The database includes an ID-data table holding data provided in response to an inquiry using an ID as a key, and an access log table holding each record of inquiry using an ID as a key. The ID-data table includes an ID transmitted from a transmitter, data provided in response to an inquiry using the ID as a key, a data provision condition, the number of times access is made using the ID as a key, and the number of times the data is provided as a result of clearing the condition. Examples of the data provision condition include the date and time, the number of accesses, the number of successful accesses, terminal information of the inquirer (terminal model, application making inquiry, current position of terminal, etc.), and user information of the inquirer (age, sex, occupation, nationality, language, religion, etc.). By using the number of successful accesses as the condition, a method of providing such a service that "1 yen per access, though no data is returned after 100 yen as upper limit" is possible. When access is made using an ID as a key, the log table records the ID, the user ID of the requester, the time, other ancillary information, whether or not data is provided as a result of clearing the condition, and the provided data.

[1892]

(Reception start gesture)

FIG. 468 is a diagram illustrating an example of gesture

operation for starting reception by the present communication scheme.

[1893]

A user sticks out a receiver such as a smartphone and turns his or her wrist right and left, to start reception. The receiver detects these operations from the measurement of a 9-axis sensor, and starts reception. The receiver may start reception in the case of detecting at least one of these operations. The operation of sticking out the receiver has the effect of enhancing the reception speed and accuracy, because the receiver comes closer to a transmitter and so captures the transmitter in a larger size. The operation of turning the wrist right and left has the effect of stabilizing reception, because the angle dependence of the scheme is resolved by changing the angle of the receiver.

[1894]

Note that these operations may be performed only when the receiver's home screen is in the foreground. This can prevent the communication from being launched despite the user's intension while the user is using another application.

[1895]

The following modification is also possible: an image sensor is activated upon detection of the operation of sticking out the receiver and, if the operation of turning the wrist right and left is not conducted, the reception is canceled. Since activating the image sensor takes about several hundred milliseconds to 2 seconds, the responsiveness can be enhanced in this way.

[1896]

(Control of transmitter by power line)

FIG. 469 is a diagram illustrating an example of a transmitter according to the present invention.

[1897]

A signal control unit 8410g controls the transmission state (the contents of a transmission signal, whether or not to transmit the signal, the intensity of luminance change used for transmission, etc.) of a transmitter 8410a. The signal control unit 8410g transmits the

details of control of the transmitter 8410a, to a power distribution control unit 8410f. The power distribution control unit 8410f changes the voltage or current supplied to a power supply unit 8410b of the transmitter 8410a or its frequency, thereby notifying the details of control in the form of the magnitude of the change or the time of the change. The power supply unit 8410b produces constant output, without being affected by a slight change in voltage, current, or frequency. Accordingly, the signal is transmitted by being expressed by such a change that exceeds the stabilizing ability of the power supply unit 8410b, e.g. a timing or duration that cuts power supply. A luminance control unit 8410d receives the signal transmitted from the power distribution control unit 8410f while taking into account the conversion by the power supply unit 8410b, and changes the luminance change pattern of a light emitting unit.

[1898]

(Coding scheme)

FIG. 470 is a diagram illustrating a coding scheme for a visible light communication image.

[1899]

This coding scheme has the advantage that flicker is unlikely to be perceived by humans, because black and white are substantially equal in proportion and so the normal phase image and the reverse phase image are substantially equal in average luminance.

[1900]

(Coding scheme capable of light reception even in the case of capturing image from diagonal direction)

FIG. 471 is a diagram illustrating a coding scheme for a visible light communication image.

[1901]

An image 1001a is an image displayed with black and white lines of uniform width. In an image 1001b obtained by capturing the image 1001a from a diagonal direction, left lines appear thinner and right lines appear thicker. In an image 1001i obtained by capturing the image 1001a in a manner of projecting the image 1001a on a

curved surface, lines that differ in thickness appear.

[1902]

In view of this, a visible light communication image is generated by the following coding scheme. A visible light communication image 1001c is made up of a white line, a black line whose thickness is three times that of the white line, and a white line whose thickness is 1/3 that of the black line, from left. A preamble is coded as such an image in which a line whose thickness is three times that of its left adjacent line is followed by a line whose thickness is 1/3 that of its left adjacent line. As in visible light communication images 1001d and 1001e, a line whose thickness is equal to that of its left adjacent line is coded as "0". As in visible light communication images 1001f and 1001g, a line whose thickness is twice that of its left adjacent line or 1/2 that of its left adjacent line is coded as "1". That is, a line whose thickness is different from that of its left adjacent line is coded as "1". As an example using this coding scheme, a signal including "010110001011" following the preamble is expressed by an image such as a visible light communication image 1001h. Though the line whose thickness is equal to that of its left adjacent line is coded as "0" and the line whose thickness is different from that of its left adjacent line is coded as "1" in this example, the line whose thickness is equal to that of its left adjacent line may be coded as "1" and the line whose thickness is different from that of its left adjacent line as "0". Moreover, the reference thickness is not limited to the thickness of the left adjacent line, and may be the thickness of the right adjacent line. In detail, "1" or "0" may be coded depending on whether the thickness of the line to be coded is equal to or different from the thickness of its right adjacent line. Thus, a transmitter codes "0" by setting the line to be coded to be equal in thickness to the line that is different in color from and adjacent to the line to be coded, and codes "1" by setting the line to be coded to be different in thickness from the line that is different in color from and adjacent to the line to be coded.

[1903]

A receiver captures the visible light communication image, and

detects the thickness of the white or black line in the captured visible light communication image. The receiver compares the thickness of the line to be decoded, with the thickness of the line that is different in color from and adjacent (left adjacent or right adjacent) to the line to be decoded. The line is decoded as "0" in the case where the thicknesses are equal, and "1" in the case where the thicknesses are different. Alternatively, the line may be decoded as "1" in the case where the thicknesses are equal, and "0" in the case where the thicknesses are different. The receiver lastly decodes the data based on the decoded data sequence of 1 and 0.

[1904]

This coding scheme employs the local line thickness relation. Since the thickness ratio between neighboring lines does not change significantly as seen in the images 1001b and 1001i, the visible light communication image generated by this coding scheme can be properly decoded even in the case of being captured from a diagonal direction or being projected on a curved surface.

[1905]

This coding scheme has the advantage that flicker is unlikely to be perceived by humans, because black and white are substantially equal in proportion and so the normal phase image and the reverse phase image are substantially equal in average luminance. This coding scheme also has the advantage that the visible light communication images of both the normal phase signal and the reverse phase signal are decodable by the same algorithm, because the coding scheme does not depend on the distinction between black and white.

[1906]

This coding scheme further has the advantage that a code can be added easily. As an example, a visible light communication image 1001j is a combination of a line whose thickness is four times that of its left adjacent line and a line whose thickness is 1/4 that of its left adjacent line. Like this, many unique patterns such as "five times that of its left adjacent line and 1/5 that of its left adjacent line" and "three times that of its left adjacent line and 2/3 that of its

left adjacent line" are available, enabling definition as a signal having a special meaning. For instance, given that one set of data can be expressed by a plurality of visible light communication images, the visible light communication image 1001j may be used as a cancel signal indicating that, since the transmission data is changed, part of the previously received data is no longer valid. Note that the colors are not limited to black and white, and any colors may be used so long as they are different. For instance, complementary colors may be used.

[1907]

(Coding scheme that differs in information amount depending on distance)

FIGS. 472 and 473 are diagrams illustrating a coding scheme for a visible light communication image.

[1908]

As in (a-1) in FIG. 472, when a 2-bit signal is expressed in a form that one part of an image divided by four is black and the other parts are white, the average luminance of the image is 75%, where white is 100% and black is 0%. As in (a-2) in FIG. 472, when black and white are reversed, the average luminance is 25%.

[1909]

An image 1003a is a visible light communication image in which the white part of the visible light communication image generated by the coding scheme in FIG. 471 is expressed by the image in (a-1) in FIG. 472 and the black part is expressed by the image in (a-2) in FIG. 472. This visible light communication image represents signal A coded by the coding scheme in FIG. 471 and signal B coded by (a-1) and (a-2) in FIG. 472. When a nearby receiver 1003b captures the visible light communication image 1003a, a fine image 1003d is obtained and both of signals A and B can be received. When a distant receiver 1003c captures the visible light communication image 1003a, a small image 1003e is obtained. In the image 1003e, the details are not recognizable, and the part corresponding to (a-1) in FIG. 472 is white and the part corresponding to (a-2) in FIG. 472 is black, so that only signal A can

be received. Thus, more information can be transmitted when the distance between the visible light communication image and the receiver is shorter. The scheme for coding signal B may be the combination of (b-1) and (b-2) or the combination of (c-1) and (c-2) in FIG. 472.

[1910]

The use of signals A and B enables basic important information to be expressed by signal A and additional information to be expressed by signal B. In the case where the receiver transmits signals A and B to a server as ID information and the server transmits information corresponding to the ID information to the receiver, the information transmitted from the server may be varied depending on whether or not signal B is present.

[1911]

(Coding scheme with data division)

FIG. 474 is a diagram illustrating a coding scheme for a visible light communication image.

[1912]

A transmission signal 1005a is divided into a plurality of data segments 1005b, 1005c, and 1005d. Frame data 1005e, 1005f, and 1005g are generated by adding, to each data segment, an address indicating the position of the data segment, a preamble, an error detection/correction code, a frame type description, and the like. The frame data are coded to generate visible light communication images 1005h, 1005i, and 1005j, and the visible light communication images 1005h, 1005i, and 1005j are displayed. In the case where the display area is sufficiently large, a visible light communication image 1005k obtained by concatenating the plurality of visible light communication images is displayed.

[1913]

A method of inserting the visible light communication image in video as in FIG. 474 is described below. In the case of a display device including a solid state light source, the visible light communication image is displayed in normal time, and the solid state light source is on only during the period for displaying the visible

light communication image and off during the other period. This method is applicable to a wide range of display devices including a projector using a DMD, a projector using a liquid crystal such as LCOS, and a display device using MEMS. The method is also applicable to display devices that divide image display into subframes, e.g. a display device such as a PDP or an EL display that does not use a light source such as a backlight, by replacing part of the subframes with the visible light communication image. Examples of the solid state light source include a semiconductor laser and an LED light source.

[1914]

(Effect of inserting reverse phase image)

FIGS. 475 and 476 are diagrams illustrating a coding scheme for a visible light communication image.

[1915]

As in (1006a) in FIG. 475, a transmitter inserts a black image between video and a visible light communication image (normal phase image). An image obtained by capturing this by a receiver is as illustrated in (1006b) in FIG. 475. Since it is easy to search for a part where a simultaneously exposed pixel line is all black, the receiver can easily specify the position where the visible light communication image is captured, as the pixel position exposed at the next timing.

[1916]

As in (1006a) in FIG. 475, after displaying a visible light communication image (normal phase image), the transmitter displays a visible light communication image of reverse phase with black and white being inverted. The receiver calculates the difference in pixel value between the normal phase image and the reverse phase image, thus attaining an SN ratio that is twice as compared with the case of using only the normal phase image. Conversely, when ensuring the same SN ratio, the luminance difference between black and white can be reduced to half, with it being possible to suppress flicker perceived by humans. As in (1007a) and (1007b) in FIG. 476, the moving average of the

expected value of the luminance difference between the video and the visible light communication image is canceled out by the normal phase image and the reverse phase image. Since the temporal resolution of human vision is about 1/60 second, by setting the time for displaying the visible light communication image to less than or equal to this, it is possible to make humans perceive as if the visible light communication image is not being displayed.

[1917]

As in (1006c) in FIG. 475, the transmitter may further insert a black image between the normal phase image and the reverse phase image. In this case, an image illustrated in (1006d) in FIG. 475 is obtained as a result of image capture by the receiver. In the image illustrated in (1006b) in FIG. 475, the pattern of the normal phase image and the pattern of the reverse phase image are adjacent to each other, which might cause averaging of pixel values at the boundary. In the image illustrated in (1006d) in FIG. 475, no such problem occurs.

[1918]

(Superresolution)

FIG. 477 is a diagram illustrating a coding scheme for a visible light communication image.

[1919]

In (a) in FIG. 477, in the case where video data and signal data transmitted by visible light communication are separated, a superresolution process is performed on the video data, and the visible light communication image is superimposed on the obtained superresolution image. That is, the superresolution process is not performed on the visible light communication image. In (b) in FIG. 477, in the case where a visible light communication image is already superimposed on video data, the superresolution process is performed so that (1) the edges (parts indicating data by the difference between colors such as black and white) of the visible light communication image are maintained sharp and (2) the average image of the normal phase image and the reverse phase image of the visible light communication image is of uniform luminance. By

changing the process for the visible light communication image depending on whether or not the visible light communication image is superimposed on the video data in this way, visible light communication can be performed more appropriately (with reduced error rate).

[1920]

(Display of support for visible light communication)

FIG. 478 is a diagram illustrating operation of a transmitter.

[1921]

A transmitter 8500a displays information indicating that the transmitter 8500a is capable of visible light communication, by superimposing the information on a projected or displayed image. The information is displayed, for example, only for a predetermined time after the transmitter 8500a is activated.

[1922]

The transmitter 8500a transmits the information indicating that the transmitter 8500a is capable of visible light communication, to a connected device 8500c. The device 8500c displays that the transmitter 8500a is capable of visible light communication. As an example, the device 8500c displays that the transmitter 8500a is capable of visible light communication, on a display of the device 8500c. In the case where the connected transmitter 8500a is capable of visible light communication, the device 8500c transmits visible light communication data to the transmitter 8500a. The information that the transmitter 8500a is capable of visible light communication may be displayed when the device 8500c is connected to the transmitter 8500a or when the visible light communication data is transmitted from the device 8500c to the transmitter 8500a. In the case of displaying the information when the visible light communication data is transmitted from the device 8500c, the transmitter 8500a may obtain identification information indicating visible light communication from the data and, if the identification information indicates that the visible light communication data is included in the data, display that the transmitter 8500a is capable of visible light communication.

[1923]

By displaying that the transmitter (lighting, projector, video display device, etc.) is capable of visible light communication or whether or not the transmitter is capable of visible light communication on the projection screen or the display of the device in this way, the user can easily recognize whether or not the transmitter is capable of visible light communication. This prevents a failure of visible light communication even though visible light communication data is transmitted from the device to the transmitter.

[1924]

(Information obtainment using visible light communication signal)

FIG. 479 is a diagram illustrating an example of application of visible light communication.

[1925]

A transmitter 8501a receives video data and signal data from a device 8501c, and displays a visible light communication image 8501b. A receiver 8501d captures the visible light communication image 8501b, to receive a signal included in the visible light communication image. The receiver 8501d communicates with the device 8501c based on information (address, password, etc.) included in the received signal, and receives the video displayed by the transmitter 8501a and its ancillary information (video ID, URL, password, SSID, translation data, audio data, hash tag, product information, purchase information, coupon, availability information, etc.). The device 8501c may transmit, to a server 8501e, the status of transmission to the transmitter 8501a so that the receiver 8501d may obtain the information from the server 8501e.

[1926]

(Data format)

FIG. 480 is a diagram illustrating a format of visible light communication data.

[1927]

Data illustrated in (a) in FIG. 480 has a video address table indicating the position of video data in a storage area, and a position address table indicating the position of signal data transmitted by

visible light communication. A video display device not capable of visible light communication refers only to the video address table, and therefore video display is not affected even when the signal address table and signal data are included in the input. Backward compatibility with the video display device not capable of visible light communication is maintained in this manner.

[1928]

In a data format illustrated in (b) in FIG. 480, an identifier indicating that data which follows is video data is positioned before video data, and an identifier indicating that data which follows is signal data is positioned before signal data. Since the identifier is inserted in the data only when there is video data or signal data, the total amount of code can be reduced. Alternatively, identification information indicating whether data is video data or signal data may be provided. Moreover, program information may include identification information indicating whether or not the program information includes visible light communication data. The inclusion of the identification information indicating whether or not the program information includes visible light communication data allows the user to determine, upon program search, whether or not visible light communication is possible. The program information may include an identifier indicating that the program information includes visible light communication data. Furthermore, adding an identifier or identification information on a data basis makes it possible to switch the luminance or switch the process such as superresolution on a data basis, which contributes to a lower error rate in visible light communication.

[1929]

The data format illustrated in (a) in FIG. 480 is suitable for a situation of reading data from a storage medium such a an optical disc, and the data format illustrated in (b) in FIG. 480 is suitable for streaming data such as television broadcasting. Note that the signal data includes information such as the signal value transmitted by visible light communication, the transmission start time, the transmission end time, the area used for transmission on a display or

a projection surface, the luminance of the visible light communication image, the direction of barcode of the visible light communication image, and so on.

[1930]

(Estimation of stereoscopic shape and reception)

FIGS. 481 and 482 are diagrams illustrating an example of application of visible light communication.

[1931]

As illustrated in FIG. 481, a transmitter 8503a such as a projector projects not only video and a visible light communication image but also a distance measurement image. A dot pattern indicated by the distance measurement image is a dot pattern in which the position relation between a predetermined number of dots near an arbitrary dot is different from the position relation between other arbitrary combination of dots. A receiver captures the distance measurement image to specify a local dot pattern, with it being possible to estimate the stereoscopic shape of a projection surface 8503b. The receiver restores the visible light communication image distorted due to the stereoscopic shape of the projection surface to a 2D image, thereby receiving a signal. The distance measurement image and the visible light communication image may be projected by infrared which is not perceivable by humans.

[1932]

As illustrated in FIG. 482, a transmitter 8504a such as a projector includes an infrared projection device 8504b for projecting a distance measurement image by infrared. A receiver estimates the stereoscopic shape of a projection surface 8504c, and restores a distorted visible light communication image to receive a signal. The transmitter 8504a may project video by visible light, and a visible light communication image by infrared. The infrared projection device 8403b may project a visible light communication image by infrared.

[1933]

(Stereoscopic projection)

FIGS. 483 and 484 are diagrams illustrating a visible light communication image display method.

[1934]

In the case of performing stereoscopic projection or in the case of displaying a visible light communication image on a cylindrical display surface, displaying visible light communication images 8505a to 8505f as illustrated in FIG. 483 enables reception from a wide angle. Displaying the visible light communication images 8505a and 8505b enables reception from a horizontally wide angle. By combining the visible light communication images 8505a and 8505b, reception is possible even when a receiver is tilted. The visible light communication images 8505a and 8505b may be displayed alternately, or the visible light communication image 8505f obtained by synthesizing these images may be displayed. Moreover, adding the visible light communication images 8505c and 8505d enables reception from a vertically wide angle. The visible light communication image boundary may be expressed by providing a part projected in an intermediate color or an unprojected part, as in the visible light communication image 8505e. Rotating the visible light communication images 8505a to 8505f enables reception from a wider angle. Though the visible light communication image is displayed on the cylindrical display surface in FIG. 483, the visible light communication image may be displayed on a columnar display surface.

[1935]

In the case of performing stereoscopic projection or in the case of displaying a visible light communication image on a spherical display surface, displaying visible light communication images 8506a to 8506d as illustrated in FIG. 484 enables reception from a wide angle. In the visible light communication image 8506a, the receivable area in the horizontal direction is wide, but the receivable area in the vertical direction is narrow. Hence, the visible light communication image 8506a is combined with the visible light communication image 8506b having the opposite property. The visible light communication images 8506a and 8506b may be

displayed alternately, or the visible light communication image 8506c obtained by synthesizing these images may be displayed. The part where barcodes concentrate as in the upper part of the visible light communication image 8506a is fine in display, and there is a high possibility of a signal reception error. Such a reception error can be prevented by displaying this part in an intermediate color as in the visible light communication image 8506d or by not projecting any image in this part.

[1936]

(Communication protocol different according to zone)

FIG. 485 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[1937]

A receiver 8420a receives zone information form a base station 8420h, recognizes in which position the receiver 8420a is located, and selects a reception protocol. The base station 8420h is, for example, a mobile phone communication base station, a W-Fi access point, an IMES transmitter, a speaker, or a wireless transmitter (Bluetooth®, ZigBee, specified low power radio station, etc.). The receiver 8420a may specify the zone based on position information obtained from GPS or the like. As an example, it is assumed that communication is performed at a signal frequency of 9.6 kHz in zone A, and communication is performed at a signal frequency of 15 kHz by a ceiling light and at a signal frequency of 4.8 kHz by a signage in zone B. At a position 8420j, the receiver 8420a recognizes that the current position is zone A from information from the base station 8420h, and performs reception at the signal frequency of 9.6 kHz, thus receiving signals transmitted from transmitters 8420b and 8420c. At a position 8420l, the receiver 8420a recognizes that the current position is zone B from information from a base station 8420i, and also estimates that a signal from a ceiling light is to be received from the movement of directing the in camera upward. The receiver 8420a performs reception at the signal frequency of 15 kHz, thus receiving signals transmitted from transmitters 8420e and 8420f. At a position 8420m, the receiver

8420a recognizes that the current position is zone B from information from the base station 8420i, and also estimates that a signal transmitted from a signage is to be received from the movement of sticking out the out camera. The receiver 8420a performs reception at the signal frequency of 4.8 kHz, thus receiving a signal transmitted from a transmitter 8420g. At a position 8420k, the receiver 8420a receives signals from both of the base stations 8420h and 8420i and cannot determine whether the current position is zone A or zone B. The receiver 8420a accordingly performs reception at both 9.6 kHz and 15 kHz. The part of the protocol different according to zone is not limited to the frequency, and may be the transmission signal modulation scheme, the signal format, or the server inquired using an ID. The base station 8420h or 8420i may transmit the protocol in the zone to the receiver, or transmit only the ID indicating the zone to the receiver so that the receiver obtains protocol information from a server using the zone ID as a key.

[1938]

Transmitters 8420b to 8420f each receive the zone ID or protocol information from the base station 8420h or 8420i, and determine the signal transmission protocol. The transmitter 8420d that can receive the signals from both the base stations 8420h and 8420i uses the protocol of the zone of the base station with a higher signal strength, or alternately use both protocols.

[1939]

(Recognition of zone and service for each zone)

FIG. 486 is a diagram illustrating an example of operation of a transmitter and a receiver in Embodiment 17.

[1940]

A receiver 8421a recognizes a zone to which the position of the receiver 8421a belongs, from a received signal. The receiver 8421a provides a service (coupon distribution, point assignment, route guidance, etc.) determined for each zone. As an example, the receiver 8421a receives a signal transmitted from the left of a transmitter 8421b, and recognizes that the receiver 8421a is located in zone A. Here, the transmitter 8421b may transmit a different

signal depending on the transmission direction. Moreover, the transmitter 8421b may, through the use of a signal of the light emission pattern such as 2217a, transmit a signal so that a different signal is received depending on the distance to the receiver. The receiver 8421a may recognize the position relation with the transmitter 8421b from the direction and size in which the transmitter 8421b is captured, and recognize the zone in which the receiver 8421a is located.

[1941]

Signals indicating the same zone may have a common part. For example, the first half of an ID indicating zone A, which is transmitted from each of the transmitters 8421b and 8421c, is common. This enables the receiver 8421a to recognize the zone where the receiver 8421a is located, merely by receiving the first half of the signal.

[1942]

(Summary of this embodiment)

An information communication method in this embodiment is an information communication method of transmitting a signal using a change in luminance, the information communication method including: determining a plurality of patterns of the change in luminance, by modulating each of a plurality of signals to be transmitted; and transmitting, by each of a plurality of light emitters changing in luminance according to any one of the plurality of determined patterns of the change in luminance, a signal corresponding to the pattern, wherein in the transmitting, each of two or more light emitters of the plurality of light emitters changes in luminance at a different frequency so that light of one of two types of light different in luminance is output per a time unit determined for the light emitter beforehand and that the time unit determined for each of the two or more light emitters is different.

[1943]

In this way, two or more light emitters (e.g. transmitters as lighting devices) each change in luminance at a different frequency, as in the operation described with reference to FIG. 441. Therefore,

a receiver that receives signals (e.g. light emitter IDs) from these light emitters can easily obtain the signals separately from each other.

[1944]

For example, in the transmitting, each of the plurality of light emitters may change in luminance at any one of at least four types of frequencies, and the two or more light emitters of the plurality of transmitters may change in luminance at the same frequency. For example, in the transmitting, the plurality of light emitters each change in luminance so that a luminance change frequency is different between all light emitters which, in the case where the plurality of light emitters are projected on a light receiving surface of an image sensor for receiving the plurality of signals, are adjacent to each other on the light receiving surface.

[1945]

In this way, as long as there are at least four types of frequencies used for luminance changes, even in the case where two or more light emitters change in luminance at the same frequency, i.e. in the case where the number of types of frequencies is smaller than the number of light emitters, it can be ensured that the luminance change frequency is different between all light emitters adjacent to each other on the light receiving surface of the image sensor based on the four color problem or the four color theorem, as in the operation described with reference to FIG. 442. As a result, the receiver can easily obtain the signals transmitted from the plurality of light emitters, separately from each other.

[1946]

For example, in the transmitting, each of the plurality of light emitters may transmit the signal, by changing in luminance at a frequency specified by a hash value of the signal.

[1947]

In this way, each of the plurality of light emitters changes in luminance at the frequency specified by the hash value of the signal (e.g. light emitter ID), as in the operation described with reference to FIG. 441. Accordingly, upon receiving the signal, the receiver

can determine whether or not the frequency specified from the actual change in luminance and the frequency specified by the hash value match. That is, the receiver can determine whether or not the received signal (e.g. light emitter ID) has an error.

[1948]

For example, the information communication method may further include: calculating, from a signal to be transmitted which is stored in a signal storage unit, a frequency corresponding to the signal according to a predetermined function, as a first frequency; determining whether or not a second frequency stored in a frequency storage unit and the calculated first frequency match; and in the case of determining that the first frequency and the second frequency do not match, reporting an error, wherein in the case of determining that the first frequency and the second frequency match, in the determining, a pattern of the change in luminance is determined by modulating the signal stored in the signal storage unit, and in the transmitting, the signal stored in the signal storage unit is transmitted by any one of the plurality of light emitters changing in luminance at the first frequency according to the determined pattern.

[1949]

In this way, whether or not the frequency stored in the frequency storage unit and the frequency calculated from the signal stored in the signal storage unit (ID storage unit) match is determined and, in the case of determining that the frequencies do not match, an error is reported, as in the operation described with reference to FIG. 448. This eases abnormality detection on the signal transmission function of the light emitter.

[1950]

For example, the information communication method may further include: calculating a first check value from a signal to be transmitted which is stored in a signal storage unit, according to a predetermined function; determining whether or not a second check value stored in a check value storage unit and the calculated first check value match; and in the case of determining that the first check value and the second check value do not match, reporting an

error, wherein in the case of determining that the first check value and the second check value match, in the determining, a pattern of the change in luminance is determined by modulating the signal stored in the signal storage unit, and in the transmitting, the signal stored in the signal storage unit is transmitted by any one of the plurality of light emitters changing in luminance at the first frequency according to the determined pattern.

[1951]

In this way, whether or not the check value stored in the check value storage unit and the check value calculated from the signal stored in the signal storage unit (ID storage unit) match is determined and, in the case of determining that the check values do not match, an error is reported, as in the operation described with reference to FIG. 448. This eases abnormality detection on the signal transmission function of the light emitter.

[1952]

An information communication method in this embodiment is an information communication method of obtaining information from a subject, the information communication method including: setting an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a plurality of bright lines corresponding to a plurality of exposure lines included in the image sensor appear according to a change in luminance of the subject; obtaining a bright line image including the plurality of bright lines, by capturing the subject that changes in luminance by the image sensor with the set exposure time; obtaining the information by demodulating data specified by a pattern of the plurality of bright lines included in the obtained image; and specifying a luminance change frequency of the subject, based on the pattern of the plurality of bright lines included in the obtained bright line image. For example, in the specifying, a plurality of header patterns that are included in the pattern of the plurality of bright lines and are a plurality of patterns each determined beforehand to indicate a header are specified, and a frequency corresponding to the number of pixels between the plurality of header patterns is specified as the

luminance change frequency of the subject.

[1953]

In this way, the luminance change frequency of the subject is specified, as in the operation described with reference to FIG. 443. In the case where a plurality of subjects that differ in luminance change frequency are captured, information from these subjects can be easily obtained separately from each other.

[1954]

For example, in the obtaining of a bright line image, the bright line image including a plurality of patterns represented respectively by the plurality of bright lines may be obtained by capturing a plurality of subjects each of which changes in luminance, and in the obtaining of the information, in the case where the plurality of patterns included in the obtained bright line image overlap each other in a part, the information may be obtained from each of the plurality of patterns by demodulating the data specified by a part of each of the plurality of patterns other than the part.

[1955]

In this way, data is not demodulated from the overlapping part of the plurality of patterns (the plurality of bright line patterns), as in the operation described with reference to FIG. 445. Obtainment of wrong information can thus be prevented.

[1956]

For example, in the obtaining of a bright line image, a plurality of bright line images may be obtained by capturing the plurality of subjects a plurality of times at different timings from each other, in the specifying, for each bright line image, a frequency corresponding to each of the plurality of patterns included in the bright line image may be specified, and in the obtaining of the information, the plurality of bright line images may be searched for a plurality of patterns for which the same frequency is specified, the plurality of patterns searched for may be combined, and the information may be obtained by demodulating the data specified by the combined plurality of patterns.

[1957]

In this way, the plurality of bright line images are searched for the plurality of patterns (the plurality of bright line patterns) for which the same frequency is specified, the plurality of patterns searched for are combined, and the information is obtained from the combined plurality of patterns. Hence, even in the case where the plurality of subjects are moving, information from the plurality of subjects can be easily obtained separately from each other.

[1958]

For example, the information communication method may further include: transmitting identification information of the subject included in the obtained information and specified frequency information indicating the specified frequency, to a server in which a frequency is registered for each set of identification information; and obtaining related information associated with the identification information and the frequency indicated by the specified frequency information, from the server.

[1959]

In this way, the related information associated with the identification information (ID) obtained based on the luminance change of the subject (transmitter) and the frequency of the luminance change is obtained, as in the operation described with reference to FIG. 447. By changing the luminance change frequency of the subject and updating the frequency registered in the server with the changed frequency, a receiver that has obtained the identification information before the change of the frequency is prevented from obtaining the related information from the server. That is, by changing the frequency registered in the server according to the change of the luminance change frequency of the subject, it is possible to prevent a situation where a receiver that has previously obtained the identification information of the subject can obtain the related information from the server for an indefinite period of time.

[1960]

For example, the information communication method may further include: obtaining identification information of the subject, by extracting a part from the obtained information; and specifying a

number indicated by the obtained information other than the part, as a luminance change frequency set for the subject.

[1961]

In this way, the identification information of the subject and the luminance change frequency set for the subject can be included independently of each other in the information obtained from the pattern of the plurality of bright lines, as in the operation described with reference to FIG. 444. This contributes to a higher degree of freedom of the identification information and the set frequency.

[1962]

[Embodiment 18]

This embodiment describes each example of application using a receiver such as a smartphone and a transmitter for transmitting information as an LED blink pattern in Embodiments 1 to 17 described above.

[1963]

FIG. 487 is a diagram illustrating an example of a transmission signal in Embodiment 18.

[1964]

A transmission signal D is divided into data segments Dx (e.g. Dx = D1, D2, D3) of a predetermined size, and a header Hdr and an error detection/correction frame check sequence FCS calculated from each data segment are added to the data segment. A header Hdr2 and an error detection/correction frame check sequence FCS2 calculated from the original data are added, too. Data made up of Hdr, Dx, and FCS is a structure for reception by an image sensor. Since the image sensor is suitable for reception of continuous data in a short time, Hdr, Dx, and FCS are transmitted continuously. Data made up of Hdr2, Dx, and FCS2 is a structure for reception by an illuminance sensor. While Hdr and FCS received by the image sensor are desirably short, Hdr2 and FCS2 received by the illuminance sensor may each be a longer signal sequence. The use of a longer signal sequence for Hdr2 enhances the header detection accuracy. When FCS2 is longer, a code capable of detecting and correcting many bit errors can be employed, which leads to improved

error detection/correction performance. Note that, instead of transmitting Hdr2 and FCS2, Hdr and FCS may be received by the illuminance sensor. The illuminance sensor may receive both Hdr and Hdr2 or both FCS and FCS2.

[1965]

FIG. 488 is a diagram illustrating an example of a transmission signal in Embodiment 18.

[1966]

FCS2 is a long signal. Frequently inserting such FCS2 causes a decrease in reception efficiency of the image sensor. In view of this, the insertion frequency of FCS2 is reduced, and a signal PoFCS2 indicating the location of FCS2 is inserted instead. For example, in the case of using 4-value PPM having 2-bit information per unit time for signal representation, 16 transmission time units are necessary when CRC32 is used for FCS2, whereas PoFCS2 with a range of 0 to 3 can be transmitted in one time unit. Since the transmission time is shortened as compared with the case of inserting only FCS2, the reception efficiency of the image sensor can be improved. The illuminance sensor receives PoFCS2 following the transmission signal D, specifies the transmission time of FCS2 from PoFCS2, and receives FCS2. The illuminance sensor further receives PoFCS2 following FCS2, specifies the transmission time of the next FCS2, and receives the next FCS2. If FCS2 received first and FCS2 received next are the same, the receiver estimates that the same signal is being received.

[1967]

FIGS. 489A to 489C are each a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[1968]

In the captured image illustrated in FIG. 489A, a transmitter is shown small and so the number of bright lines is small. Only a small amount of data can be received at one time from this captured image. The captured image illustrated in FIG. 489B is an image captured using zoom, where the transmitter is shown large and so the number

of bright lines is large. Thus, a large amount of data can be received at one time by using zoom. In addition, data can be received from far away, and a signal of a small transmitter can be received. Optical zoom or Ex zoom is employed as the zoom method. Optical zoom is realized by increasing the focal length of a lens. Ex zoom is a zoom method in which, in the case of performing imaging with a lower resolution than the imaging element capacity, not all but only a part of the imaging elements is used to thereby enlarge a part of the captured image. The captured image illustrated in FIG. 489C is an image captured using electronic zoom (image enlargement). Though the transmitter is shown large, bright lines are thicker in the enlargement by electronic zoom, and the number of bright lines is unchanged from pre-zoom. Hence, the reception characteristics are unchanged from pre-zoom.

[1969]

FIGS. 490A and 490B are each a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[1970]

The captured image illustrated in FIG. 490A is an image captured with focus on a subject. The captured image illustrated in FIG. 490B is an image captured out of focus. In the captured image illustrated in FIG. 490B, bright lines can be observed even in the surroundings of the actual transmitter because the image is captured out of focus, so that more bright lines can be observed. Thus, more data can be received at one time and also data can be received farther away, by out-of-focus imaging. Imaging in macro mode can produce the same image as the captured image illustrated in FIG. 490B.

[1971]

FIGS. 491A to 491C are each a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18.

[1972]

The image illustrated in FIG. 491A is obtained by setting the

exposure time to be longer than that in the visible light communication mode and shorter than that in the normal imaging mode. The imaging mode for obtaining such an image is referred to as "bright line detection mode" (intermediate mode). In the image illustrated in FIG. 491A, bright lines of a transmitter are observed at the center left, while a darker normal captured image appears in the other part. When this image is displayed on the receiver, the user can easily point the receiver at the intended transmitter and capture the transmitter. In the bright line detection mode, an image is captured darker than in the normal imaging mode. Accordingly, imaging is performed in a high sensitivity mode to capture an image having brightness easily visible by humans, i.e. an image similar to that in the normal imaging mode. Since excessively high sensitivity causes the darker parts of the bright lines to become brighter, the sensitivity is set to such a level that allows the bright lines to be observed. The receiver switches to the visible light communication mode, and receives the transmission signal of the transmitter captured in the part designated by, for example, the user touching the image. The receiver may automatically switch to the visible light communication mode and receive the signal in the case where any bright line (transmission signal) is found in the captured image.

[1973]

The receiver detects the transmission signal from the bright lines in the captured image, and highlights the detected part as illustrated in FIG. 491B. The receiver can thus present the signal transmission part clearly to the user. The bright lines may be observed with regard to not only the transmission signal but also the pattern of the subject. Therefore, instead of determining whether or not there is the transmission signal from the bright lines in one image, it may be determined that there is the transmission signal in the case where the positions of the bright lines change in a plurality of images.

[1974]

The image captured in the bright line detection mode is darker than the image captured in the normal imaging mode, and is not

easily visible. Hence, the image with visibility increased by image processing may be displayed. The image illustrated in FIG. 491C is an example of an image in which the edges are extracted and the boundary of the imaging object is enhanced.

[1975]

FIG. 492 is a diagram illustrating an example of an image (bright line image) captured by a receiver in Embodiment 18. In detail, FIG. 492 illustrates an image obtained by capturing a transmitter whose signal transmission period is 1/9600 second, with the ratio of exposure time indicated in the lower part of the drawing. When the exposure time is shorter than the transmission period of 1/9600 second, the captured image is roughly the same, and clear bright lines can be captured. When the exposure time is longer, the bright line contours are blurred. In this signal representation example, however, the bright line pattern is observable and the signal can be received as long as the exposure time is up to about 1.5 times the transmission period. Moreover, in this signal representation example, the bright lines are observable as long as the exposure time is up to about 20 times the transmission period. The exposure time of this range is available as the exposure time in the bright line detection mode.

[1976]

The upper limit of the exposure time that enables signal reception differs depending on the method of signal representation. The use of such a signal representation rule in which the number of bright lines is smaller and the interval between the bright lines is longer enables signal reception with a longer exposure time and also enables observation of bright lines with a longer exposure time, though the transmission efficiency is lower.

[1977]

(Exposure time in intermediate imaging mode)

As illustrated in FIG. 492, clear bright lines are observable when the exposure time is up to about 3 times the modulation period. Since the modulation frequency is greater than or equal to 480 Hz, the exposure time in the intermediate imaging mode (intermediate

mode) is desirably less than or equal to 1/160 second.

[1978]

If the exposure time is less than or equal to 1/10000 second, an object not emitting light is hard to be seen under illumination light even when captured in the high sensitivity mode. Accordingly, the exposure time in the intermediate imaging mode is desirably greater than or equal to 1/10000 second. This limitation is, however, expected to be eased by future improvement in sensitivity of imaging elements.

[1979]

FIG. 493 is a diagram illustrating an example of a transmission signal in Embodiment 18.

[1980]

A receiver receives a series of signals by combining a plurality of received data segments. Therefore, if a transmission signal is abruptly changed, data segments before and after the change are mixed with each other, making it impossible to accurately combine the signals. In view of this, upon changing the transmission signal, a transmitter performs normal illumination for a predetermined time as a buffer zone while transmitting no signal, as in (a) in FIG. 493. In the case where no signal can be received for a predetermined time T2 shorter than the above-mentioned predetermined time T1, the receiver abandons previously received data segments, thus avoiding mixture of data segments before and after the change. As an alternative, upon changing the transmission signal, the transmitter repeatedly transmits a signal X for notifying the change of the transmission signal, as in (b) in FIG. 493. Such repeated transmission prevents a failure to receive the transmission signal change notification X. As another alternative, upon changing the transmission signal, the transmitter repeatedly transmits a preamble, as in (c) in FIG. 493. In the case of receiving the preamble in a shorter period than the period in which the preamble appears in the normal signal, the receiver abandons previously received data segments.

[1981]

FIG. 494 is a diagram illustrating an example of operation of a receiver in Embodiment 18.

[1982]

An image illustrated in (a) in FIG. 494 is an image obtained by capturing a transmitter in just focus. By out-of-focus imaging, a receiver can capture an image illustrated in (b) in FIG. 494. Further out of focus leads to a captured image illustrated in (c) in FIG. 494. In (c) in FIG. 494, bright lines of a plurality of transmitters overlap each other, and the receiver cannot perform signal reception. Hence, the receiver adjusts the focus so that the bright lines of the plurality of transmitters do not overlap each other. In the case where only one transmitter is present in the imaging range, the receiver adjusts the focus so that the size of the transmitter is maximum in the captured image.

[1983]

The receiver may compress the captured image in the direction parallel to the bright lines, but do not perform image compression in the direction perpendicular to the bright lines. Alternatively, the receiver reduces the degree of compression in the perpendicular direction. This prevents a reception error caused by the bright lines being blurred by compression.

[1984]

FIGS. 495 and 496 are each a diagram illustrating an example of an instruction to a user displayed on a screen of a receiver in Embodiment 18.

[1985]

By capturing a plurality of transmitters, a receiver can estimate the position of the receiver using triangulation from position information of each transmitter and the position, size, and angle of each transmitter in the captured image. Accordingly, in the case where only one transmitter is captured in a receivable state, the receiver instructs the imaging direction or the moving direction by displaying an image including an arrow or the like, to cause the user to change the direction of the receiver or move backward so as to capture a plurality of transmitters. (a) in FIG. 495 illustrates a

display example of an instruction to turn the receiver to the right to capture a transmitter on the right side. (b) in FIG. 495 illustrates a display example of an instruction to move backward to capture a transmitter in front. FIG. 496 illustrates a display example of an instruction to shake the receiver or the like to capture another transmitter, because the position of another transmitter is unknown to the receiver. Though it is desirable to capture a plurality of transmitters in one image, the position relation between transmitters in a plurality of images may be estimated using image processing or the sensor value of the 9-axis sensor. The receiver may inquire of a server about position information of nearby transmitters using an ID received from one transmitter, and instruct the user to capture a transmitter that is easiest to capture.

[1986]

The receiver detects that the user is moving the receiver from the sensor value of the 9-axis sensor and, after a predetermined time from the end of the movement, displays a screen based on the last received signal. This prevents a situation where, when the user points the receiver to the intended transmitter, a signal of another transmitter is received during the movement of the receiver and as a result a process based on the transmission signal of the unintended transmitter is accidentally performed.

[1987]

The receiver may continue the reception process during the movement, and perform a process based on the received signal, e.g. information obtainment from the server using the received signal as a key. In this case, after the process the receiver still continues the reception process, and performs a process based on the last received signal as a final process.

[1988]

The receiver may process a signal received a predetermined number of times, or notify the signal received the predetermined number of times to the user. The receiver may process a signal received a largest number of times during the movement.

[1989]

The receiver may include notification means for notifying the user when signal reception is successful or when a signal is detected in a captured image. The notification means performs notification by sound, vibration, display update (e.g. popup display), or the like. This enables the user to recognize the presence of a transmitter.

[1990]

FIG. 497 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[1991]

A plurality of transmitters such as displays are arranged adjacent to each other. In the case of transmitting the same signal, the plurality of transmitters synchronize the signal transmission timing, and transmit the signal from the entire surface as in (a) in FIG. 497. This allows a receiver to observe the plurality of displays as one large transmitter, so that the receiver can receive the signal faster or from a longer distance. In the case where the plurality of transmitters transmit different signals, the plurality of transmitters transmit the signals while providing a buffer zone (non-transmission area) where no signal is transmitted, as in (b) in FIG. 497. This allows the receiver to recognize the plurality of transmitters as separate transmitters with the buffer zone in between, so that the receiver can receive the signals separately.

[1992]

FIG. 498 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[1993]

As illustrated in (a) in FIG. 498, a liquid crystal display provides a backlight off period, and changes the liquid crystal state during backlight off to make the image in the state change invisible, thus enhancing dynamic resolution. On the liquid crystal display performing such backlight control, a signal is superimposed according to the backlight on period as illustrated in (b) in FIG. 498. Continuously transmitting the set of data (Hdr, Data, FCS) contributes to higher reception efficiency. The light emitting unit is in a bright state (Hi) in the first and last parts of the backlight on

period. This is because, if the dark state (Lo) of the light emitting unit is continuous with the backlight off period, the receiver cannot determine whether Lo is transmitted as a signal or the light emitting unit is in a dark state due to the backlight off period.

[1994]

A signal decreased in average luminance may be superimposed in the backlight off period.

[1995]

Signal superimposition causes the average luminance to change as compared with the case where no signal is superimposed. Hence, adjustment such as increasing/decreasing the backlight off period or increasing/decreasing the luminance during backlight on is performed so that the average luminance is equal.

[1996]

FIG. 499 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[1997]

A liquid crystal display can reduce the luminance change of the entire screen, by performing backlight control at a different timing depending on position. This is called backlight scan. Backlight scan is typically performed so that the backlight is turned on sequentially from the end, as in (a) in FIG. 499. A captured image 8802a is obtained as a result. In the captured image 8802a, however, the part including the bright lines is divided, and there is a possibility that the entire screen of the display cannot be estimated as one transmitter. The backlight scan order is accordingly set so that all light emitting parts (signal superimposition parts) are connected when the vertical axis is the spatial axis in the backlight scan division direction and the horizontal axis is the time axis, as in (b) in FIG. 499. A captured image 8802b is obtained as a result. In the captured image 8802b, all bright line parts are connected, facilitating estimation that this is a transmission signal from one transmitter. Besides, since the number of continuously receivable bright lines increases, faster or longer-distance signal reception is possible. Moreover, the size of the transmitter is easily estimated,

and therefore the position of the receiver can be accurately estimated from the position, size, and angle of the transmitter in the captured image.

[1998]

FIG. 500 is a diagram illustrating an example of a signal transmission method in Embodiment 18.

[1999]

In time-division backlight scan, in the case where the backlight on period is short and the light emitting parts (signal superimposition parts) cannot be connected on the graph in which the vertical axis is the spatial axis in the backlight scan division direction and the horizontal axis is the time axis, signal superimposition is performed in each light emitting part according to the backlight illumination timing, in the same way as in FIG. 498. Here, by controlling the backlight so that the distance from another backlight on part on the graph is maximum, it is possible to prevent mixture of bright lines in adjacent parts.

[2000]

FIG. 501 is a diagram for describing a use case in Embodiment 18. A system in this embodiment includes a lighting fixture 100 that performs visible light communication, a wearable device 101 having a visible light communication function, a smartphone 102, and a server 103.

[2001]

This embodiment is intended to save, through the use of visible light communication, the user's trouble when shopping in a store, thereby reducing the time for shopping. Conventionally, when the user buys a product in a store, the user needs to search for the site of the store and obtain coupon information beforehand. There is also a problem that it takes time to search the store for the product for which the coupon is available.

[2002]

As illustrated in FIG. 501, the lighting fixture 100 periodically transmits lighting ID information of the lighting fixture 100 using visible light communication, in front of the store (an electronics retail

store is assumed as an example). The wearable device 101 of the user receives the lighting ID information, and transmits the lighting ID information to the smartphone 102 using near field communication. The smartphone 102 transmits information of the user and the lighting ID information to the server 103 using a mobile line or the like. The smartphone 102 receives point information, coupon information, and the like of the store in front of the user, from the server 103. The user views the information received from the server 103, on the wearable device 101 or the smartphone 102. Thus, the user can buy displayed product information of the store on the spot, or be guided to an exhibit in the store. This is described in detail below, with reference to drawings.

[2003]

FIG. 502 is a diagram illustrating an information table transmitted from the smartphone 102 to the server 103. The smartphone 102 transmits not only the membership number, the store ID information, the transmission time, and the position information of the store held in the smartphone 102, but also the user preference information, biological information, search history, and behavior history information held in the smartphone 102.

[2004]

FIG. 503 is a block diagram of the server 103. A transmission and reception unit 201 receives the information from the smartphone 102. A control unit 202 performs overall control. A membership information DB 203 holds each membership number and the name, date of birth, point information, purchase history, and the like of the user of the membership number. A store DB 204 holds each store ID and in-store information such as product information sold in the store, display information of the store, and map information of the store. A notification information generation unit 205 generates coupon information or recommended product information according to user preference.

[2005]

FIG. 504 is a flowchart illustrating an overall process of the system. The wearable device 101 receives the lighting ID from the

lighting 100 (Step S301). The wearable device 101 then transmits the lighting ID to the smartphone 102, for example using proximity wireless communication such as Bluetooth® (Step S302). The smartphone 102 transmits the user history information and the membership number held in the smartphone 102 illustrated in FIG. 502 and the lighting ID, to the server 103 (Step S303). When the server 103 receives the data, the data is first sent to the control unit 202 (Step S304). The control unit 202 refers to the membership DB 203 with the membership number, and obtains membership information (Step S305). The control unit 202 also refers to the store DB 204 with the lighting ID, and obtains store information (Step S306). The store information includes product information in stock in the store, product information which the store wants to promote, coupon information, in-store map information, and the like. The control unit 202 sends the membership information and the store information to the notification information generation unit (Step S307). The notification information generation unit 205 generates advertisement information suitable for the user from the membership information and the store information, and sends the advertisement information to the control unit 202 (Step S308). The control unit 202 sends the membership information and the advertisement information to the transmission and reception unit 201 (Step S309). The membership information includes point information, expiration date information, and the like of the user. The transmission and reception unit 201 transmits the membership information and the advertisement information to the smartphone 102 (Step S310). The smartphone 102 displays the received information on the display screen (Step S311).

[2006]

The smartphone 102 further transfers the information received from the server 103, to the wearable device 101 (Step S312). If the notification setting of the wearable device 101 is ON, the wearable device 101 displays the information (Step S314). When the wearable device displays the information, it is desirable to alert the user by vibration or the like, for the following reason.

Since the user does not always enter the store, even when the coupon information or the like is transmitted, the user might be unaware of it.

[2007]

FIG. 505 is a diagram illustrating an information table transmitted from the server 103 to the smartphone 102. A store map DB is in-store guide information indicating which product is displayed in which position in the store. Store product information is product information in stock in the store, product price information, and the like. User membership information is point information, membership card expiration date information, and the like of the user.

[2008]

FIG. 506 is a diagram illustrating flow of screen displayed on the wearable device 101 from when the user receives the information from the server 103 in front of the store to when the user actually buys a product. In front of the store, the points provided when the user visits the store and the coupon information are displayed. When the user taps the coupon information, the information according to the user preference transmitted from the server 103 is displayed. For example when the user taps "TV", recommended TV information is displayed. When the user presses the buy button, a receiving method selection screen is displayed to enable the user to select the delivery to the home or the reception in the store. In this embodiment, in which store the user is present is known, and so there is an advantage that the user can receive the product in the store. When the user selects "guide to sales floor" in flow 403, the wearable device 101 switches to a guide mode. This is a mode of guiding the user to a specific location using an arrow and the like, and the user can be guided to the location where the selected product is actually on display. After the user is guided to the store shelf, the wearable device 101 switches to a screen inquiring whether or not to buy the product. The user can determine whether or not to buy the product, after checking the size, the color, the usability and the like with the actual product.

[2009]

Visible light communication in the present invention allows the position of the user to be specified accurately. Therefore, for example in the case where the user is likely to enter a dangerous area in a factory as in FIG. 507, a warning can be issued to the user. Whether or not to issue a warning may be determined by the wearable device. It is thus possible to create such a warning system with a high degree of freedom that warns children of a specific age or below.

[2010]

[Embodiment 19]

FIG. 508 is a diagram illustrating a service provision system using the reception method described in any of the foregoing embodiments.

[2011]

First, a company A ex8000 managing a server ex8002 is requested to distribute information to a mobile terminal, by another company B or individual ex8001. For example, the distribution of detailed advertisement information, coupon information, map information, or the like to the mobile terminal that performs visible light communication with a signage is requested. The company A ex8000 managing the server manages information distributed to the mobile terminal in association with arbitrary ID information. A mobile terminal ex8003 obtains ID information from a subject ex8004 by visible light communication, and transmits the obtained ID information to the server ex8002. The server ex8002 transmits the information corresponding to the ID information to the mobile terminal, and counts the number of times the information corresponding to the ID information is transmitted. The company A ex8000 managing the server charges the fee corresponding to the count, to the requesting company B or individual ex8001. For example, a larger fee is charged when the count is larger.

[2012]

FIG. 509 is a flowchart illustrating service provision flow.

[2013]

In Step ex8000, the company A managing the server receives the request for information distribution from another company B. In Step ex8001, the information requested to be distributed is managed in association with the specific ID information in the server managed by the company A. In Step ex8002, the mobile terminal receives the specific ID information from the subject by visible light communication, and transmits it to the server managed by the company A. The visible light communication method has already been described in detail in the other embodiments, and so its description is omitted here. The server transmits the information corresponding to the specific ID information received from the mobile terminal, to the mobile terminal. In Step ex8003, the number of times the information is distributed is counted in the server. Lastly, in Step ex8004, the fee corresponding to the information distribution count is charged to the company B. By such charging according to the count, the appropriate fee corresponding to the advertising effect of the information distribution can be charged to the company B.

[2014]

FIG. 510 is a flowchart illustrating service provision in another example. The description of the same steps as those in FIG. 509 is omitted here.

[2015]

In Step ex8008, whether or not a predetermined time has elapsed from the start of the information distribution is determined. In the case of determining that the predetermined time has not elapsed, no fee is charged to the company B in Step ex8011. In the case of determining that the predetermined time has elapsed, the number of times the information is distributed is counted in Step ex8009. In Step ex8010, the fee corresponding to the information distribution count is charged to the company B. Since the information distribution is performed free of charge within the predetermined time, the company B can receive the accounting service after checking the advertising effect and the like.

[2016]

FIG. 511 is a flowchart illustrating service provision in another example. The description of the same steps as those in FIG. 510 is omitted here.

[2017]

In Step ex8014, the number of times the information is distributed is counted. In the case of determining that the predetermined time has not elapsed from the start of the information distribution in Step ex8015, no fee is charged in Step ex8016. In the case of determining that the predetermined time has elapsed, on the other hand, whether or not the number of times the information is distributed is greater than or equal to a predetermined number is determined in Step ex8017. In the case where the number of times the information is distributed is less than the predetermined number, the count is reset, and the number of times the information is distributed is counted again. In this case, no fee is charged to the company B regarding the predetermined time during which the number of times the information is distributed is less than the predetermined number. In the case where the count is greater than or equal to the predetermined number in Step ex8017, the count is reset and started again in Step ex8018. In Step ex8019, the fee corresponding to the count is charged to the company B. Thus, in the case where the count during the free distribution time is small, the free distribution time is provided again. This enables the company B to receive the accounting service at an appropriate time. Moreover, in the case where the count is small, the company A can analyze the information and, for example when the information is out of season, suggest the change of the information to the company B. In the case where the free distribution time is provided again, the time may be shorter than the predetermined time provided first. The shorter time than the predetermined time provided first reduces the burden on the company A. Further, the free distribution time may be provided again after a fixed time period. For instance, if the information is influenced by seasonality, the free distribution time is provided again after the fixed time period until the new season begins.

[2018]

Note that the charge fee may be changed according to the amount of data, regardless of the number of times the information is distributed. Distribution of a predetermined amount of data or more may be charged, while distribution is free of charge within the predetermined amount of data. The charge fee may be increased with the increase of the amount of data. Moreover, when managing the information in association with the specific ID information, a management fee may be charged. By charging the management fee, it is possible to determine the fee upon requesting the information distribution.

[2019]

[Embodiment 20]

(Modulation scheme that facilitates reception)

FIGS. 512A, 512B, and 513 are diagrams illustrating an example of signal coding in Embodiment 20.

[2020]

A transmission signal is made up of a header (H) and a body (Body). The header includes a unique signal pattern. A receiver finds this unique pattern from a received signal, recognizes which part of the received signal represents the header or the body based on the position of the unique pattern, and receives data.

[2021]

In the case where the transmission signal is modulated in a pattern (a) in FIG. 512A, the receiver can receive data when successively receiving the header and the body that follows the header. The duration in which the receiver can continuously receive the signal depends on the size of a transmitter shown in a captured image (taken image). In the case where the transmitter is small or the transmitter is captured from a distance, the duration in which the receiver can continuously receive the signal is short. In the case where the duration (continuous reception time) in which the receiver can continuously receive the signal is the same as the time taken for transmitting one block including the header and the body, the receiver can receive data only when the transmission start point and

the reception start point of the header are the same. (a) in FIG. 512A illustrates the case where the continuous reception time is a little longer than the transmission time for one block including the header and the body. Each arrow indicates the continuous reception time. The receiver can receive data when receiving the signal at the timings indicated by the thick arrows, but cannot receive data when receiving the signal at the timings indicated by the thin arrows because the header and the body are not completely contained in the received signal.

[2022]

In the case where the transmission signal is modulated in a pattern (b) in FIG. 512A, the receiver can receive data at more reception timings. The transmitter transmits the signal modulated with "body, header, body" as one set. The two bodies in the same set represent the same signal. The receiver does not need to continuously receive the whole signal included in the body, but can restore the body by concatenating the body parts before and after the header. Hence, the receiver can receive data so long as it can continuously receive the whole signal included in the header. In FIG. 512A, the reception timings at which data can be received are indicated by the thick lines. As illustrated in FIG. 512A, data reception is possible at more reception timings in (b) than in (a).

[2023]

In the modulation scheme (b) in FIG. 512A, the receiver can restore the body in the case where the body signal length is fixed. The receiver can also restore the body in the case where information of the body signal length is included in the header.

[2024]

In detail, as illustrated in FIG. 512B, the receiver first detects the header having a unique bright line pattern, from the captured image (bright line image) including bright lines. The receiver then sequentially reads each signal of the body following the header (in the direction (1) in FIG. 512B). Each time the receiver reads a signal, the receiver determines whether or not the signal of the body has been read for the body signal length. That is, the receiver

determines whether or not the whole signal included in the body has been read. In the case of determining that the whole signal has not been read, the receiver reads a signal following the read signal. If there is no following signal, the receiver sequentially reads each signal of the body preceding the header (in the direction (2) in FIG. 512B). The whole signal included in the body is read in this way. Here, in the case where the body signal length is fixed, the receiver holds the body signal length beforehand, and makes the above-mentioned determination using the body signal length. Alternatively, the receiver specifies the body signal length from the header, and makes the above-mentioned determination using the body signal length.

[2025]

Even in the case where the body signal length is variable, if the modulation scheme is defined so that the body modulated by the same transmitter has the same signal length, the receiver can restore the body by estimating the body signal length from the signal length between two headers. In this case, in the modulation scheme (b) in FIG. 512A, a signal corresponding to two headers and two bodies needs to be received at one time. In a modulation scheme illustrated in FIG. 513, on the other hand, merely receiving a signal corresponding to two headers and one body enables the body signal length to be estimated. FIG. 513 illustrates the modulation scheme in which "body, header, body, header 2 (H2)" constitute one set, where the receiver can receive data so long as it can continuously receive the whole signal included in the header.

[2026]

Thus, the transmitter in this embodiment determines a first luminance change pattern corresponding to a body which is a part of a signal to be transmitted and a second luminance change pattern indicating a header for specifying the body, and transmits the header and the body by changing in luminance according to the first luminance change pattern, the second luminance change pattern, and the first luminance change pattern in this order. The transmitter may also determine a third luminance change pattern

indicating another header different from the header, and transmit the header, the body, and the other header by changing in luminance according to the first luminance change pattern, the second luminance change pattern, the first luminance change pattern, and the third luminance change pattern in this order.

[2027]

(Communication using bright lines and image recognition)

FIG. 514 is a diagram illustrating an example of a captured image in Embodiment 20.

[2028]

A receiver can not only read a signal from bright lines in the captured image, but also analyze a part other than the bright lines by image processing. For instance, the receiver receives a signal from a transmitter such as a digital signage. Even in the case where the receiver receives the same signal, the receiver can display a different advertisement depending on an image displayed on a screen of the transmitter.

[2029]

Since the bright lines are noise in image processing, image processing may be performed after interpolating pixel values in the bright line part from pixels right and left of the bright lines. Alternatively, image processing may be performed on an image except the bright line part.

[2030]

(Imaging element use method suitable for visible light signal reception)

FIGS. 515A to 515C are diagrams illustrating an example of a structure and operation of a receiver in Embodiment 20.

[2031]

The receiver includes an imaging element 8910a, as illustrated in FIG. 515A. The imaging element includes effective pixels which constitute a part for capturing an image, optical black for measuring noise such as dark current, and an ineffective area 8910b. The optical black includes VOB for measuring vertical noise and HOB for measuring horizontal noise. Since bright lines appear in a direction

8910c (horizontal direction), during exposure of the VOB or the ineffective area 8910b, bright lines are not obtained and signal reception is impossible. The time during which signal reception is possible can be increased by switching, upon visible light communication, to such an imaging mode that does not use the VOB and the ineffective area 8910b or minimally uses the VOB and the ineffective area 8910b.

[2032]

As illustrated in FIG. 515B, the exposure time in an effective pixel area which is an area including the effective pixels can be increased by not using the VOB and the ineffective area 8910b. In detail, in normal imaging, one captured image is obtained in each of time t0 to t10, time t10 to t20, and time t20 to t30, as illustrated in (a) in FIG. 515B. Since the VOB and the ineffective area 8910b are also used when obtaining each captured image, the exposure time (the time during which electric charge is read, the shaded part in FIG. 515B) in the effective pixel area is time t3 to t10, time t13 to t20, and time t23 to t30.

[2033]

In visible light communication, by not using the VOB and the ineffective area 8910b, the exposure time in the effective pixel area can be increased by the time during which the VOB and the ineffective area 8910b are used, as illustrated in (b) in FIG. 515B. That is, the time during which reception is possible in visible light communication can be increased. This enables reception of more signals.

[2034]

In normal imaging, the exposure of each exposure line in the effective pixel area starts after a predetermined time m elapses from when the exposure of its adjacent exposure line starts, as illustrated in (a) in FIG. 515C. In visible light communication, on the other hand, since the exposure time in the effective pixel area is increased, the exposure of each exposure line in the effective pixel area starts after a predetermined time n (n > m) elapses from when the exposure of its adjacent exposure line starts, as illustrated in (b) in

FIG. 515C.

[2035]

Thus, in normal imaging, the receiver in this embodiment performs electric charge reading on each of a plurality of exposure lines in an area including optical black in the image sensor, after a predetermined time elapses from when electric charge reading is performed on an exposure line adjacent to the exposure line. In visible light communication, the receiver performs electric charge reading on each of a plurality of exposure lines in an area other than the optical black in the image sensor, after a time longer than the predetermined time elapses from when electric charge reading is performed on an exposure line adjacent to the exposure line, the optical black not being used in electric charge reading.

[2036]

The time during which signal reception is possible can be further increased by switching, upon visible light communication, to such an imaging mode that does not reduce the number of vertical pixels by a process such as demosaicing or clipping.

[2037]

When an image is captured in such a mode that does not use the VOB and the ineffective area 8910b and does not reduce the number of vertical pixels, the timing of exposing the bottom edge of the captured image and the timing of exposing the top edge of the captured image at the next frame are continuous, so that continuous signal reception is possible. Even in the case where the VOB and the like cannot be completely disabled, by modulating the transmission signal by an error correctable scheme, continuous signal reception is possible.

[2038]

In FIG. 515A, photodiodes in the horizontal direction are exposed simultaneously, as a result of which horizontal bright lines appear. In visible light communication, this exposure mode and an exposure mode of exposing photodiodes in the vertical direction simultaneously are alternately applied to obtain horizontal bright lines and vertical bright lines. Thus, the signal can be stably

received regardless of the shape of the transmitter.

[2039]

(Continuous signal reception)

FIG. 515D is a diagram illustrating an example of a signal reception method in Embodiment 21.

[2040]

An imaging element includes effective pixels which are pixels for converting received light intensity to an image and ineffective pixels for not converting received light intensity to an image but using it as, for example, reference intensity of dark current. In the normal imaging mode, there is the time during which only the ineffective pixels receive light, i.e. the time during which signal reception is impossible, as illustrated in (a). In the visible light communication mode, the time during which reception is possible is increased by minimizing the time during which only the ineffective pixels receive light as illustrated in (b) or by setting the effective pixels to constantly receive light as illustrated in (c). This also enables continuous reception. Though there is the time during which reception is impossible in the case of (b), the use of error correction code in the transmission data allows the whole signal to be estimated even when a part of the signal cannot be received.

[2041]

(Method of receiving signal from transmitter captured in small size)

FIG. 515E is a flowchart illustrating an example of a signal reception method in Embodiment 21.

[2042]

As illustrated in FIG. 515E, the process starts in Step 9000a. In Step 9000b, a receiver receives a signal. In Step 9000c, the receiver detects a header. In Step 9000d, the receiver determines whether or not the data size of a body following the header is known. In the case of Yes, the process proceeds to Step 9000f. In the case of No, the process proceeds to Step 9000e, and the receiver reads the data size of the body following the header, from the header. The process then proceeds to Step 9000f. In Step 9000f, the receiver determines whether or not the signal indicating the body is all

successively received following the header. In the case of Yes, the process proceeds to Step 9000g, and the receiver reads the body part from the signal received following the header. In Step 9000p, the process ends. In the case of No, the process proceeds to Step 9000h, and the receiver determines whether or not the total data length of the part received following the header and the part received before the header is sufficient for the data length of the body. In the case of Yes, the process proceeds to Step 9000i, and the receiver reads the body part by concatenating the part received following the header and the part received before the header. In Step 9000p, the process ends. In the case of No, the process proceeds to Step 9000j, and the receiver determines whether or not means for capturing many bright lines from a transmitter is available. In the case of Yes, the process proceeds to Step 9000n, and the receiver changes to a setting capable of capturing many bright lines. The process then returns to Step 9000b. In the case of No, the process proceeds to Step 9000k, and the receiver notifies that a transmitter is present but the image capture size is insufficient. In Step 9000m, the receiver notifies the direction toward the transmitter and that reception is possible if moving closer to the transmitter. In Step 9000p, the process ends.

[2043]

With this method, the signal can be stably received even in the case where the number of exposure lines passing through the transmitter in the captured image is small.

[2044]

(Captured image size suitable for visible light signal reception)

FIGS. 516 and 517A are diagrams illustrating an example of a reception method in Embodiment 20.

[2045]

In the case where an effective pixel area of an imaging element is 4:3, if an image is captured at 16:9, top and bottom parts of the image are clipped. When horizontal bright lines appear, bright lines are lost due to this clipping, and the time during which signal reception is possible is shortened. Likewise, in the case

where the effective pixel area of the imaging element is 16:9, if an image is captured at 4:3, right and left parts of the image are clipped. When vertical bright lines appear, the time during which signal reception is possible is shortened. In view of this, an aspect ratio that involves no clipping, i.e. 4:3 in FIG. 516 and 16:9 in FIG. 517A, is set as an aspect ratio for imaging in the visible light communication mode. This contributes to a longer time during which reception is possible.

[2046]

Thus, the receiver in this embodiment further sets an aspect ratio of an image obtained by the image sensor. In visible light communication, the receiver determines whether or not an edge of the image perpendicular to the exposure lines (bright lines) is clipped in the set aspect ratio, and changes the set aspect ratio to a non-clipping aspect ratio in which the edge is not clipped in the case of determining that the edge is clipped. The image sensor in the receiver obtains the bright line image in the non-clipping aspect ratio, by capturing the subject changing in luminance.

[2047]

FIG. 517B is a flowchart illustrating an example of a reception method in Embodiment 20.

[2048]

This reception method sets an imaging aspect ratio for increasing the reception time and receiving a signal from a small transmitter.

[2049]

As illustrated in FIG. 517B, the process starts in Step 8911Ba. In Step 8911Bb, the receiver changes the imaging mode to the visible light communication mode. In Step 8911Bc, the receiver determines whether or not the captured image aspect ratio is set to be closest to the effective pixel aspect ratio. In the case of Yes, the process proceeds to Step 8911Bd, and the receiver sets the captured image aspect ratio to be closest to the effective pixel aspect ratio. In Step 8911Be, the process ends. In the case of No, the process ends in Step 8911Be. Setting the aspect ratio in the visible light

communication mode in this way reduces the time during which reception is impossible, and also enables signal reception from a small transmitter or a distant transmitter.

[2050]

FIG. 517C is a flowchart illustrating an example of a reception method in Embodiment 20.

[2051]

This reception method sets an imaging aspect ratio for increasing the number of samples per unit time.

[2052]

As illustrated in FIG. 517C, the process starts in Step 8911Ca. In Step 8911Cb, the receiver changes the imaging mode to the visible light communication mode. In Step 8911Cc, the receiver determines whether or not, though bright lines of exposure lines can be recognized, signal reception is impossible because the number of samples per unit time is small. In the case of Yes, the process proceeds to Step 8911Cd, and the receiver sets the captured image aspect ratio to be most different from the effective pixel aspect ratio. In Step 8911Ce, the receiver increases the imaging frame rate. The process then returns to Step 8911Cc. In the case of No, the process proceeds to Step 8911Cf, and the receiver receives a signal. The process then ends.

[2053]

Setting the aspect ratio in the visible light communication mode in this way enables reception of a high frequency signal, and also enables reception even in an environment with a large amount of noise.

[2054]

(Visible light signal reception using zoom)

FIG. 518 is a diagram illustrating an example of a reception method in Embodiment 20.

[2055]

A receiver finds an area where bright lines are present in a captured image 8913a, and performs zoom so that as many bright lines as possible appear. The number of bright lines can be

maximized by enlarging the bright line area in the direction perpendicular to the bright line direction until the bright line area lies over the top and bottom edges of the screen as in a captured image 8913b.

[2056]

The receiver may find an area where bright lines are displayed clearly, and perform zoom so that the area is shown in a large size as in a captured image 8913c.

[2057]

In the case where a plurality of bright line areas are present in a captured image, the above-mentioned process may be performed for each of the bright line areas, or performed for a bright line area designated by a user from the captured image.

[2058]

(Image data size reduction method suitable for visible light signal reception)

FIG. 519 is a diagram illustrating an example of a reception method in Embodiment 20.

[2059]

In the case where the image data size needs to be reduced when sending a captured image (a) from an imaging unit to an image processing unit or from an imaging terminal (receiver) to a server, reduction or pixel omission in the direction parallel to bright lines as in (c) enables the data size to be reduced without decreasing the amount of information of bright lines. When reduction or pixel omission is performed as in (b) or (d), on the other hand, the number of bright lines decreases or it becomes difficult to recognize bright lines. Upon image compression, too, a decrease in reception efficiency can be prevented by not performing compression in the direction perpendicular to bright lines or by setting the compression rate in the perpendicular direction lower than that in the parallel direction. Note that a moving average filter is applicable to any of the parallel and perpendicular directions, and is effective in both data size reduction and noise reduction.

[2060]

Thus, the receiver in this embodiment further: compresses the bright line image in a direction parallel to each of the plurality of bright lines included in the bright line image, to generate a compressed image; and transmits the compressed image.

[2061]

(Modulation scheme with high reception error detection accuracy)

FIG. 520 is a diagram illustrating an example of a signal modulation method in Embodiment 20.

[2062]

Error detection by a parity bit detects a 1-bit reception error, and so cannot detect a mix-up between "01" and "10" and a mix-up between "00" and "11". In a modulation scheme (a), "01" and "10" tend to be mixed up because the L position differs only by one between "01" and "10". In a modulation scheme (b), on the other hand, the L position differs by two between "01" and "10" and between "00" and "11". Hence, a reception error can be detected with high accuracy through the use of the modulation scheme (b). The same applies to the modulation schemes in FIGS. 404 to 406.

[2063]

Thus, in this embodiment, luminance change patterns between which the timing at which a predetermined luminance value (e.g. L) occurs is different are assigned to different signal units beforehand, to prevent two luminance change patterns from being assigned to signal units of the same parity (e.g. "01" and "10"), the timing at which the predetermined luminance value occurs in one of the two luminance change patterns being adjacent to the timing at which the predetermined luminance value occurs in the other one of the two luminance change patterns. The transmitter in this embodiment determines, for each signal unit included in the transmission signal, a luminance change pattern assigned to the signal unit.

[2064]

(Change of operation of receiver according to situation)

FIG. 521 is a diagram illustrating an example of operation of a receiver in Embodiment 20.

[2065]

A receiver 8920a operates differently according to a situation in which reception starts. For instance, in the case of being activated in Japan, the receiver 8920a receives a signal modulated by phase shift keying at 60 kHz, and downloads data from a server 8920d using the received ID as a key. In the case of being activated in the US, the receiver 8920a receives a signal modulated by frequency shift keying at 50 kHz, and downloads data from a server 8920e using the received ID as a key. The situation according to which the operation of the receiver changes includes a location (country or building) where the receiver 8920a is present, a base station or a wireless access point (Wi-Fi, Bluetooth, IMES, etc.) in communication with the receiver 8920a, a time of day, and so on.

[2066]

For example, the receiver 8920a transmits, to a server 8920f, position information, information of a last accessed wireless base station (a base station of a carrier communication network, Wi-Fi, Bluetooth®, IMES, etc.), or an ID last received by visible light communication. The server 8920f estimates the position of the receiver 8920a based on the received information, and transmits a reception algorithm capable of receiving transmission signals of transmitters near the position and information (e.g. URI) of an ID management server managing IDs of transmitters near the position. The receiver 8920a receives a signal of a transmitter 8920b or 8920c using the received algorithm, and inquires of an ID management server 8920d or 8920e indicated by the received information using the ID as a key.

[2067]

With this method, communication can be performed by a scheme that differs depending on country, region, building, or the like. The receiver 8920a in this embodiment may, upon receiving a signal, switch the server to be accessed, the reception algorithm, or the signal modulation method illustrated in FIG. 520, according to the frequency used for modulating the signal.

[2068]

(Notification of visible light communication to humans)

FIG. 522 is a diagram illustrating an example of operation of a transmitter in Embodiment 20.

[2069]

A light emitting unit in a transmitter 8921a repeatedly performs blinking visually recognizable by humans and visible light communication, as illustrated in (a) in FIG. 522. Blinking visually recognizable by humans can notify humans that visible light communication is possible. Upon seeing that the transmitter 8921a is blinking, a user notices that visible light communication is possible. The user accordingly points a receiver 8921b at the transmitter 8921a to perform visible light communication, and conducts user registration of the transmitter 8921a.

[2070]

Thus, the transmitter in this embodiment repeatedly alternates between a step of a light emitter transmitting a signal by changing in luminance and a step of the light emitter blinking so as to be visible to the human eye.

[2071]

The transmitter may include a visible light communication unit and a blinking unit (communication state display unit) separately, as illustrated in (b) in FIG. 522.

[2072]

The transmitter may operate as illustrated in (c) in FIG. 522 using the modulation scheme in FIG. 405 or 406, thereby making the light emitting unit appear blinking to humans while performing visible light communication. In detail, the transmitter repeatedly alternates between high-luminance visible light communication with brightness 75% and low-luminance visible light communication with brightness 1%. As an example, by operating as illustrated in (c) in FIG. 522 when an abnormal condition or the like occurs in the transmitter and the transmitter is transmitting a signal different from normal, the transmitter can alert the user without stopping visible light communication.

[2073]

(Expansion in reception range by diffusion plate)

FIG. 523 is a diagram illustrating an example of a receiver in Embodiment 20.

[2074]

A receiver 8922a is in a normal mode in (a) in FIG. 523, and in a visible light communication mode in (b) in FIG. 523. The receiver 8922a includes a diffusion plate 8922b in front of an imaging unit. In the visible light communication mode, the receiver 8922a moves the diffusion plate 8922b to be in front of the imaging unit so that a light source is captured wider. Here, the position of the diffusion plate 8922b is adjusted to prevent light from a plurality of light sources from overlapping each other. A macro lens or a zoom lens may be used instead of the diffusion plate 8922b. This enables signal reception from a distant transmitter or a small transmitter.

[2075]

The imaging direction of the imaging unit may be moved instead of moving the diffusion plate 8922b.

[2076]

An area of an image sensor where the diffusion plate 8922b is shown may be used only in the visible light communication mode and not in the normal imaging mode. In this way, the above-mentioned advantageous effect can be achieved without moving the diffusion plate 8922b or the imaging unit.

[2077]

(Method of synchronizing signal transmission from a plurality of transmitters)

FIGS. 524 and 525 are diagrams illustrating an example of a transmission system in Embodiment 20.

[2078]

In the case of using a plurality of projectors for projection mapping or the like, for projection onto one part, there is a need to transmit a signal only from one projector or synchronize the signal transmission timings of the plurality of projectors, in order to avoid interference. FIG. 524 illustrates a mechanism for synchronization of transmission.

[2079]

Projectors A and B that project onto the same projection surface transmit signals as illustrated in FIG. 524. A receiver captures the projection surface for signal reception, calculates the time difference between signals a and b, and adjusts the signal transmission timing of each projector.

[2080]

Since the projectors A and B are not synchronous at the operation start, a time (total pause time) during which both the projectors A and B transmit no signal is provided to prevent the signals a and b from overlapping and being unable to be received. The signal transmitted from each projector may be changed as the timing adjustment for the projector progresses. For example, efficient timing adjustment can be made by taking a longer total pause time at the operation start and shortening the total pause time as the timing adjustment progresses.

[2081]

For accurate timing adjustment, it is desirable that the signals a and b are contained in one captured image. The imaging frame rate of the receiver tends to be 60 fps to 7.5 fps. By setting the signal transmission period to less than or equal to 1/7.5 second, the signals a and b can be contained in an image captured at 7.5 fps. By setting the signal transmission period to less than or equal to 1/60 second, the signals a and b can be reliably contained in an image captured at 30 fps.

[2082]

FIG. 525 illustrates synchronization of a plurality of transmitters as displays. The displays to be synchronized are captured so as to be contained within one image, to perform timing adjustment.

[2083]

(Visible light signal reception by illuminance sensor and image sensor)

FIG. 526 is a diagram illustrating an example of operation of a receiver in Embodiment 20.

[2084]

An image sensor consumes more power than an illuminance sensor. Accordingly, when a signal is detected by an illuminance sensor 8940c, a receiver 8940a activates an image sensor 8940b to receive the signal. As illustrated in (a) in FIG. 526, the receiver 8940a receives a signal transmitted from a transmitter 8940d, by the illuminance sensor 8940c. After this, the receiver 8940a activates the image sensor 8940b, receives the transmission signal of the transmitter 8940d by the image sensor, and also recognizes the position of the transmitter 8940d. At the time when the image sensor 8940b receives a part of the signal, if the part is the same as the signal received by the illuminance sensor 8940c, the receiver 8940a provisionally determines that the same signal is received, and performs a subsequent process such as displaying the current position. The determination is completed once the image sensor 8940b has successfully received the whole signal.

[2085]

Upon the provisional determination, information that the determination is not completed may be displayed. For instance, the current position is displayed semi-transparently, or a position error is displayed.

[2086]

The part of the signal may be, for example, 20% of the total signal length or an error detection code portion.

[2087]

In a situation as illustrated in (b) in FIG. 526, the receiver 8940a cannot receive signals by the illuminance sensor 8940c due to interference, but can recognize the presence of signals. For example, the receiver 8940a can estimate that signals are present, in the case where a peak appears in transmission signal modulation frequency when the sensor value of the illuminance sensor 8940c is Fourier transformed. Upon estimating that signals are present from the sensor value of the illuminance sensor 8940c, the receiver 8940a activates the image sensor 8940b and receives signals from transmitters 8940e and 8940f.

[2088]

(Reception start trigger)

FIG. 527 is a diagram illustrating an example of operation of a receiver in Embodiment 20.

[2089]

Power is consumed while an image sensor or an illuminance sensor (hereafter collectively referred to as "light receiving sensor") is on. Stopping the light receiving sensor when not needed and activating it when needed contributes to improved power consumption efficiency. Here, since the illuminance sensor consumes less power than the image sensor, only the image sensor may be controlled while the illuminance sensor is always on.

[2090]

In (a) in FIG. 527, a receiver 8941a detects movement from a sensor value of a 9-axis sensor, and activates a light receiving sensor to start reception.

[2091]

In (b) in FIG. 527, the receiver 8941a detects an operation of tilting the receiver horizontally from the sensor value of the 9-axis sensor, and activates a light receiving sensor pointed upward to start reception.

[2092]

In (c) in FIG. 527, the receiver 8941a detects an operation of sticking the receiver out from the sensor value of the 9-axis sensor, and activates a light receiving sensor in the stick out direction to start reception.

[2093]

In (d) in FIG. 527, the receiver 8941a detects an operation of directing the receiver upward or shaking the receiver from the sensor value of the 9-axis sensor, and activates a light receiving sensor pointed upward to start reception.

[2094]

Thus, the receiver in this embodiment further: determines whether or not the receiver (reception device) is moved in a predetermined manner; and activates the image sensor, in the case

of determining that the reception device is moved in the predetermined manner.

[2095]

(Reception start gesture)

FIG. 528 is a diagram illustrating an example of gesture operation for starting reception by the present communication scheme.

[2096]

A receiver 8942a such as a smartphone detects an operation of setting the receiver upright and sliding the receiver in the horizontal direction or repeatedly sliding the receiver in the horizontal direction, from a sensor value of a 9-axis sensor. The receiver 8942a then starts reception, and obtains the position of each transmitter 8942b based on the received ID. The receiver 8942a obtains the position of the receiver, from the relative position relations between the receiver and the plurality of transmitters 8942b. The receiver 8942a can stably capture the plurality of transmitters 8942b by being slid, and estimate the position of the receiver with high accuracy by triangulation.

[2097]

This operation may be performed only when the receiver's home screen is in the foreground. This can prevent the communication from being launched despite the user's intension while the user is using another application.

[2098]

(Example of application to car navigation system)

FIGS. 529 and 530 are diagrams illustrating an example of application of a transmission and reception system in Embodiment 20.

[2099]

A transmitter 8950b such as a car navigation system transmits information for wirelessly connecting to the transmitter 8950b, such as Bluetooth® pairing information, Wi-Fi SSID and password, or an IP address. A receiver 8950a such as a smartphone establishes wireless connection with the transmitter 8950b based on the received information, and performs subsequent communication via

the wireless connection.

[2100]

As an example, a user inputs a destination, store information to be searched for, or the like to the smartphone 8950a. The smartphone 8950a transmits the input information to the car navigation system 8950b via the wireless connection, and the car navigation system 8950b displays route information. As another example, the smartphone 8950a operates as a controller of the car navigation system 8950b, to control music or video reproduced in the car navigation system 8950b. As another example, music or video held in the smartphone 8950a is reproduced in the car navigation system 8950b. As another example, the car navigation system 8950b obtains nearby store information or road congestion information, and has the smartphone 8950a display the information. As another example, upon receiving a call, the smartphone 8950a uses a microphone and a speaker of the wirelessly connected car navigation system 8950b for a conversation process. The smartphone 8950a may establish wireless connection and performs the above-mentioned operation upon receiving a call.

[2101]

In the case where the car navigation system 8950b is set in an automatic connection mode for wireless connection, the car navigation system 8950b is wirelessly connected to a registered terminal automatically. In the case where the car navigation system 8950b is not in the automatic connection mode, the car navigation system 8950b transmits connection information using visible light communication, and waits for connection. The car navigation system 8950b may transmit connection information using visible light communication and wait for connection, even in the automatic connection mode. In the case where the car navigation system is manually connected, the automatic connection mode may be cleared, and a terminal automatically connected to the car navigation system may be disconnected.

[2102]

(Example of application to content protection)

FIG. 531 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2103]

A transmitter 8951b such as a television transmits content protection information held in the transmitter 8951b or a device 8951c connected to the transmitter 8951b. A receiver 8951a such as a smartphone receives the content protection information, and performs content protection for a predetermined time afterward so that content protected by the content protection information in the transmitter 8951b or the device 8951c can be reproduced. Thus, content held in another device possessed by the user can be reproduced in the receiver.

[2104]

The transmitter 8951b may store the content protection information in a server, and the receiver 8951a may obtain the content protection information from the server using a received ID of the transmitter 8951b as a key.

[2105]

The receiver 8951a may transmit the obtained content protection information to another device.

[2106]

(Example of application to electronic lock)

FIG. 532 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2107]

A receiver 8952a receives an ID transmitted from a transmitter 8952b, and transmits the ID to a server 8952c. When receiving the ID of the transmitter 8952b from the receiver 8952a, the server 8952c unlocks a door 8952d, opens an automatic door, or calls an elevator for moving to a floor registered in the receiver 8952a to a floor on which the receiver 8952a is present. The receiver 8952a thus functions as a key, allowing the user to unlock the door 8952d before reaching the door 8952d as an example.

[2108]

Thus, the receiver in this embodiment: obtains a first bright

line image which is an image including a plurality of bright lines, by capturing a subject (e.g. the above-mentioned transmitter) changing in luminance; and obtains first transmission information (e.g. the ID of the subject) by demodulating data specified by a pattern of the plurality of bright lines included in the obtained first bright line image. After the first transmission information is obtained, the receiver causes an opening and closing drive device of a door to open the door, by transmitting a control signal (e.g. the ID of the subject).

[2109]

To prevent malicious operation, the server 8952c may verify that the device in communication is the receiver 8952a, through the use of security protection such as a secure element of the receiver 8952a. Moreover, to make sure that the receiver 8952a is near the transmitter 8952b, the server 8952c may, upon receiving the ID of the transmitter 8952b, issue an instruction to transmit a different signal to the transmitter 8952b and, in the case where the signal is transmitted from the receiver 8952a, unlock the door 8952d.

[2110]

In the case where a plurality of transmitters 8952b as lighting devices are arranged along a passageway to the door 8952d, the receiver 8952a receives IDs from these transmitters 8952b, to determine whether or not the receiver 8952a is approaching the door 8952d. For example, in the case where the values indicated by the IDs decrease in the order in which the IDs are obtained, the receiver determines that the receiver is approaching the door. Alternatively, the receiver specifies the position of each transmitter 8952b based on the corresponding ID, and estimates the position of the receiver based on the position of each transmitter 8952b and the position of the transmitter 8952b shown in the captured image. The receiver then compares the position of the door 8952d held beforehand and the estimated position of the receiver as needed, to determine whether or not the receiver is approaching the door 8952d. Upon determining that the receiver is approaching the door 8952d, the receiver transmits any of the obtained IDs to the server 8952c. The server 8952c responsively performs a process for opening the door

8952d as an example.

[2111]

Thus, the receiver in this embodiment: obtains a second bright line image which is an image including a plurality of bright lines, by capturing another subject changing in luminance; and obtains second transmission information (e.g. the ID of the other subject) by demodulating data specified by a pattern of the plurality of bright lines included in the obtained second bright line image. The receiver determines whether or not the receiver is approaching the door, based on the obtained first transmission information and second transmission information. In the case of determining that the receiver is approaching the door, the receiver transmits the control signal (e.g. the ID of any of the subjects).

[2112]

(Example of application to store visit information transmission)

FIG. 533 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2113]

A receiver 8953a transmits an ID transmitted from a transmitter 8953b, to a server 8953c. The server 8953c notifies a store staff 8953d of order information associated with the receiver 8953a. The store staff 8953d prepares a product or the like, based on the order information. Since the order has already been processed when the user enters the store, the user can promptly receive the product or the like.

[2114]

(Example of application to location-dependent order control)

FIG. 534 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2115]

A receiver 8954a displays a screen allowing an order only when a transmission signal of a transmitter 8954b is received. In this way, a store can avoid taking an order from a customer who is not nearby.

[2116]

Alternatively, the receiver 8954a places an order by transmitting an ID of the transmitter 8954b in addition to order information. This enables the store to recognize the position of the orderer, and recognize the position to which a product is to be delivered or estimate the time by which the orderer is likely to arrive at the store. The receiver 8954a may add the travel time to the store calculated from the moving speed, to the order information. Regarding suspicious purchase based on the current position (e.g. purchase of a ticket of a train departing from a station other than the current position), the receiver may reject the purchase.

[2117]

(Example of application to route guidance)

FIG. 535 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2118]

A receiver 8955a receives a transmission ID of a transmitter 8955b such as a guide sign, obtains data of a map displayed on the guide sign from a server, and displays the map data. Here, the server may transmit an advertisement suitable for the user of the receiver 8955a, so that the receiver 8955a displays the advertisement information, too. The receiver 8955a displays the route from the current position to the location designated by the user.

[2119]

(Example of application to location notification)

FIG. 536 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2120]

A receiver 8956a receives an ID transmitted from a transmitter 8956b such as a home or school lighting, and transmits position information obtained using the ID as a key, to a terminal 8956c. A parent having the terminal 8956c can thus be notified that his or her child having the receiver 8956a has got back home or arrived at the school. As another example, a supervisor having the terminal 8956c can recognize the current position of a worker having the receiver 8956a.

[2121]

(Example of application to use log storage and analysis)

FIG. 537 is a diagram illustrating an example of application of a transmission and reception system in Embodiment 20.

[2122]

A receiver 8957a receives an ID transmitted from a transmitter 8957b such as a sign, obtains coupon information from a server, and displays the coupon information. The receiver 8957a stores the subsequent behavior of the user such as saving the coupon, moving to a store displayed in the coupon, shopping in the store, or leaving without saving the coupon, in the server 8957c. In this way, the subsequent behavior of the user who has obtained information from the sign 8957b can be analyzed to estimate the advertisement value of the sign 8957b.

[2123]

(Example of application to screen sharing)

FIGS. 538 and 539 are diagrams illustrating an example of application of a transmission and reception system in Embodiment 20.

[2124]

A transmitter 8960b such as a projector or a display transmits information (an SSID, a password for wireless connection, an IP address, a password for operating the transmitter) for wirelessly connecting to the transmitter 8960b, or transmits an ID which serves as a key for accessing such information. A receiver 8960a such as a smartphone, a tablet, a notebook computer, or a camera receives the signal transmitted from the transmitter 8960b to obtain the information, and establishes wireless connection with the transmitter 8960b. The wireless connection may be made via a router, or directly made by Wi-Fi Direct, Bluetooth®, Wireless Home Digital Interface, or the like. The receiver 8960a transmits a screen to be displayed by the transmitter 8960b. Thus, an image on the receiver can be easily displayed on the transmitter.

[2125]

When connected with the receiver 8960a, the transmitter 8960b may notify the receiver 8960a that not only the information

transmitted from the transmitter but also a password is needed for screen display, and refrain from displaying the transmitted screen if a correct password is not obtained. In this case, the receiver 8960a displays a password input screen 8960d or the like, and prompts the user to input the password.

[2126]

FIG. 539 is a diagram illustrating an example where a screen of a transmitter 8961c is displayed on the transmitter 8960b via the receiver 8960a. The transmitter 8961c such as a notebook computer transmits information for connecting to the terminal 8961c, or an ID associated with the information. The receiver 8960a receives the signal transmitted from the transmitter 8960b and the signal transmitted from the transmitter 8961c, establishes connection with each of the transmitters, and causes the transmitter 8961c to transmit an image to be displayed on the transmitter 8960b. The transmitters 8960b and 8961c may communicate directly, or communicate via the receiver 8960a or a router. Hence, even in the case where the transmitter 8961c cannot receive the signal transmitted from the transmitter 8960b, an image on the transmitter 8961c can be easily displayed on the transmitter 8960b.

[2127]

The above-mentioned operation may be performed only in the case where the difference between the time at which the receiver 8960a receives the signal transmitted from the transmitter 8960b and the time at which the receiver 8960a receives the signal transmitted from the transmitter 8961c is within a predetermined time.

[2128]

The transmitter 8961c may transmit the image to the transmitter 8960b only in the case where the transmitter 8961c receives a correct password from the receiver 8960a.

[2129]

(Example of application to position estimation using wireless access point)

FIG. 540 is a diagram illustrating an example of application of

a transmission and reception system in Embodiment 20.

[2130]

A receiver 8963a such as a smartphone receives an ID transmitted from a transmitter 8963b. The receiver 8963a obtains position information of the transmitter 8963b using the received ID as a key, and estimates the position of the receiver 8963a based on the position and direction of the transmitter 8963b in the captured image. The receiver 8963a also receives a signal from a radio wave transmitter 8963c such as a Wi-Fi access point. The receiver 8963a estimates the position of the receiver 8963a, based on position information and radio wave transmission direction information of the radio wave transmitter 8963c included in the signal. The receiver 8963a estimates the position of the receiver 8963a by a plurality of means in this manner, and so can estimate its position with high accuracy.

[2131]

A method of estimating the position of the receiver 8963a using the information of the radio transmitter 8963c is described below. The radio transmitter 8963c transmits synchronous signals in different directions, from a plurality of antennas. The radio transmitter 8963c also changes the signal transmission direction in sequence. The receiver 8963a estimates that a radio wave transmission direction in which the radio field intensity is highest is the direction from the radio transmitter 8963c to the receiver 8963a. Moreover, the receiver 8963a calculates path differences from the differences in arrival time of radio waves transmitted from the different antennas and respectively passing through paths 8963d, 8963e, and 8963f, and calculates the distance between the radio transmitter 8963c and the receiver 8963a from radio wave transmission angle differences θ12, θ13, and θ23. By further using surrounding electric field information and radio wave reflector information, the receiver 8963a can estimate its position with higher accuracy.

[2132]

(Position estimation by visible light communication and wireless

communication)

FIG. 541 is a diagram illustrating a structure for performing position estimation by visible light communication and wireless communication. In other words, FIG. 541 illustrates a structure for performing terminal position estimation using visible light communication and wireless communication.

[2133]

A mobile terminal performs visible light communication with a light emitting unit, to obtain an ID of the light emitting unit. The mobile terminal inquires of a server using the obtained ID, and obtains position information of the light emitting unit. An actual distance L1 can be obtained as a result. Moreover, since a tilt θ1 of the mobile terminal is detectable using a gyroscope or the like as already described in other embodiments, L3 can be calculated. The use of L1 and L3 enables calculation of the value of x1 of the mobile terminal.

[2134]

Regarding the value of y1, position estimation is performed using wireless communication. In the case where beamforming is performed from an MIMO access point toward the mobile terminal, a beamforming angle θ2 is set by the MIMO access point and is a known value. Accordingly, by obtaining the beamforming angle θ2 by wireless communication or the like, the mobile terminal can calculate the value of y1 from x1 and θ2. MIMO is capable of forming a plurality of beams, and so a plurality of beamformings may be used for position estimation of higher accuracy.

[2135]

As described above, according to this embodiment, the position estimation accuracy can be enhanced by employing both the position estimation by visible light communication and the position estimation by wireless communication.

[2136]

Though the information communication method according to one or more aspects has been described by way of the embodiments above, the present invention is not limited to these embodiments.

Modifications obtained by applying various changes conceivable by those skilled in the art to the embodiments and any combinations of structural elements in different embodiments are also included in the scope of one or more aspects without departing from the scope of the present invention.

[2137]

FIG. 542A is a flowchart of an information communication method according to an aspect of the present invention.

[2138]

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, and includes steps SK91 to SK93.

[2139]

In detail, the information communication method includes: a first exposure time setting step SK91 of setting a first exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a plurality of bright lines corresponding to a plurality of exposure lines included in the image sensor appear according to a change in luminance of the subject; a first image obtainment step SK92 of obtaining a bright line image including the plurality of bright lines, by capturing the subject changing in luminance by the image sensor with the set first exposure time; and an information obtainment step SK93 of obtaining the information by demodulating data specified by a pattern of the plurality of bright lines included in the obtained bright line image, wherein in the first image obtainment step SK92, exposure starts sequentially for the plurality of exposure lines each at a different time, and exposure of each of the plurality of exposure lines starts after a predetermined blank time elapses from when exposure of an adjacent exposure line adjacent to the exposure line ends.

[2140]

FIG. 542B is a block diagram of an information communication device according to an aspect of the present invention.

[2141]

An information communication device K90 according to an aspect of the present invention is an information communication device that obtains information from a subject, and includes structural elements K91 to K93.

[2142]

In detail, the information communication device K90 includes: an exposure time setting unit K91 that sets an exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a plurality of bright lines corresponding to a plurality of exposure lines included in the image sensor appear according to a change in luminance of the subject; an image obtainment unit K92 that includes the image sensor, and obtains a bright line image including the plurality of bright lines by capturing the subject changing in luminance with the set exposure time; and an information obtainment unit K93 that obtains the information by demodulating data specified by a pattern of the plurality of bright lines included in the obtained bright line image, wherein exposure starts sequentially for the plurality of exposure lines each at a different time, and exposure of each of the plurality of exposure lines starts after a predetermined blank time elapses from when exposure of an adjacent exposure line adjacent to the exposure line ends.

[2143]

In the information communication method and the information communication device K90 illustrated in FIGS. 542A and 542B, the exposure of each of the plurality of exposure lines starts a predetermined blank time after the exposure of the adjacent exposure line adjacent to the exposure line ends, for instance as illustrated in FIG. 24D. This eases the recognition of the change in luminance of the subject. As a result, the information can be appropriately obtained from the subject.

[2144]

It should be noted that in the above embodiments, each of the constituent elements may be constituted by dedicated hardware, or may be obtained by executing a software program suitable for the constituent element. Each constituent element may be achieved by

a program execution unit such as a CPU or a processor reading and executing a software program stored in a recording medium such as a hard disk or semiconductor memory. For example, the program causes a computer to execute the information communication method illustrated in the flowchart of FIG. 542A.

[2145]

An information communication method according to an aspect of the present invention is also applicable as in the following example.

[2146]

FIG. 543 is a diagram illustrating a watch including light sensors.

[2147]

A collecting lens is placed on the top surface of each sensor, as illustrated in the cross sectional view. In FIG. 543, the collecting lens has a predetermined tilt. The shape of the collecting lens is not limited to this, and may be any other shape capable of collecting light. With this structure, the light sensor can collect and receive light from a light source in the external world, by the lens. Even a small light sensor as included in a watch can thus perform visible light communication. In FIG. 543, the watch is divided into 12 areas and 12 light sensors are arranged in the areas, with the collecting lens being placed on the top surface of each light sensor. By dividing the inside of the watch into a plurality of areas and arranging a plurality of light sensors in this way, it is possible to obtain information from a plurality of light sources. For example, in FIG. 543, a first light sensor can receive light from a light source 1, and a second light sensor can receive light from a light source 2. A solar cell may be used as a light sensor. The use of a solar cell as a light sensor enables solar power to be generated and also visible light communication to be performed by a single sensor, which contributes to lower cost and a more compact shape. Moreover, in the case where a plurality of light sensors are arranged, information from a plurality of light sources can be obtained simultaneously, with it being possible to improve the position estimation accuracy. Though this embodiment describes a structure of providing light sensors in a

watch, this is not a limit for the present invention, and any movable device such as a mobile phone or a mobile terminal is available. An information communication method according to an aspect of the present invention may also be applied as illustrated in FIGS. 544, 545, and 546.

[2148]

(Summary of each of the above embodiments)

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, the information communication method including: setting a first exposure time of an image sensor so that, in an image obtained by capturing the subject by the image sensor, a plurality of bright lines corresponding to a plurality of exposure lines included in the image sensor appear according to a change in luminance of the subject; obtaining a bright line image including the plurality of bright lines, by capturing the subject changing in luminance by the image sensor with the set first exposure time; and obtaining the information by demodulating data specified by a pattern of the plurality of bright lines included in the obtained bright line image, wherein in the obtaining of a bright line image, exposure starts sequentially for the plurality of exposure lines each at a different time, and exposure of each of the plurality of exposure lines starts after a predetermined blank time elapses from when exposure of an adjacent exposure line adjacent to the exposure line ends.

[2149]

In this way, the exposure of each of the plurality of exposure lines starts a predetermined blank time after the exposure of the adjacent exposure line adjacent to the exposure line ends, for instance as illustrated in FIG. 24D. This eases the recognition of the change in luminance of the subject. As a result, the information can be appropriately obtained from the subject.

[2150]

For example, in the obtaining of a bright line image, each of the plurality of exposure lines may not overlap in exposure time the

adjacent exposure line, and the predetermined blank time may be provided between the exposure of each of the plurality of exposure lines and the exposure of the adjacent exposure line.

[2151]

For example, the information communication method may further include: setting a second exposure time of the image sensor so that exposure starts sequentially for the plurality of exposure lines in the image sensor each at a different time and each of the plurality of exposure lines partially overlaps in exposure time the adjacent exposure line; and obtaining a normal image by capturing the subject with the second exposure time, wherein in the obtaining of a bright line image, the first exposure time is shorter than the second exposure time and is less than or equal to 1/480 second so that the plurality of bright lines appear in the bright line image.

[2152]

For example, a same reading method may be used to read data from the image sensor in the obtaining of a bright line image and in the obtaining of a normal image.

[2153]

For example, the first exposure time of each of the plurality of exposure lines may be shorter than a shortest one of light emission times during each of which the subject changing in luminance maintains a predetermined luminance value.

[2154]

For example, the first exposure time of each of the plurality of exposure lines may be longer than a transition time during which the subject changes in luminance from a maximum value to a minimum value.

[2155]

For example, the first exposure time of each of the plurality of exposure lines may be longer than one cycle of high frequency noise in the change in luminance of the subject.

[2156]

[Embodiment 21]

This embodiment describes each example of application using

a receiver such as a smartphone and a transmitter for transmitting information as a blink pattern of an LED or an organic EL device in each of the embodiments described above.

[2157]

FIG. 547 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[2158]

A robot 8970 has a function as, for example, a self-propelled vacuum cleaner and a function as a receiver in each of the above embodiments. Lighting devices 8971a and 8971b each have a function as a transmitter in each of the above embodiments.

[2159]

For instance, the robot 8970 cleans a room and also captures the lighting device 8971a illuminating the interior of the room, while moving in the room. The lighting device 8971a transmits the ID of the lighting device 8971a by changing in luminance. The robot 8970 accordingly receives the ID from the lighting device 8971a, and estimates the position (self-position) of the robot 8970 based on the ID, as in each of the above embodiments. That is, the robot 8970 estimates the position of the robot 8970 while moving, based on the result of detection by a 9-axis sensor, the relative position of the lighting device 8971a shown in the captured image, and the absolute position of the lighting device 8971a specified by the ID.

[2160]

When the robot 8970 moves away from the lighting device 8971a, the robot 8970 transmits a signal (turn off instruction) instructing to turn off, to the lighting device 8971a. For example, when the robot 8970 moves away from the lighting device 8971a by a predetermined distance, the robot 8970 transmits the turn off instruction. Alternatively, when the lighting device 8971a is no longer shown in the captured image or when another lighting device is shown in the image, the robot 8970 transmits the turn off instruction to the lighting device 8971a. Upon receiving the turn off instruction from the robot 8970, the lighting device 8971a turns off according to the turn off instruction.

[2161]

The robot 8970 then detects that the robot 8970 approaches the lighting device 8971b based on the estimated position of the robot 8970, while moving and cleaning the room. In detail, the robot 8970 holds information indicating the position of the lighting device 8971b and, when the distance between the position of the robot 8970 and the position of the lighting device 8971b is less than or equal to a predetermined distance, detects that the robot 8970 approaches the lighting device 8971b. The robot 8970 transmits a signal (turn on instruction) instructing to turn on, to the lighting device 8971b. Upon receiving the turn on instruction, the lighting device 8971b turns on according to the turn on instruction.

[2162]

In this way, the robot 8970 can easily perform cleaning while moving, by making only its surroundings illuminated.

[2163]

FIG. 548 is a diagram illustrating an example of application of a transmitter in Embodiment 21.

[2164]

For example, a plurality of light emitting areas A to F are arranged in a display, and each of the light emitting areas A to F changes in luminance to transmit a signal, as illustrated in (a) in FIG. 548. In the example illustrated in (a) in FIG. 548, the light emitting areas A to F are each a rectangle, and are aligned along the horizontal and vertical directions. In such a case, a non-luminance change area that does not change in luminance extends across the display along the horizontal direction of the display, between the light emitting areas A, B, and C and the light emitting areas D, E, and F. Another non-luminance change area that does not change in luminance also extends across the display along the vertical direction of the display, between the light emitting areas A and D and the light emitting areas B and E. Another non-luminance change area that does not change in luminance also extends across the display along the vertical direction of the display, between the light emitting areas B and E and the light emitting areas C and F.

[2165]

When a receiver in each of the above embodiments captures the display in a state where the exposure lines of the receiver are in the horizontal direction, no bright line appears in the part of the image obtained by image capture (captured image) corresponding to the non-luminance change area along the horizontal direction. That is, the area (bright line area) where bright lines appear is discontinuous in the captured image. When the receiver captures the display in a state where the exposure lines of the receiver are in the vertical direction, no bright line appears in the parts of the captured image corresponding to the two non-luminance change areas along the vertical direction. In this case, too, the bright line area is discontinuous in the captured image. When the bright line area is discontinuous, it is difficult to receive the signal transmitted by luminance change.

[2166]

In view of this, a display 8972 in this embodiment has a function as a transmitter in each of the above embodiments, and has each of the plurality of light emitting areas A to F shifted in position so that the bright line area is continuous.

[2167]

For example, the upper light emitting areas A, B, and C and the lower light emitting areas D, E, and F are shifted in position from each other in the horizontal direction in the display 8972, as illustrated in (b) in FIG. 548. Alternatively, the light emitting areas A to F that are each a parallelogram or a rhombus are arranged in the display 8972, as illustrated in (c) in FIG. 548. This eliminates a non-luminance change area lying across the display 8972 along the vertical direction of the display 8972 between the light emitting areas A to F. As a result, the bright line area is continuous in the captured image, even when the receiver captures the display 8972 in a state where the exposure lines are in the vertical direction.

[2168]

The light emitting areas A to F may be shifted in position in the vertical direction in the display 8972, as illustrated in (d) and (e) in

FIG. 548. This eliminates a non-luminance change area lying across the display 8972 along the horizontal direction of the display 8972 between the light emitting areas A to F. As a result, the bright line area is continuous in the captured image, even when the receiver captures the display 8972 in a state where the exposure lines are in the horizontal direction.

[2169]

The light emitting areas A to F that are each a hexagon may be arranged in the display 8972 so that the sides of the areas are parallel to each other, as illustrated in (f) in FIG. 548. This eliminates a non-luminance change area lying across the display 8972 along any of the horizontal and vertical directions of the display 8972 between the light emitting areas A to F, as in the above-mentioned cases. As a result, the bright line area is continuous in the captured image, even when the receiver captures the display 8972 in a state where the exposure lines are in the horizontal direction or captures the display 8972 in a state where the exposure lines are in the vertical direction.

[2170]

FIG. 549A is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[2171]

A receiver 8973 is a smartphone having a function as a receiver in each of the above embodiments. As illustrated in (a) in FIG. 549A, the receiver 8973 captures a display 8972, and tries to read bright lines appearing in the captured image. In the case where the display 8972 is dark, the receiver 8973 may not be able to read the bright lines and receive the signal from the display 8972. In such a case, the receiver 8973 flashes in a predetermined rhythm, as illustrated in (b) in FIG. 549A. Upon receiving the flash, the display 8972 increases the luminance and produces bright display, as illustrated in (c) in FIG. 549A. As a result, the receiver 8973 can read the bright lines appearing in the captured image and receive the signal from the display 8972.

[2172]

FIG. 549B is a flowchart illustrating operation of the receiver 8973 in Embodiment 21.

[2173]

First, the receiver 8973 determines whether or not an operation or gesture by the user to start reception is received (Step S831). In the case of determining that the operation or gesture is received (Step S831: Y), the receiver 8973 starts reception by image capture using an image sensor (Step S832). The receiver 8973 then determines whether or not a predetermined time has elapsed from the reception start without completing the reception (Step S833). In the case of determining that the predetermined time has elapsed (Step S833: Y), the receiver 8973 flashes in a predetermined rhythm (Step S834), and repeats the process from Step S833. In the case of repeating the process from Step S833, the receiver 8973 determines whether or not a predetermined time has elapsed from the flash without completing the reception. In Step S834, instead of flashing, the receiver 8973 may output a predetermined sound of a frequency inaudible to humans, or transmit, to the transmitter which is the display 8972, a signal indicating that the receiver 8973 is waiting for reception.

[2174]

FIG. 550 is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[2175]

A lighting device 8974 has a function as a transmitter in each of the above embodiments. The lighting device 8974 illuminates, for example, a line guide sign 8975 in a train station, while changing in luminance. A receiver 8973 pointed at the line guide sign 8975 by the user captures the line guide sign 8975. The receiver 8973 thus obtains the ID of the line guide sign 8975, and obtains information associated with the ID, i.e. detailed information of each line shown in the line guide sign 8975. The receiver 8973 displays a guide image 8973a indicating the detailed information. For example, the guide image 8973a indicates the distance to the line shown in the line guide sign 8975, the direction to the line, and the time of arrival of the next

train on the line.

[2176]

When the user touches the guide image 8973a, the receiver 8973 displays a supplementary guide image 8973b. For instance, the supplementary guide image 8973b is an image for displaying any of a train timetable, information about lines other than the line shown by the guide image 8973a, and detailed information of the station, according to selection by the user.

[2177]

FIG. 551 is a diagram illustrating an example of application of a transmitter in Embodiment 21.

[2178]

Lighting devices 8976a to 8976c each have a function as a transmitter in each of the above embodiments, and illuminate a store sign 8977. As illustrated in (a) in FIG. 551, the lighting devices 8976a to 8976c may transmit the same ID by changing in luminance synchronously. As illustrated in (b) in FIG. 551, the lighting devices 8976a and 8976c located at both ends may transmit the same ID by changing in luminance synchronously, while the lighting device 8976b located between these lighting devices illuminates the sign 8977 without transmitting an ID by luminance change. As illustrated in (c) in FIG. 551, the lighting devices 8976a and 8976c located at both ends may transmit different IDs by changing in luminance, in a state where the lighting device 8976b does not transmit an ID. In this case, since the lighting device 8976b between the lighting devices 8976a and 8976c does not change in luminance for ID transmission, the signals from the lighting devices 8976a and 8976c can be kept from interfering with each other. Though the ID transmitted from the lighting device 8976a and the ID transmitted from the lighting device 8976c are different, these IDs may be associated with the same information.

[2179]

FIG. 552A is a diagram illustrating an example of application of a transmitter and a receiver in Embodiment 21.

[2180]

A lighting device 8978 has a function as a transmitter in each of the above embodiments, and constantly transmits a signal by changing in luminance as illustrated in (1) in FIG. 552A.

[2181]

A receiver in this embodiment captures the lighting device 8978. Here, an imaging range 8979 of the receiver includes the lighting device 8978 and a part other than the lighting device 8978, as illustrated in FIG. 552A. In detail, a part other than the lighting device 8978 is included in each of an upper area a and a lower area c in the imaging range 8979, and the lighting device 8978 is included in a center area b in the imaging range 8979.

[2182]

The receiver captures the lighting device 8978 to obtain a captured image (bright line image) including a plurality of bright lines that appear according to the change in luminance of the lighting device 8978, as illustrated in (2) and (3) in FIG. 552A. In the bright line image, bright lines appear only in the part corresponding to the center area b, while no bright line appears in the parts corresponding to the upper area a and the lower area c.

[2183]

In the case where the receiver captures the lighting device 8978 at a frame rate of 30 fps as an example, the length b of the bright line area in the bright line image is short, as illustrated in (2) in FIG. 552A. In the case where the receiver captures the lighting device 8978 at a frame rate of 15 fps as an example, the length b of the bright line area in the bright line image is long, as illustrated in (3) in FIG. 552A. Note that the length of the bright line area (bright line pattern) is the length perpendicular to each bright line included in the bright line area.

[2184]

Hence, the receiver in this embodiment captures the lighting device 8978 at a frame rate of 30 fps as an example, and determines whether or not the length b of the bright line area in the bright line image is less than a predetermined length. For example, the predetermined length is the length corresponding to one block of

signal transmitted by luminance change by the lighting device 8978. In the case where the receiver determines that the length b is less than the predetermined length, the receiver changes the frame rate to 15 fps as an example. Thus, the receiver can receive one block of signal from the lighting device 8978 at one time.

[2185]

FIG. 552B is a flowchart illustrating operation of a receiver in Embodiment 21.

[2186]

First, the receiver determines whether or not bright lines are included in a captured image, i.e. whether or not stripes by exposure lines are captured (Step S841). In the case of determining that the stripes are captured (Step S841: Y), the receiver determines in which imaging mode (image capture mode) the receiver is set (Step S842). In the case of determining that the imaging mode is the intermediate imaging mode (intermediate mode) or the normal imaging mode (normal image capture mode), the receiver changes the imaging mode to the visible light imaging mode (visible light communication mode) (Step S843).

[2187]

The receiver then determines whether or not the length perpendicular to the bright lines in the bright line area (bright line pattern) is greater than or equal to a predetermined length (Step S844). That is, the receiver determines whether or not there is a stripe area greater than or equal to a predetermined size in the direction perpendicular to the exposure lines. In the case of determining that the length is not greater than or equal to the predetermined length (Step S844: N), the receiver determines whether or not optical zoom is available (Step S845). In the case of determining that optical zoom is available (Step S845: Y), the receiver performs optical zoom to lengthen the bright line area, i.e. to enlarge the stripe area (Step S846). In the case of determining that optical zoom is not available (Step S845: N), the receiver determines whether or not Ex zoom (Ex optical zoom) is available (Step S847). In the case of determining that Ex zoom is available

(Step S847: Y), the receiver performs Ex zoom to lengthen the bright line area, i.e. to enlarge the stripe area (Step S848). In the case of determining that Ex zoom is not available (Step S847: N), the receiver decreases the imaging frame rate (Step S849). The receiver then captures the lighting device 8978 at the set frame rate, to receive a signal (Step S850).

[2188]

Though the frame rate is decreased in the case where optical zoom and Ex zoom are not available in the example illustrated in FIG. 552B, the frame rate may be decreased in the case where optical zoom and Ex zoom are available. Ex zoom is a function of limiting the use area of the image sensor and reducing the imaging angle of view so that the apparent focal length is telephoto.

[2189]

FIG. 553 is a diagram illustrating operation of a receiver in Embodiment 21.

[2190]

In the case where a lighting device 8978 which is a transmitter is shown in a small size in a captured image 8980a, the receiver can obtain a captured image 8980b in which the lighting device 8978 is shown in a larger size, through the use of optical zoom or Ex zoom. Thus, the use of optical zoom or Ex zoom enables the receiver to obtain a bright line image (captured image) having a bright line area that is long in the direction perpendicular to bright lines.

[2191]

FIG. 554 is a diagram illustrating an example of application of a transmitter in Embodiment 21.

[2192]

A transmitter 8981 has a function as a transmitter in each of the above embodiments, and communicates with an operation panel 8982 as an example. The operation panel 8982 includes a transmission switch 8982a and a power switch 8982b.

[2193]

When the transmission switch 8982a is turned on, the operation panel 8982 instructs the transmitter 8981 to perform

visible light communication. Upon receiving the instruction, the transmitter 8981 transmits a signal by changing in luminance. When the transmission switch 8982a is turned off, the operation panel 8982 instructs the transmitter 8981 to stop visible light communication. Upon receiving the instruction, the transmitter 8981 stops signal transmission without changing in luminance.

[2194]

When the power switch 8982b is turned on, the operation panel 8982 instructs the transmitter 8981 to turn on the power of the transmitter 8981. Upon receiving the instruction, the transmitter 8981 turns its power on. For example, in the case where the transmitter 8981 is a lighting device, the transmitter 8981 turns its power on to illuminate the surroundings. In the case where the transmitter 8981 is a television, the transmitter 8981 turns its power on to display video and the like. When the power switch 8982b is turned off, the operation panel 8982 instructs the transmitter 8981 to turn off the power of the transmitter 8981. Upon receiving the instruction, the transmitter 8981 turns its power off and enters a standby state.

[2195]

FIG. 555 is a diagram illustrating an example of application of a receiver in Embodiment 21.

[2196]

For example, a receiver 8973 as a smartphone has a function as a transmitter in each of the above embodiments, and obtains an authentication ID and an expiration date from a server 8983. In the case where the current time is within the expiration date, the receiver 8973 transmits the authentication ID to a peripheral device 8984 by changing, for example, its display in luminance. Examples of the peripheral device 8984 include a camera, a barcode reader, and a personal computer.

[2197]

Having received the authentication ID from the receiver 8973, the peripheral device 8984 transmits the authentication ID to the server 8983, and requests verification. The server 8983 compares

the authentication ID transmitted from the peripheral device 8984 and the authentication ID held in the server 8983 and transmitted to the receiver 8973. When they match, the server 8983 notifies the peripheral device 8984 of the match. Having received the notification of the match from the server 8983, the peripheral device 8984 releases a lock set therein, executes electronic payment, or performs a login process or the like.

[2198]

FIG. 556A is a flowchart illustrating an example of operation of a transmitter in Embodiment 21.

[2199]

The transmitter in this embodiment has a function as a transmitter in each of the above embodiments, and is a lighting device or a display as an example. For instance, the transmitter determines whether or not the light control level (brightness level) is less than a predetermined level (Step S861a). In the case of determining that the light control level is less than the predetermined level (Step S861a: Y), the transmitter stops signal transmission by luminance change (Step S861b).

[2200]

FIG. 556B is a flowchart illustrating an example of operation of a transmitter in Embodiment 21.

[2201]

The transmitter in this embodiment determines whether or not the light control level (brightness level) is greater than a predetermined level (Step S862a). In the case of determining that the light control level is greater than the predetermined level (Step S862a: Y), the transmitter starts signal transmission by luminance change (Step S862b).

[2202]

FIG. 557 is a flowchart illustrating an example of operation of a transmitter in Embodiment 21.

[2203]

The transmitter in this embodiment determines whether or not a predetermined mode is selected (Step S863a). For example, the

predetermined mode is eco mode or power saving mode. In the case of determining that the predetermined mode is selected (Step S863a: Y), the transmitter stops signal transmission by luminance change (Step S863b). In the case of determining that the predetermined mode is not selected (Step S863a: N), the transmitter starts signal transmission by luminance change (Step S863c).

[2204]

FIG. 558 is a flowchart illustrating an example of operation of an imaging device in Embodiment 21.

[2205]

The imaging device in this embodiment is a video camera as an example, and determines whether or not the imaging device is in a recording process (Step S864a). In the case of determining that the imaging device is in a recording process (Step S864a: Y), the imaging device transmits a visible light transmission stop instruction to a transmitter transmitting a signal by luminance change (Step S864b). Upon receiving the visible light transmission stop instruction, the transmitter stops signal transmission by luminance change (visible light transmission). In the case of determining that the imaging device is not in a recording process (Step S864a: N), the imaging device further determines whether or not recording has been stopped, i.e. the imaging device has just stopped recording (Step S864c). In the case of determining that recording has been stopped (Step S864c: Y), the imaging device transmits a visible light transmission start instruction to the transmitter (Step S864d). Upon receiving the visible light transmission start instruction, the transmitter starts signal transmission by luminance change (visible light transmission).

[2206]

FIG. 559 is a flowchart illustrating an example of operation of an imaging device in Embodiment 21.

[2207]

The imaging device in this embodiment is a digital still camera as an example, and determines whether or not an imaging button (shutter button) is being half pressed or whether or not focus is being

adjusted (Step S865a). The imaging device then determines whether or not a light and dark area appears in the direction along exposure lines in an image sensor included in the imaging device (Step S865b). In the case of determining that the light and dark area appears (Step S865b: Y), there is a possibility that a transmitter transmitting a signal by luminance change is near the imaging device. The imaging device accordingly transmits a visible light transmission stop instruction to the transmitter (Step S865c). After this, the imaging device performs imaging to obtain a captured image (Step S865d). The imaging device then transmits a visible light transmission start instruction to the transmitter (Step S865e). Thus, the imaging device can obtain the captured image, without being affected by the luminance change by the transmitter. Moreover, since the time during which signal transmission by luminance change is stopped is a very short period of time when the imaging device performs imaging, the time during which visible light communication is disabled can be reduced.

[2208]

FIG. 560 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[2209]

The transmitter in this embodiment has a function as a transmitter in each of the above embodiments, and outputs high-luminance light (Hi) or low-luminance light (Lo) per slot, thereby transmitting a signal. In detail, the slot is a time unit of 104.2 μs. The transmitter outputs Hi to transmit a signal indicating 1, and outputs Lo to transmit a signal indicating 0.

[2210]

FIG. 561 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[2211]

The above-mentioned transmitter outputs Hi or Lo per slot, thereby transmitting each PHY (physical layer) frame which is a signal unit in sequence. The PHY frame includes a preamble made up of 8 slots, an FCS (Frame Check Sequence) made up of 2 slots,

and a body made up of 20 slots. The parts included in the PHY frame are transmitted in the order of the preamble, the FCS, and the body.
[2212]

The preamble corresponds to the header of the PHY frame, and includes "01010111" as an example. The preamble may be made up of 7 slots. In this case, the preamble includes "0101011". The FCS includes "01" in the case where the number of 1s included in the body is an even number, and "11" in the case where the number of 1s included in the body is an odd number. The body includes 5 symbols each of which is made up of 4 slots. In the case of 4-value PPM, the symbol includes "0111", "1011", "1101", or "1110".
[2213]

FIG. 562 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.
[2214]

The above-mentioned symbol is converted to a 2-bit value by a receiver. For example, the symbols "0111", "1011", "1101", and "1110" are respectively converted to "00", "01", "10", and "11". Accordingly, the body (20 slots) of the PHY frame is converted to a 10-bit signal. The 10-bit body includes 3-bit TYPE indicating the type of the PHY frame, 2-bit ADDR indicating the address of the PHY frame or the body, and 5-bit DATA indicating the entity of data. For example, in the case where the type of the PHY frame is TYPE1, TYPE indicates "000". ADDR indicates "00", "01", "10", or "11".
[2215]

The receiver concatenates DATA included in the respective bodies of 4 PHY frames. ADDR mentioned above is used in this concatenation. In detail, the receiver concatenates DATA included in the body of the PHY frame having ADDR "00", DATA included in the body of the PHY frame having ADDR "01", DATA included in the body of the PHY frame having ADDR "10", and DATA included in the body of the PHY frame having ADDR "11", thus generating 20-bit data. The four PHY frames are decoded in this way. The generated data includes 16-bit effective DATA and 4-bit CRC (Cyclic Redundancy Check).

[2216]

FIG. 563 is a diagram illustrating an example of a signal transmitted by a transmitter in Embodiment 21.

[2217]

The type of the PHY frame mentioned above includes TYPE1, TYPE2, TYPE3, and TYPE4. The body length, the ADDR length, the DATA length, the number of DATA concatenated (concatenation number), the effective DATA length, and the CRC type differ between these types.

[2218]

For example, in TYPE1, TYPE (TYPEBIT) indicates "000", the body length is 20 slots, the ADDR length is 2 bits, the DATA length is 5 bits, the concatenation number is 4, the effective DATA length is 16 bits, and the CRC type is CRC-4. In TYPE2, on the other hand, TYPE (TYPEBIT) indicates "001", the body length is 24 slots, the ADDR length is 4 bits, the DATA length is 5 bits, the concatenation number is 8, the effective DATA length is 32 bits, and the CRC type is CRC-8.

[2219]

The use of such a signal illustrated in FIGS. 560 to 563 enables visible light communication to be performed appropriately.

[2220]

FIG. 564 is a diagram illustrating an example of a structure of a system including a transmitter and a receiver in Embodiment 21.

[2221]

The system in this embodiment includes a transmitter 8991 having the same function as a transmitter in each of the above embodiments, a receiver 8973 such as a smartphone, a content sharing server 8992, and an ID management server 8993.

[2222]

For instance, a content creator uploads, to the content sharing server 8992, content such as audio video data representing a still image or a moving image for introducing a product, and product information indicating the manufacturer, area of production, material, specifications, etc. of the product. The content sharing server 8992 registers the product information in the ID management server 8993,

in association with a content ID for identifying the content.

[2223]

Following this, the transmitter 8991 downloads the content and the content ID from the content sharing server 8992, displays the content, and transmits the content ID by changing in luminance, i.e. by visible light communication, according to an operation by the user. The user views the content. In the case where the user is interested in the product introduced in the content, the user points the receiver 8973 at the transmitter 8991 to capture the transmitter 8991. The receiver 8973 captures the content displayed on the transmitter 8991, thus receiving the content ID.

[2224]

The receiver 8973 then accesses the ID management server 8993, and inquires of the ID management server 8993 for the content ID. As a result, the receiver 8973 receives the product information associated with the content ID from the ID management server 8993, and displays the product information. When the receiver 8973 receives an operation requesting to buy the product corresponding to the product information, the receiver 8973 accesses the manufacturer of the product and executes a process for buying the product.

[2225]

Next, the ID management server notifies inquiry information indicating the number of inquiries or the number of accesses made for the content ID, to the manufacturer indicated by the product information associated with the content ID. Having received the inquiry information, the manufacturer pays an affiliate reward corresponding to the number of inquiries or the like indicated by the inquiry information to the content creator specified by the content ID, by electronic payment via the ID management server 8993 and the content sharing server 8992.

[2226]

FIG. 565 is a diagram illustrating an example of a structure of a system including a transmitter and a receiver in Embodiment 21.

[2227]

In the example illustrated in FIG. 564, when the content and the product information are uploaded, the content sharing server 8992 registers the product information in the ID management server 8993 in association with the content ID. However, such registration may be omitted. For example, the content sharing server 8992 searches the ID management server for a product ID for identifying the product of the uploaded product information, and embeds the product ID in the uploaded content, as illustrated in FIG. 565.

[2228]

Following this, the transmitter 8991 downloads the content in which the product ID is embedded and the content ID from the content sharing server 8992, displays the content, and transmits the content ID and the product ID by changing in luminance, i.e. by visible light communication, according to an operation by the user. The user views the content. In the case where the user is interested in the product introduced in the content, the user points the receiver 8973 at the transmitter 8991 to capture the transmitter 8991. The receiver 8973 captures the content displayed on the transmitter 8991, thus receiving the content ID and the product ID.

[2229]

The receiver 8973 then accesses the ID management server 8993, and inquires of the ID management server 8993 for the content ID and the product ID. As a result, the receiver 8973 receives the product information associated with the product ID from the ID management server 8993, and displays the product information. When the receiver 8973 receives an operation requesting to buy the product corresponding to the product information, the receiver 8973 accesses the manufacturer of the product and executes a process for buying the product.

[2230]

Next, the ID management server notifies inquiry information indicating the number of inquiries or the number of accesses made for the content ID and the product ID, to the manufacturer indicated by the product information associated with the product ID. Having received the inquiry information, the manufacturer pays an affiliate

reward corresponding to the number of inquiries or the like indicated by the inquiry information to the content creator specified by the content ID, by electronic payment via the ID management server 8993 and the content sharing server 8992.

[2231]

FIG. 566 is a diagram illustrating an example of a structure of a system including a transmitter and a receiver in Embodiment 21.

[2232]

The system in this embodiment includes a content sharing server 8992a instead of the content sharing server 8992 illustrated in FIG. 565, and further includes an SNS server 8994. The SNS server 8994 is a server providing a social networking service, and performs part of the process performed by the content sharing server 8992 illustrated in FIG. 565.

[2233]

In detail, the SNS server 8994 obtains the content and the product information uploaded from the content creator, searches for the product ID corresponding to the product information, and embeds the product ID in the content. The SNS server 8994 then transfers the content in which the product ID is embedded, to the content sharing server 8992a. The content sharing server 8992a receives the content transferred from the SNS server 8994, and transmits the content in which the product ID is embedded and the content ID to the transmitter 8991.

[2234]

Thus, in the example illustrated in FIG. 566, the unit including the SNS server 8994 and the content sharing server 8992a serves as the content sharing server 8992 illustrated in FIG. 565.

[2235]

In the system illustrated in each of FIGS. 564 to 566, an appropriate affiliate reward can be paid for an advertisement (content) for which inquiries have been made using visible light communication.

[2236]

Though the information communication method according to

one or more aspects has been described by way of the embodiments above, the present invention is not limited to these embodiments. Modifications obtained by applying various changes conceivable by those skilled in the art to the embodiments and any combinations of structural elements in different embodiments are also included in the scope of one or more aspects without departing from the scope of the present invention.

[2237]

FIG. 567A is a flowchart of an information communication method according to an aspect of the present invention.

[2238]

An information communication method according to an aspect of the present invention is an information communication method of transmitting a signal by a change in luminance, and includes steps SK11 and SK12.

[2239]

In detail, the information communication method includes: a determination step SK11 of determining a pattern of the change in luminance, by modulating the signal to be transmitted; and a transmission step SK12 of transmitting the signal, by a plurality of light emitters changing in luminance according to the determined pattern of the change in luminance. The plurality of light emitters are arranged on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.

[2240]

FIG. 542B is a block diagram of an information communication device according to an aspect of the present invention.

[2241]

An information communication device K10 according to an aspect of the present invention is an information communication device that transmits a signal by a change in luminance, and includes

structural elements K11 and K12.

[2242]

In detail, the information communication device K10 includes: a determination unit K11 that determines a pattern of the change in luminance, by modulating the signal to be transmitted; and a transmission unit K12 that transmits the signal, by a plurality of light emitters changing in luminance according to the determined pattern of the change in luminance. The plurality of light emitters are arranged on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.

[2243]

In the information communication method and the information communication device K10 illustrated in FIGS. 567A and 567B, the bright line area can be made continuous in the captured image obtained by capturing the surface (display) by the image sensor included in the receiver, for instance as illustrated in FIG. 548. This eases the reception of the transmission signal, and enables communication between various devices including a device with low computational performance.

[2244]

It should be noted that in the above embodiments, each of the constituent elements may be constituted by dedicated hardware, or may be obtained by executing a software program suitable for the constituent element. Each constituent element may be achieved by a program execution unit such as a CPU or a processor reading and executing a software program stored in a recording medium such as a hard disk or semiconductor memory. For example, the program causes a computer to execute the information communication method illustrated in the flowchart of FIG. 567A.

[2245]

FIG. 568A is a flowchart of an information communication

method according to an aspect of the present invention.

[2246]

An information communication method according to an aspect of the present invention is an information communication method of obtaining information from a subject, and includes steps SK21 to SK24.

[2247]

In detail, the information communication method includes: a first exposure time setting step SK21 of setting a first exposure time of an image sensor so that, in an image obtained by capturing a first subject by the image sensor, a plurality of bright lines corresponding to exposure lines included in the image sensor appear according to a change in luminance of the first subject, the first subject being the subject; a first bright line image obtainment step SK22 of obtaining a first bright line image which is an image including the plurality of bright lines, by capturing the first subject changing in luminance by the image sensor with the set first exposure time; a first information obtainment step SK23 of obtaining first transmission information by demodulating data specified by a pattern of the plurality of bright lines included in the obtained first bright line image; and a door control step SK24 of causing an opening and closing drive device of a door to open the door, by transmitting a control signal after the first transmission information is obtained.

[2248]

FIG. 568B is a block diagram of an information communication device according to an aspect of the present invention.

[2249]

An information communication device K20 according to an aspect of the present invention is an information communication device that obtains information from a subject, and includes structural elements K21 to K24.

[2250]

In detail, the information communication device K20 includes: an exposure time setting unit K21 that sets an exposure time of an image sensor so that, in an image obtained by capturing the subject

by the image sensor, a plurality of bright lines corresponding to exposure lines included in the image sensor appear according to a change in luminance of the subject; a bright line image obtainment unit K22 that includes the image sensor, and obtains a bright line image which is an image including the plurality of bright lines, by capturing the subject changing in luminance with the set exposure time; an information obtainment unit K23 that obtains transmission information by demodulating data specified by a pattern of the plurality of bright lines included in the obtained bright line image; and a door control unit K24 that causes an opening and closing drive device of a door to open the door, by transmitting a control signal after the transmission information is obtained.

[2251]

In the information communication method and the information communication device K20 illustrated in FIGS. 568A and 568B, the receiver including the image sensor can be used as a door key, thus eliminating the need for a special electronic lock, for instance as illustrated in FIG. 532. This enables communication between various devices including a device with low computational performance.

[2252]

It should be noted that in the above embodiments, each of the constituent elements may be constituted by dedicated hardware, or may be obtained by executing a software program suitable for the constituent element. Each constituent element may be achieved by a program execution unit such as a CPU or a processor reading and executing a software program stored in a recording medium such as a hard disk or semiconductor memory. For example, the program causes a computer to execute the information communication method illustrated in the flowchart of FIG. 568A.

[2253]

The following describes the embodiment.

[2254]

(Mixed modulation scheme)

FIGS. 569 and 570 are diagrams illustrating an example of

operation of a transmitter in Embodiment 21.

[2255]

As illustrated in FIG. 569, the transmitter modulates a transmission signal by a plurality of modulation schemes, and transmits modulated signals alternately or simultaneously.

[2256]

By modulating the same signal by the plurality of modulation schemes and transmitting the modulated signals, even a receiver that supports only one of the modulation schemes can receive the signal. Moreover, for example, the combined use of a modulation scheme with high transmission speed, a modulation scheme with high noise resistance, and a modulation scheme with long communication distance allows reception to be performed using an optimal method according to the receiver environment.

[2257]

In the case where the receiver supports reception by the plurality of modulation schemes, the receiver receives the signals modulated by the plurality of schemes. When modulating the same signal, the transmitter assigns the same signal ID to the modulated signals, and transmits the modulated signals. By checking the signal ID, the receiver can recognize that the same signal is modulated by the different modulation schemes. The receiver synthesizes the signal having the same signal ID from the plurality of types of modulated signals, with it being possible to receive the signal promptly and accurately.

[2258]

As illustrated in FIG. 570, the transmitter transmits signals modulated by a plurality of modulation schemes together. In the example in FIG. 570, by setting a long exposure time, the receiver can receive only a signal modulated by a frequency modulation scheme using a low frequency band. By setting a short exposure time, the receiver can receive only a signal modulated by a pulse position modulation scheme using a high frequency band. Here, the receiver averages the luminance in the direction perpendicular to bright lines to thereby time-average the received light intensity, as a

result of which the signal in the case where the exposure time is long can be obtained.

[2259]

(Transmission signal verification and digital modulation)

FIGS. 571 and 572 are diagrams illustrating an example of operation of a transmitter in Embodiment 21.

[2260]

In FIG. 571, a signal storage unit stores a transmission signal and a signal conversion value obtained by converting the transmission signal using a verification key described later. A one-way function is used for this conversion. A source key storage unit stores a source key which is a source value of a key, for example as a circuit constant such as a time constant or a resistance. A key generation unit generates the verification key from the source key.

[2261]

A signal verification unit converts the transmission signal stored in the signal storage unit using the verification key, to obtain a signal conversion value. The signal verification unit determines whether or not the signal has not been tampered with, depending on whether or not the obtained signal conversion value and the signal conversion value stored in the signal storage unit are equal. Even when the signal in the signal storage unit is copied to another transmitter, this other transmitter cannot transmit the signal because the verification key is different. Transmitter forgery can thus be prevented.

[2262]

In the case where the signal has been tampered with, an abnormality notification unit notifies that the signal has been tampered with. Examples of the notification method include blinking a light emitting unit in a cycle visible to humans, outputting a sound, and so on. By limiting the abnormality notification to a predetermined time immediately after power on, the transmitter can be put to use other than transmission even in the case where the signal has an abnormality.

[2263]

In the case where the signal has not been tampered with, a signal modulation unit converts the signal to a light emission pattern. Various modulation schemes are available. For example, the following modulation schemes are available: amplitude shift keying (ASK); phase shift keying (PSK); frequency shift keying (FSK); quadrature amplitude modulation (QAM); delta modulation (DM); minimum shift keying (MSK); complementary code keying (CCK); orthogonal frequency division multiplexing (OFDM); amplitude modulation (AM); frequency modulation (FM); phase modulation (PM); pulse width modulation (PWM); pulse amplitude modulation (PAM); pulse density modulation (PDM); pulse position modulation (PPM); pulse code modulation (PCM); frequency hopping spread spectrum (FHSS); and direct sequence spread spectrum (DSSS). A modulation scheme is selected according to the property of the transmission signal (whether analog or digital, whether continuous data transmission or not, etc.) and the required performance (transmission speed, noise resistance, transmission distance). Moreover, two or more modulation schemes may be used in combination.

[2264]

In Embodiments 1 to 21, the same advantageous effects can be achieved in the case where the signal modulated by any of the above-mentioned modulation schemes is used.

[2265]

In FIG. 572, a signal storage unit holds an encrypted transmission signal obtained by encrypting a transmission signal using an encryption key that is paired with a decryption key generated in a key generation unit. A signal demodulation unit decrypts the encrypted transmission signal, using the decryption key. This structure makes it difficult to forge a transmitter, i.e. to produce a transmitter for transmitting an arbitrary signal.

(Signal reception from a plurality of directions by a plurality of light receiving units)

FIG. 573 is a diagram illustrating an example of a receiver in Embodiment 21.

[2266]

A receiver 9020a such as a watch includes a plurality of light receiving units. As an example, by arranging a light receiving unit 9020b so that the light receiving unit 9020b can receive light from above when the user holds the receiver 9020a in front of his or her chest as when checking the time, it is possible to receive a signal from a ceiling light. As another example, by arranging a light receiving unit 9020c so that the light receiving unit 9020c can receive light from the front when the user holds the receiver 9020a in front of his or her chest as when checking the time, it is possible to receive a signal from a signage or the like in front of the user.

[2267]

When these light receiving units have directivity, the signal can be received without interference even in the case where a plurality of transmitters are located nearby.

[2268]

(Signal reception from a plurality of directions by a plurality of light receiving units)

FIG. 574 is a diagram illustrating an example of a receiver in Embodiment 21.

[2269]

The direction of the received signal can be estimated by arranging a plurality of light receiving elements having directivity. Providing prisms such as 9021a for guiding light in front of the light receiving elements allows the accurate direction of the transmitter to be estimated even with a small number of light receiving elements. For example, in the case where only a light receiving unit 9021d receives light, the transmitter is estimated to be situated in the direction of the prism 9021a. In the case where light receiving units 9021d and 9021e receive the same signal, the transmitter is estimated to be situated in the direction of a prism 9021b. Note that windshield glass is provided at the directivity parts or the prisms.

[2270]

(Cooperation between watch-type receiver and smartphone)

FIG. 575 is a diagram illustrating an example of a reception

system in Embodiment 21.

[2271]

A receiver 9022b such as a watch is connected to a smartphone 9022a or a glasses-type display 9022c via wireless communication such as Bluetooth. In the case where the receiver 9022b receives a signal or detects the presence of a signal, the receiver 9022b displays it on the display 9022c. The receiver 9022b transmits the received signal to the smartphone 9022a. The smartphone 9022a obtains data associated with the received signal from a server 9022d, and displays the obtained data on the display 9022c.

[2272]

(Route guidance by watch-type display)

FIG. 576 is a diagram illustrating an example of a reception system in Embodiment 21.

[2273]

A receiver 9023b such as a watch is connected to a smartphone 9023a via wireless communication such as Bluetooth®. The receiver 9023b has a watch face composed of a display such as a liquid crystal display, and is capable of displaying information other than the time. The smartphone 9022a recognizes the current position from a signal received by the receiver 9023b, and displays the route and distance to the destination on the display surface of the receiver 9023b.

[2274]

(Frequency shift keying and frequency multiplex modulation)

FIGS. 577A and 577B are diagrams illustrating an example of a modulation scheme in Embodiment 21.

[2275]

In (a) in FIG. 577A, a specific signal is expressed as a specific modulation frequency. The receiver performs frequency analysis on a light pattern to determine a dominant modulation frequency, and reconstructs a signal.

[2276]

In (a') in FIG. 577B, the modulation frequency is changed with

time. This enables many values to be expressed. A typical image sensor has an imaging frame rate of 30 fps. Accordingly, reception can be ensured by continuing one modulation frequency for 1/30 second or more. In (a'') in FIG. 577B, a time during which no signal is superimposed is inserted when changing the frequency. As a result, the receiver can easily recognize the change of the modulation frequency. A light pattern in the time during which no signal is superimposed can be distinguished from that in the signal superimposition part, by maintaining constant brightness or using a specific modulation frequency. When a frequency that is an integer multiple of 30 Hz is set as the specific modulation frequency, the non-signal superimposition part is unlikely to appear in the difference image and hamper the reception process. The length of the time during which no signal is superimposed may be greater than or equal to the same length as a signal of a longest period among light patterns used for signals. This facilitates reception. As an example, if a light pattern of a lowest modulation frequency is 100 Hz, the time during which no signal is superimposed is set to greater than or equal to 1/100 second.

[2277]

In (b) in FIG. 577A, a specific bit and a specific modulation frequency are associated with each other, and a light pattern is expressed as a waveform in which modulation frequencies corresponding to bit "1" are overlapped. This enables more values to be expressed though a higher CN ratio is necessary than the modulation scheme (a).

[2278]

In (b') in FIG. 577B, the modulation frequency overlap is changed with time in the same way as (a). This enables many values to be expressed.

[2279]

A signal of a high modulation frequency cannot be received unless the exposure time is short. Up to a certain level of modulation frequency, however, can be used without setting the exposure time. When a signal modulated using frequencies from

low to high modulation frequencies is transmitted, all terminals can receive the signal expressed by the low modulation frequency. Besides, a terminal capable of setting a short exposure time also receives the signal up to the high modulation frequency, with it being possible to receive more information from the same transmitter at high speed.

[2280]

The frequency shift keying scheme and the frequency multiplex modulation scheme have an advantageous effect of causing no flicker perceivable by the human eye even in the case where a lower modulation frequency than when expressing a signal by pulse position is used, and so is applicable to many frequency bands.

[2281]

In Embodiments 1 to 21, the same advantageous effects can be achieved in the case where the signal modulated by the above-mentioned reception scheme and modulation scheme is used.

[2282]

(Separation of mixed signal)

FIGS. 577C and 577D are diagrams illustrating an example of separation of a mixed signal in Embodiment 21.

[2283]

A receiver has functions of (a) in FIG. 577C. A light receiving unit receives a light pattern. A frequency analysis unit Fourier transforms the light pattern, to map a signal in a frequency domain. A peak detection unit detects a peak of a frequency component in the light pattern. In the case where no peak is detected by the peak detection unit, the subsequent process is suspended. A peak time change analysis unit analyzes a time change of a peak frequency. A signal source specification unit specifies, in the case where a plurality of frequency peaks are detected, a combination of modulation frequencies of signals transmitted from the same transmitter.

[2284]

Thus, reception can be performed without signal interference

even in the case where a plurality of transmitters are located nearby. When light from a transmitter is reflected off a floor, a wall, or a ceiling and received, light from a plurality of transmitters tends to be mixed. Even in such a case, reception can be performed without signal interference.

[2285]

As an example, in the case where a light pattern in which a signal of a transmitter A and a signal of a transmitter B are mixed is received, frequency peaks are obtained as in (b) in FIG. 577C. Since fA1 disappears and fA2 appears, fA1 and fA2 can be specified as signals from the same transmitter. Likewise, fA1, fA2, and fA3 can be specified as signals from the same transmitter, and fB1, fB2, and fB3 can be specified as signals from the same transmitter.

[2286]

By fixing the time interval at which one transmitter changes the modulation frequency, it is possible to easily specify the signals from the same transmitter.

[2287]

When a plurality of transmitters change the modulation frequency at the same timing, the signals from the same transmitter cannot be specified by the above-mentioned method. Hence, the time interval at which the modulation frequency is changed differs between transmitters. This prevents a situation where the plurality of transmitters change the modulation frequency always at the same timing, so that the signals from the same transmitter can be specified.

[2288]

As illustrated in (c) in FIG. 577C, the time from when the transmitter changes the modulation frequency to when the transmitter changes the modulation frequency next time is calculated from the current modulation frequency and the modulation frequency before the change. In so doing, even in the case where the plurality of transmitters change the modulation frequency at the same timing, it is possible to specify which signals of modulation frequencies are transmitted from the same transmitter.

[2289]

Each transmitter may recognize the transmission signal of the other transmitter, and adjust the modulation frequency change timing to be different from the other transmitter.

[2290]

The method described above produces the same advantageous effects not only in the case of frequency shift keying where one transmission signal has one modulation frequency but also in the case where one transmission signal has a plurality of modulation frequencies.

[2291]

In the case where the light pattern is not changed with time in the frequency multiplex modulation scheme as illustrated in (d1) in FIG. 577D, the signals from the same transmitter cannot be specified. However, by inserting a segment with no signal or by changing to a specific modulation frequency as illustrated in (d2) in FIG. 577D, the signals from the same transmitter can be specified based on the time change of the peak.

[2292]

(Operation of home appliance through lighting by visible light communication)

FIG. 578 is a diagram illustrating an example of a visible light communication system in Embodiment 21.

[2293]

A transmitter such as a ceiling light has a wireless communication function of Wi-Fi, Bluetooth®, or the like. The transmitter transmits, by visible light communication, information for connecting to the transmitter by wireless communication. A receiver A such as a smartphone performs wireless communication with the transmitter, based on the received information. The receiver A may connect to the transmitter using other information. In such a case, the receiver A does not need to have a reception function. A receiver B is an electronic device such as a microwave, as an example. The transmitter transmits information of the paired receiver B, to the receiver A. The receiver A displays the information of the receiver B, as an operable device. The receiver A

notifies an instruction to operate the receiver B to the transmitter via wireless communication, and the transmitter notifies the operation instruction to the receiver B via visible light communication. As a result, the user can operate the receiver B through the receiver A. Moreover, a device connected to the receiver A via the Internet or the like can operate the receiver B through the receiver A.

[2294]

Bidirectional communication is possible when the receiver B has a transmission function and the transmitter has a reception function. The transmission function may be realized as visible light by light emission, or communication by sound. For instance, the transmitter includes a sound collection unit, and recognizes the sound output from the receiver B to thereby recognize the state of the receiver B. As an example, the receiver B recognizes the operation end sound of the receiver B, and notifies it to the receiver A. The receiver A displays the operation end of the receiver B on the display, thus notifying the user.

[2295]

The receivers A and B include NFC. The receiver A receives a signal from the transmitter, communicates with the receiver B via NFC, and registers in the receiver A and the transmitter that a signal from the transmitter transmitting the signal received immediately before is receivable by the receiver B. This is referred to as "pairing" between the transmitter and the receiver B. For example in the case where the receiver B is moved, the receiver A registers in in the transmitter that the pairing is cleared. In the case where the receiver B is paired with another transmitter, the newly paired transmitter notifies this to the previously paired transmitter, to clear the previous pairing.

[2296]

(Reception in which interference is eliminated)

FIG. 579 is a flowchart illustrating a reception method in which interference is eliminated in Embodiment 21.

[2297]

In Step 9001a, the process starts. In Step 9001b, the

receiver determines whether or not there is a periodic change in the intensity of received light. In the case of Yes, the process proceeds to Step 9001c. In the case of No, the process proceeds to Step 9001d, and the receiver receives light in a wide range by setting the lens of the light receiving unit at wide angle. The process then returns to Step 9001b. In Step 9001c, the receiver determines whether or not signal reception is possible. In the case of Yes, the process proceeds to Step 9001e, and the receiver receives a signal. In Step 9001g, the process ends. In the case of No, the process proceeds to Step 9001f, and the receiver receives light in a narrow range by setting the lens of the light receiving unit at telephoto. The process then returns to Step 9001c.

[2298]

With this method, a signal from a transmitter in a wide direction can be received while eliminating signal interference from a plurality of transmitters.

[2299]

(Transmitter direction estimation)

FIG. 580 is a flowchart illustrating a transmitter direction estimation method in Embodiment 21.

[2300]

In Step 9002a, the process starts. In Step 9002b, the receiver sets the lens of the light receiving unit at maximum telephoto. In Step 9002c, the receiver determines whether or not there is a periodic change in the intensity of received light. In the case of Yes, the process proceeds to Step 9002d. In the case of No, the process proceeds to Step 9002e, and the receiver receives light in a wide range by setting the lens of the light receiving unit at wide angle. The process then returns to Step 9002c. In Step 9002d, the receiver receives a signal. In Step 9002f, the receiver sets the lens of the light receiving unit at maximum telephoto, changes the light reception direction along the boundary of the light reception range, detects the direction in which the light reception intensity is maximum, and estimates that the transmitter is in the detected direction. In Step 9002d, the process ends.

[2301]

With this method, the direction in which the transmitter is present can be estimated. Here, the lens may be initially set at maximum wide angle, and gradually changed to telephoto.

[2302]

(Reception start)

FIG. 581 is a flowchart illustrating a reception start method in Embodiment 21.

[2303]

In Step 9003a, the process starts. In Step 9003b, the receiver determines whether or not a signal is received from a base station of Wi-Fi, Bluetooth®, IMES, or the like. In the case of Yes, the process proceeds to Step 9003c. In the case of No, the process returns to Step 9003b. In Step 9003c, the receiver determines whether or not the base station is registered in the receiver or the server as a reception start trigger. In the case of Yes, the process proceeds to Step 9003d, and the receiver starts signal reception. In Step 9003e, the process ends. In the case of No, the process returns to Step 9003b.

[2304]

With this method, reception can be started without the user performing a reception start operation. Moreover, power can be saved as compared with the case of constantly performing reception.

[2305]

(Generation of ID additionally using information of another medium)

FIG. 582 is a flowchart illustrating a method of generating an ID additionally using information of another medium in Embodiment 21.

[2306]

In Step 9004a, the process starts. In Step 9004b, the receiver transmits either an ID of a connected carrier communication network, Wi-Fi, Bluetooth, etc. or position information obtained from the ID or position information obtained from GPS, etc., to a high order bit ID index server. In Step 9004c, the receiver receives the high order bits of a visible light ID from the high order bit ID index

server. In Step 9004d, the receiver receives a signal from a transmitter, as the low order bits of the visible light ID. In Step 9004e, the receiver transmits the combination of the high order bits and the low order bits of the visible light ID, to an ID solution server. In Step 9004f, the process ends.

[2307]

With this method, the high order bits commonly used in the neighborhood of the receiver can be obtained. This contributes to a smaller amount of data transmitted from the transmitter, and faster reception by the receiver.

[2308]

Here, the transmitter may transmit both the high order bits and the low order bits. In such a case, a receiver employing this method can synthesize the ID upon receiving the low order bits, whereas a receiver not employing this method obtains the ID by receiving the whole ID from the transmitter.

[2309]

(Reception scheme selection by frequency separation)

FIG. 583 is a flowchart illustrating a reception scheme selection method by frequency separation in Embodiment 21.

[2310]

In Step 9005a, the process starts. In Step 9005b, the receiver applies a frequency filter circuit to a received light signal, or performs frequency resolution on the received light signal by discrete Fourier series expansion. In Step 9005c, the receiver determines whether or not a low frequency component is present. In the case of Yes, the process proceeds to Step 9005d, and the receiver decodes the signal expressed in a low frequency domain of frequency modulation or the like. The process then proceeds to Step 9005e. In the case of No, the process proceeds to Step 9005e. In Step 9005e, the receiver determines whether or not the base station is registered in the receiver or the server as a reception start trigger. In the case of Yes, the process proceeds to Step 9005f, and the receiver decodes the signal expressed in a high frequency domain of pulse position modulation or the like. The process then proceeds to

Step 9005g. In the case of No, the process proceeds to Step 9005g. In Step 9005g, the receiver starts signal reception. In Step 9005h, the process ends.

[2311]

With this method, signals modulated by a plurality of modulation schemes can be received.

[2312]

(Signal reception in the case of long exposure time)

FIG. 584 is a flowchart illustrating a signal reception method in the case of a long exposure time in Embodiment 21.

[2313]

In Step 9030a, the process starts. In Step 9030b, in the case where the sensitivity is settable, the receiver sets the highest sensitivity. In Step 9030c, in the case where the exposure time is settable, the receiver sets the exposure time shorter than in the normal imaging mode. In Step 9030d, the receiver captures two images, and calculates the difference in luminance. In the case where the position or direction of the imaging unit changes while capturing two images, the receiver cancels the change, generates an image as if the image is captured in the same position and direction, and calculates the difference. In Step 9030e, the receiver calculates the average of luminance values in the direction parallel to the exposure lines in the captured image or the difference image. In Step 9030f, the receiver arranges the calculated average values in the direction perpendicular to the exposure lines, and performs discrete Fourier transform. In Step 9030g, the receiver recognizes whether or not there is a peak near a predetermined frequency. In Step 9030h, the process ends.

[2314]

With this method, signal reception is possible even in the case where the exposure time is long, such as when the exposure time cannot be set or when a normal image is captured simultaneously.

[2315]

In the case where the exposure time is automatically set, when the camera is pointed at a transmitter as a lighting, the

exposure time is set to about 1/60 second to 1/480 second by an automatic exposure compensation function. If the exposure time cannot be set, signal reception is performed under this condition. In an experiment, when a lighting blinks periodically, stripes are visible in the direction perpendicular to the exposure lines if the period of one cycle is greater than or equal to about 1/16 of the exposure time, so that the blink period can be recognized by image processing. Since the part in which the lighting is shown is too high in luminance and the stripes are hard to be recognized, the signal period may be calculated from the part where light is reflected.

[2316]

In the case of using a scheme, such as frequency shift keying or frequency multiplex modulation, that periodically turns on and off the light emitting unit, flicker is less visible to humans even with the same modulation frequency and also flicker is less likely to appear in video captured by a video camera, than in the case of using pulse position modulation. Hence, a low frequency can be used as the modulation frequency. Since the temporal resolution of human vision is about 60 Hz, a frequency not less than this frequency can be used as the modulation frequency.

[2317]

When the modulation frequency is an integer multiple of the imaging frame rate of the receiver, bright lines do not appear in the difference image between pixels at the same position in two images and so reception is difficult, because imaging is performed when the light pattern of the transmitter is in the same phase. Since the imaging frame rate of the receiver is typically 30 fps, setting the modulation frequency to other than an integer multiple of 30 Hz eases reception. Moreover, given that there are various imaging frame rates of receivers, two relatively prime modulation frequencies may be assigned to the same signal so that the transmitter transmits the signal alternately using the two modulation frequencies. By receiving at least one signal, the receiver can easily reconstruct the signal.

[2318]

The following describes other embodiments of the present invention.

[2319]

[Embodiment 22]

This embodiment relates to a device that switches a light receiving unit in visible light communication, and is assumed to be included in a mobile terminal such as a smartphone. A scene when using the mobile terminal including this device is described first.

[2320]

As illustrated in FIG. 585, the device receives an ID transmitted from a ceiling light A1101 installed on a ceiling, and also receives an ID transmitted from a base light A1103 installed in front of the user. The device has a feature that, when receiving these IDs, an optimal light receiving unit for light reception is selected from a plurality of light receiving units for receiving IDs according to the orientation of the mobile terminal. For example, a mobile terminal A1201 includes an imaging unit A1202 on the front, an imaging unit A1203 on the back, and a touch panel unit A1204 on the front, as illustrated in FIG. 586. In the case where the mobile terminal A1201 is held so that the display surface of the mobile terminal A1201 faces the ceiling as illustrated in FIG. 587, the mobile terminal A1201 determines that the mobile terminal A1201 is horizontal to the ceiling according to an accelerometer included in the mobile terminal A1201, and starts the operation of the imaging unit A1202. Meanwhile, the imaging unit A1203 stops operation, to save power. The ceiling light A1101, while being on, changes the amount of light according to a specific pattern. When the imaging unit A1202 in operation detects the light emission of the ceiling light A1101, the mobile terminal A1201 obtains an ID associated with the light emission pattern as illustrated in A1301, and changes its behavior according to the type of the ID.

[2321]

In the case where the mobile terminal A1201 is held so as to be vertical to the ground as illustrated in FIG. 588, the mobile terminal A1201 determines that the mobile terminal A1201 is not pointed at

the ceiling light on the ceiling but pointed at the base light A1103 installed on a wall or shelves A1102 according to the accelerometer included in the mobile terminal A1201, and starts the operation of the imaging unit A1203. Meanwhile, the imaging unit A1202 stops operation, to save power. The base light A1103, while being on, changes the amount of light according to a specific pattern. When the imaging unit A1203 in operation detects the light emission of the base light A1103, the mobile terminal A1201 obtains an ID associated with the light emission pattern, and changes its behavior according to the type of the ID.

[2322]

An example of behavior according to the type of the ID is described below. In the case of determining that the mobile terminal A1201 is horizontal to the ceiling as in FIG. 587, the mobile terminal A1201 transmits the ID associated with the light emission pattern to a server. The server searches for position information associated with the ID, and notifies the mobile terminal A1201 of the position information. Upon obtaining the position information from the server, the mobile terminal A1201 assumes the obtained position information as the current position of the user, and presents a map indicating the position of the user, e.g. an in-store map as illustrated in FIG. 589, to the user. In the case of determining that the mobile terminal A1201 is vertical to the ground as in FIG. 588, on the other hand, the mobile terminal A1201 transmits the obtained ID to the server. The server searches a database for a product type and stock of product shelves associated with the ID, and generates an image in which the product type and stock are reflected, e.g. an image of product shelves on which an image of the product is superimposed according to its stock as illustrated in FIG. 590 as an example. When the server transmits the generated image to the mobile terminal A1201, the mobile terminal A1201 outputs the received image, i.e. the image indicating the product stock, on the display surface. When transmitting the image data to the mobile terminal A1201, the server may transmit a plurality of images to the mobile terminal A1201. For example, the server transmits an image A1701

of shelves with a small stock and an image A1703 of shelves with a large stock in sequence, as illustrated in FIG. 591. According to the screen operation by the user, the mobile terminal A1701 changes the display from the image A1701 of shelves with a small stock to a scrolling image A1702 and then to the image A1703 of shelves with a large stock. This contributes to more intuitive and easier product stock check.

[2323]

Thus, the mobile terminal A1201 presents the product stock corresponding to the ID received from the light emitting unit, to the user. The presentation can be switched according to the received ID. Hence, for example in the case where the user changes the pointing direction of the mobile terminal A1201 from shelves A1801 to shelves A1802 as illustrated in FIG. 592, the mobile terminal A1201 receives an ID from a base light A1803 and an ID from a base light A1804 in sequence.

[2324]

The device is not limited to use in the form in which an imaging unit is provided on each of the front and the back as in the mobile terminal A1201, but is also applicable as a watch-type device A1901 in FIG. 593. The watch-type device A1901 includes a light receiving unit A1902 provided on a top surface part and a light receiving unit A1903 provided on a side surface part. The watch-type device A1901 includes an accelerometer. In the case where the top surface part is horizontal to the ground as in FIG. 593, the watch-type device A1901 operates the light receiving units A1902 and A1903, to receive light from a ceiling light A1904 by the light receiving unit A1902 and receive light from a base light A1905 by the light receiving unit A1903.

[2325]

This completes the description of an example of the scene when using the mobile terminal including the device. The following describes the structure of the device.

[2326]

FIG. 594 is a diagram of an overall structure in this

embodiment. In this embodiment, minimum structural elements include a mobile terminal A11001, a first lighting device A11002, and a second lighting device A11003. The first lighting device A11002 may be the ceiling light A1101 in FIG. 585 or the ceiling light A1904 in FIG. 593. The second lighting device A11003 may be the base light A1103 in FIG. 585 or the base light A1905 in FIG. 593.

[2327]

The first lighting device A11002 includes a first ID storage unit A11004, a first encoding unit A11005, a first illuminance pattern storage unit A11006, and a first light emitting unit A11007. Likewise, the second lighting device A11003 includes a second ID storage unit A11008, a second encoding unit A11009, a second illuminance pattern storage unit A11010, a second light emitting unit A11011, and a server device A11015. The mobile terminal A11001 includes a light reception control unit A11012, an ID storage unit A11013, a DB management unit A11014, a product information storage unit A11016, a map information storage unit A11017, a display unit A11018, a state management unit A11019, and a UI unit A11020. The relations between these structural elements are described in detail below.

[2328]

The first ID storage unit A11004 in the first lighting device A11002 and the second ID storage unit A11008 in the second lighting device A11002 are memory areas, in each of which an identifier for uniquely identifying an individual entity, such as a MAC address, is written beforehand. When power is supplied to the first lighting device A11002, the first encoding unit A11005 reads the ID from the first ID storage unit A11004, converts the ID to the illuminance pattern of the lighting, i.e. the illuminance of the lighting at each timing, and stores the illuminance pattern in the first illuminance pattern storage unit A11006. When this activation phase is completed, the first light emitting unit A11007 performs light emission control while updating the illuminance at high speed, based on the pattern stored in the first illuminance pattern storage unit A11006. Thus, the first lighting device A11002 controls the

illuminance based on the ID.

[2329]

Likewise, when power is supplied to the second lighting device A11003, the second encoding unit A11009 reads the ID from the second ID storage unit A11008, converts the ID to the illuminance pattern of the lighting, i.e. the illuminance of the lighting at each timing, and stores the illuminance pattern in the second illuminance pattern storage unit A11010. When this activation phase is completed, the second light emitting unit A11011 performs light emission control while updating the illuminance at high speed, based on the pattern stored in the second illuminance pattern storage unit A11010. Thus, the second lighting device A11003 controls the illuminance based on the ID.

[2330]

The behavior of the mobile terminal A11001 is described next. Upon detecting the illuminance pattern of the first light emitting unit A11007 or the second light emitting unit A11011, the light reception control unit A11012 in the mobile terminal A11001 converts the detected pattern to the ID, and stores the ID in the ID storage unit A11013. In this embodiment, the light reception control unit A11012 detects the illuminance pattern of the first light emitting unit A11007 or the second light emitting unit A11011. Accordingly, the ID stored in the ID storage unit A11013 is the same as the ID stored in the first ID storage unit A11004 or the second ID storage unit A11008.

[2331]

The structure of the product information storage unit A11016 is described next. As illustrated in FIG. 595, the product information storage unit A11016 includes a validity flag A11101, a shelf exterior A11102, a shelf interior A11103, product type information A11104, and product stock information A11105. The validity flag A11101 indicates whether or not to render the product stock information, and takes any of the values TRUE and FALSE. When the validity flag A11101 is TRUE, the display unit A11018 performs the rendering process on the product stock information.

The shelf exterior A11102 indicates the exterior of the shelf unit (shelves) to be rendered, and includes the height and width of the shelf unit in actual size. The display unit A11018 performs the rendering process based on the actual size information so that the shelf unit is contained in the screen. For example, the external frame of the shelf unit is rendered in a layout as illustrated in FIG. 596. The shelf interior A11103 indicates the number of shelves and the height proportion of each shelf to the whole shelf unit. The internal plates of the shelves are rendered at intervals as illustrated in FIG. 596. The product type information A11104 includes the number of product variations and the image data body of each product. In this embodiment, the format of image data received from the server device A11015 is PNG data, and PNG data itself is stored in the product type image data in the product type information A11104. Immediately before rendering, the display unit A11018 decompresses the PNG data in a cache area (not illustrated), renders the data in the cache area, and presents the product image to the user. The product stock information A11105 includes the product stock quantity, the type of the product whose stock is to be rendered, and coordinate information. In the coordinate information, the x coordinate indicates "in which position from the left of the product shelf unit", the y coordinates indicates "on which shelf from above in the shelf unit", and the z coordinates indicates "on which shelf from the front in the shelves arranged in the depth direction". The display unit A11018 renders the product information indicated by the product type number, at the coordinates matching these coordinate information.

[2332]

The structure of the map information storage unit A11017 is described next. As illustrated in FIG. 597, the map information storage unit A11017 includes a validity flag A11301, a map image data length A11302, and a map image A11303. The validity flag A11301 indicates whether or not to render the map information, and takes any of the values TRUE and FALSE. When the validity flag A11301 is TRUE, the display unit A11018 performs the rendering

process on the map information. The map image A11303 includes the image data body of the map. In this embodiment, the format of image data received from the server device A11015 is PNG data, and PNG data itself is stored in the map image A11303. The map image data length A11302 indicates the data length of the map image A11303. Immediately before rendering, the display unit A11018 decompresses the PNG data in a cache area (not illustrated), renders the data in the cache area, and presents the product image to the user.

[2333]

The state management unit A11019 is described next. As illustrated in FIG. 600, the state management unit A11019 includes an abnormality flag A11601, a previous frame rendering type A11602, a display shelf depth A11603, a map offset X A11604, a map offset Y A11605, and a previously obtained ID A11606. The previously obtained ID A11606 has an initial value as a null value. In this embodiment, the null value = −1. The abnormality flag A11601 takes the value TRUE or FALSE. In the case where the ID transmitted to the server device A11015 is an invalid ID not related to any ceiling light or base light, the DB management unit A11014 sets the abnormality flag A11601 to TRUE. When the abnormality flag A11601 is TRUE, the display unit A11018 notifies the user of a reception failure. When the user operates the touch panel unit A1204, the UI unit A11020 updates the display shelf depth A11603, the map offset X A11604, and the map offset Y A11605.

[2334]

The behavior of the DB management unit A11014 is described next. When the DB management unit A11014 reads the ID from the ID storage unit A11013, the DB management unit A11014 inquires of the server device A11015 for the ID, for comparison with the recorded IDs. If the ID is an ID of a ceiling light installed on the ceiling as a result of comparison, the DB management unit A11014 requests the server device A11015 to transmit the map image of the ceiling light and its surroundings as illustrated in FIG. 589. The DB management unit A11014 obtains the map image illustrated in FIG.

587, and stores it in the map information storage unit A11017. The DB management unit A11014 sets the validity flag A11301 in the map information storage unit A11017 to TRUE, the validity flag in the product information storage unit A11016 to FALSE, and the abnormality flag A11601 to FALSE. If the ID is an ID of a base light installed on the product shelves as a result of comparison, the DB management unit A11014 requests the server device A11015 to transmit the product information illustrated in FIG. 595, and stores the obtained product information in the product information storage unit A11016. The DB management unit A11014 sets the validity flag A11301 in the map information storage unit A11017 to FALSE, the validity flag in the product information storage unit A11016 to TRUE, and the abnormality flag A11601 to FALSE. If the ID transmitted to the server device A11015 is an invalid ID not related to any ceiling light or base light, the DB management unit A11014 sets the validity flag A11301 in the map information storage unit A11017 to FALSE, the validity flag in the product information storage unit A11016 to FALSE, and the abnormality flag A11601 to TRUE.

[2335]

The UI unit A11020 is described next. The UI unit A11020 operates with the touch panel unit A1204. In the case where the validity flag A11101 in the product information storage unit A11016 is TRUE, when the user flicks the touch panel unit A1204, the UI unit A11020 updates the map offset X A11604 and the map offset Y A11605. In detail, when the touch panel unit A1204 is flicked right, the UI unit A11020 increases the map offset X A11604 by the flick amount. When the touch panel unit A1204 is flicked left, the UI unit A11020 decreases the map offset X A11604. When the touch panel unit A1204 is flicked up, the UI unit A11020 decreases the map offset Y A11605. When the touch panel unit A1204 is flicked down, the UI unit A11020 increases the map offset Y A11605. In the case where the validity flag A11301 in the map information storage unit A11017 is TRUE, the UI unit A11020 updates the display shelf depth A11603. In detail, when the touch panel unit A1204 is flicked right, the UI unit A11020 increases the display shelf depth A11603. When the touch

panel unit A1204 is flicked left, the UI unit A11020 decreases the display shelf depth A11603. In the case where the display shelf depth A11603 is greater than "the maximum value of the z coordinates of the products in the product stock information A11105", the UI unit A11020 sets the display shelf depth A11603 to 0. In the case where the display shelf depth A11603 is less than 0, the UI unit A11020 sets the display shelf depth A11603 to "the maximum value of the z coordinates of the products in the product stock information A11105".

[2336]

The display unit A11018 updates the display, based on the processes described above. Upon executing an update process, the display unit A11018 first executes the following display update preliminary process. In the case where the validity flag A11101 in the product information storage unit A11016 is TRUE and the previous frame rendering type A11602 is other than product information, the display unit A11018 determines that the displayed shelf state needs to be initialized, and resets the display shelf depth A11603 to 0. In the case where the validity flag A11301 in the map information storage unit A11017 is TRUE and the previous frame rendering type A11602 is other than map information, the display unit A11018 determines that the displayed map state needs to be initialized, and resets the map offset X A11604 to 0 and the map offset Y A11605 to 0. In the case where the previously obtained ID in the state management unit A11019 and the ID stored in the ID storage unit A11013 are different, the display unit A11018 determines that the display state needs to be initialized, and resets the map offset X A11604 to 0, the map offset Y A11605 to 0, and the display shelf depth A11603 to 0. The display unit A11018 then copies the ID in the ID storage unit A11013 to the previously obtained ID in the state management unit A11019. Further, in the case where the validity flag A11101 in the product information storage unit A11016 is TRUE, the display unit A11018 sets the previous frame rendering type A11602 to "product information". In the case where the validity flag A11301 in the map information

storage unit A11017 is TRUE, the display unit A11018 sets the previous frame rendering type A11602 to "map information". In the case where the abnormality flag A11601 is TRUE, the display unit A11018 sets the previous frame rendering type A11602 to "abnormal".

[2337]

After completing the above-mentioned display update preliminary process, in the case where one of the validity flag A11301 in the map information storage unit A11017 and the validity flag in the product information storage unit A11016 is TRUE, the display unit A11018 executes the map information rendering process as illustrated in FIG. 589 when the validity flag A11301 in the map information storage unit A11017 is TRUE, and executes the product stock state rendering process as illustrated in FIG. 596 when the validity flag in the product information storage unit A11016 is TRUE. In the case where the abnormality flag A11601 is TRUE, on the other hand, the display unit A11018 updates the display to notify that an invalid ID is received.

[2338]

The following describes flow in this embodiment.

[2339]

The flow of the lighting device A11002 is described first, with reference to FIG. 598. When power is supplied to the first lighting device A11002 (SA11401), the first encoding unit A11005 reads the ID from the first ID storage unit A11004 (SA11402), converts the ID to the illuminance pattern of the lighting, i.e. the illuminance of the lighting at each timing, by an encoding process (SA11403), and stores the illuminance pattern in the first illuminance pattern storage unit A11006 (SA11404). When this activation phase is completed, the first light emitting unit A11007 reads the illuminance pattern from the first illuminance pattern storage unit A11006 (SA11405), and performs light emission control while updating the illuminance at high speed based on the illuminance pattern (SA11406). Thus, the first lighting device A11002 controls the illuminance based on the ID.

[2340]

Likewise, when power is supplied to the second lighting device A11003 (SA11401), the second encoding unit A11009 reads the ID from the second ID storage unit A11008 (SA11402), converts the ID to the illuminance pattern of the lighting, i.e. the illuminance of the lighting at each timing, by an encoding process (SA11403), and stores the illuminance pattern in the second illuminance pattern storage unit A11010 (SA11404). When this activation phase is completed, the second light emitting unit A11011 reads the illuminance pattern from the second illuminance pattern storage unit A11010 (SA11405), and performs light emission control while updating the illuminance at high speed based on the illuminance pattern (SA11406). Thus, the second lighting device A11003 controls the illuminance based on the ID.

[2341]

The flow of the mobile terminal A11001 is described next, with reference to FIG. 599. The light reception control unit A11012 in the mobile terminal A11001 first switches the shutter speed to high speed (SA11500). Upon detecting the illuminance pattern of the first light emitting unit A11007 or the second light emitting unit A11011, the light reception control unit A11012 converts the detected pattern to the ID by a decoding process (SA11501), and stores the ID in the ID storage unit A11013 (SA11502). The DB management unit A11014 reads the ID from the ID storage unit A11013, and inquires of the server device A11015 for the ID for comparison with the recorded IDs (SA11503). If the ID is an ID of a ceiling light installed on the ceiling as a result of comparison (SA11504), the DB management unit A11014 performs a ceiling light-related process (SA11505). If the ID is an ID of a base light installed on the product shelves as a result of comparison, the DB management unit A11014 performs a base light-related process (SA11507). If the ID transmitted to the server device A11015 is an invalid ID not related to any ceiling light or base light, the DB management unit A11014 sets the validity flag A11301 in the map information storage unit A11017 to FALSE, the validity flag in the product information storage unit A11016 to FALSE, and the

abnormality flag A11601 to TRUE (SA11508).

[2342]

The ceiling light-related process (SA11505) is described in detail below, with reference to FIG. 601. The DB management unit A11014 requests the server device A11015 to transmit the map image of the ceiling light and its surroundings as illustrated in FIG. 589 (SA11701). The DB management unit A11014 obtains the map image illustrated in FIG. 587, and stores it in the map information storage unit A11017 (SA11702). The DB management unit A11014 sets the validity flag A11301 in the map information storage unit A11017 to TRUE, and the validity flag in the product information storage unit A11016 to FALSE (SA11703).

[2343]

The base light-related process (SA11507) is described in detail below, with reference to FIG. 602. The DB management unit A11014 requests the server device A11015 to transmit the product information illustrated in FIG. 595 (SA11801), and stores the obtained product information in the product information storage unit A11016 (SA11802). The DB management unit A11014 sets the validity flag A11301 in the map information storage unit A11017 to FALSE, and the validity flag in the product information storage unit A11016 to TRUE (SA11803).

[2344]

The UI unit A11020 is described below, with reference to FIG. 603. The UI unit A11020 operates with the touch panel unit A1204. In the case where the validity flag A11301 in the map information storage unit A11017 is TRUE (SA11901), the UI unit A11020 executes a map information UI process (SA11902). In the case where the validity flag A11101 in the product information storage unit A11016 is TRUE, the UI unit A11020 executes a product information UI process (SA11904).

[2345]

The map information UI process (SA11802) is described in detail below, with reference to FIG. 604. When the user flicks the touch panel unit A1204, the UI unit A11020 updates the map offset X

A11604 and the map offset Y A11605. In detail, when the touch panel unit A1204 is flicked right (SA12001), the UI unit A11020 increases the map offset X A11604 by the flick amount (SA12002). When the touch panel unit A1204 is flicked left (SA12003), the UI unit A11020 decreases the map offset X A11604 (SA12004). When the touch panel unit A1204 is flicked up (SA12005), the UI unit A11020 decreases the map offset Y A11605 (SA12006). When the touch panel unit A1204 is flicked down (SA12007), the UI unit A11020 increases the map offset Y A11605 (SA12008).

[2346]

The product information UI process (SA11804) is described in detail below, with reference to FIG. 605. The UI unit A11020 updates the display shelf depth A11603. In detail, when the touch panel unit A1204 is flicked right (SA12101), the UI unit A11020 increases the display shelf depth A11603 (SA12102). When the touch panel unit A1204 is flicked left (SA12103), the UI unit A11020 decreases the display shelf depth A11603 (SA12104). In the case where the display shelf depth A11603 is greater than "the maximum value of the z coordinates of the products in the product stock information A11105" (SA12105), the UI unit A11020 sets the display shelf depth A11603 to 0 (SA12106). In the case where the display shelf depth A11603 is less than 0 (SA12107), the UI unit A11020 sets the display shelf depth A11603 to "the maximum value of the z coordinates of the products in the product stock information A11105" (SA12108).

[2347]

The process flow of the display unit A11018 is described below, with reference to FIG. 606. Upon executing an update process, the display unit A11018 first executes a display update preliminary process (SA12201). The display unit A11018 then executes a display update process (SA12202).

[2348]

The display update preliminary process (SA12201) is described in detail below, with reference to FIG.607. In the case where the validity flag A11101 in the product information storage

unit A11016 is TRUE (SA12301) and the previous frame rendering type A11602 is other than product information (SA12302), the display unit A11018 determines that the displayed shelf state needs to be initialized, and resets the display shelf depth A11603 to 0 (SA12303). In the case where the validity flag A11301 in the map information storage unit A11017 is TRUE (SA12304) and the previous frame rendering type A11602 is other than map information (SA12305), the display unit A11018 determines that the displayed map state needs to be initialized, and resets the map offset X A11604 to 0 and the map offset Y A11605 to 0 (SA12306). In the case where the previously obtained ID in the state management unit A11019 and the ID stored in the ID storage unit A11013 are different (SA12307), the display unit A11018 determines that the display state needs to be initialized, and resets the map offset X A11604 to 0, the map offset Y A11605 to 0, and the display shelf depth A11603 to 0 (SA12308). The display unit A11018 then copies the ID in the ID storage unit A11013 to the previously obtained ID in the state management unit A11019, to update the old ID (SA12309). Further, in the case where the validity flag A11101 in the product information storage unit A11016 is TRUE, the display unit A11018 sets the previous frame rendering type A11602 to "product information". In the case where the validity flag A11301 in the map information storage unit A11017 is TRUE, the display unit A11018 sets the previous frame rendering type A11602 to "map information". In the case where the abnormality flag A11601 is TRUE, the display unit A11018 sets the previous frame rendering type A11602 to "abnormal" (SA12310).

[2349]

The display update process is described in detail below, with reference to FIG. 608. In the case where the validity flag A11301 in the map information storage unit A11017 is TRUE (SA12401), the display unit A11018 reads the map offset X A11604 and the map offset Y A11606 (SA12402), and renders the map information as illustrated in FIG. 589 while shifting by each offset (SA12403). In the case where the validity flag in the product information storage unit A11016 is TRUE (SA12404), the display unit A11018 reads the

display shelf depth A11603 (SA12404), and renders the product stock state as illustrated in FIG. 596 so that the image of the shelves represented by the display shelf depth A11603 is presented (SA12406). In the case where the abnormality flag A11601 is TRUE, the display unit A11018 updates the display to notify that an invalid ID is received (SA12407).

[2350]

[Embodiment 23]

This embodiment specifically defines the structure and flow of the light reception control unit in addition to Embodiment 22.

[2351]

The structure of the light reception control unit A11012 in Embodiment 23 is described first, with reference to FIG. 609. The light reception control unit A11012 in Embodiment 23 includes: a first light receiving unit A12501; a second light receiving unit A12502; a selector A12503 that selects which of the two light receiving units is to operate; an acceleration detection unit A12504 that supplies information necessary for the selection process in the selector A12503; a received light signal storage unit A12505 that stores a received light signal obtained from the first light receiving unit A12501 or the second light receiving unit A12502 via the selector A12503; a decoding unit A12506 that reads the received light signal from the received light signal storage unit A12505, performs a decoding process to generate an ID, and stores the generated ID in the ID storage unit A11013; and a threshold storage unit A12507 that stores beforehand a first threshold and a second threshold for the selector A12503 to determine, from obtained acceleration, whether or not the mobile terminal A11011 including the light reception control unit A11012 is horizontal to the ground.

[2352]

The flow of the light reception control unit A11012 in Embodiment 23 is described next, with reference to FIG. 610. After activation, the light reception control unit A11012 detects acceleration in the backward direction of the mobile terminal A11011, by the acceleration detection unit A12504 (SA12601). The light

reception control unit A11012 compares the obtained acceleration with the thresholds stored in the threshold storage unit A12507 (SA12602). If the acceleration is greater than the first threshold, larger acceleration, namely, gravitational acceleration, occurs in the backward direction of the mobile terminal A11011, and so the light reception control unit A11012 determines that the mobile terminal A11011 is horizontal to the ground and the in camera A1202 faces upward with respect to the ground. The light reception control unit A11012 accordingly operates the in camera, i.e. the first light receiving unit A12501 (SA12603). If the acceleration is less than or equal to the second threshold, large gravitational acceleration does not occur in the backward direction of the mobile terminal A11011, and so the light reception control unit A11012 determines that the mobile terminal A11011 is not horizontal to the ground and the out camera A1203 faces the wall or shelves. The light reception control unit A11012 accordingly operates the out camera, i.e. the second light receiving unit A12502 (SA12604). As a result of this process, the captured image is obtained by the first light receiving unit A12501 or the second light receiving unit A12502 in operation (SA12605), the illuminance change of the lighting is obtained in the captured image, i.e. the decoding process is executed (SA12606), and the ID obtained by the decoding process is stored in the ID storage unit A11013 (SA12607).

[2353]

Through the light receiving unit selection described above, the light receiving unit can be optimally switched depending on whether the mobile terminal is viewed from above as in a bird’s eye view of building floor plan or the mobile terminal is viewed horizontally to a front subject such as shelves.

[2354]

[Embodiment 24]

This embodiment specifically defines the structure and flow of the light reception control unit in addition to Embodiment 22.

[2355]

The structure of the light reception control unit A11012 in

Embodiment 23 is described first, with reference to FIG. 611. The light reception control unit A11012 in Embodiment 23 includes: a first light receiving unit A12701; a second light receiving unit A12702; a selector A12703 that selects which of the two light receiving units is to operate; a timer control unit A12704 that supplies information necessary for the selection process in the selector A12703; a received light signal storage unit A12705 that stores a received light signal obtained from the first light receiving unit A12701 or the second light receiving unit A12702 via the selector A12503; a decoding unit A12706 that reads the received light signal from the received light signal storage unit A12705, performs a decoding process to generate an ID, and stores the generated ID in the ID storage unit A11013; and a threshold storage unit A12707 that stores beforehand a threshold 1 of the time required for the selector A12703 to switch to the light reception by the second light receiving unit A12702 from the start of the light reception by the first light receiving unit A12701 and a threshold 2 of the time required for the selector A12703 to switch to the light reception by the first light receiving unit A12701 from the start of the light reception by the second light receiving unit A12702.

[2356]

The flow of the light reception control unit A11012 in Embodiment 24 is described next, with reference to FIG. 612. After activation, if the timer control unit A12704 is not in operation (SA12801), the light reception control unit A11012 starts the timer control unit A12704, and starts the first light receiving unit A12701 (SA12802). In the case where the first light receiving unit A12701 is in operation (SA12803), if the time of the first threshold has elapsed from when the first light receiving unit A12701 starts operation (SA12804), the light reception control unit A12704 stops the first light receiving unit A12701 and starts the second light receiving unit A12702, to balance the operation of each light receiving unit (SA12806). In the case where the first light receiving unit A12701 is not in operation, i.e. the second light receiving unit A12702 is in operation (SA12803), if the time of the second threshold

has elapsed from when the second light receiving unit A12702 starts operation (SA12805), the light reception control unit A12704 stops the second light receiving unit A12702 and starts the first light receiving unit A12701, to balance the operation of each light receiving unit (SA12807). As a result of this process, the captured image is obtained by the first light receiving unit A12501 or the second light receiving unit A12502 in operation (SA12808), the illuminance change of the lighting is obtained in the captured image, i.e. the decoding process is executed (SA12809), and the ID obtained by the decoding process is stored in the ID storage unit A11013 (SA12810).

[2357]

Through the light receiving unit selection described above, in the case where the watch-type device illustrated in FIG. 593 is held horizontal, the ID from the ceiling light A1904 on the ceiling and the ID from the base light A1905 on the shelf can be obtained in a balanced manner.

[2358]

Note that the acceleration detection unit may be added in Embodiment 23 so that, in the case where it is estimated that the display surface of the watch-type device is not horizontal to the ground, i.e. the user is not viewing the display surface of the watch-type device, the first light receiving unit A12501 and the second light receiving unit A12502 are stopped to save power.

[2359]

[Embodiment 25]

This embodiment applies a gaze detection technique based in Embodiment 22, to reflect the user’s intension more appropriately in the display unit A11018.

[2360]

FIG. 613 is a schematic diagram of when using a mobile terminal in this embodiment. As illustrated in FIG. 613, in the case where the user holds a mobile terminal A12901 in his or her hand and points the back surface of the mobile terminal A12901 at a shelf unit A12903, information of the shelf unit A12903 is displayed on the

display unit of the mobile terminal A12901. In the case where the user turns right from the shelf unit A12901 in this state, the mobile terminal A12901 detects the user's gaze by an image recognition process, and determines that "the user is looking at not the shelf unit A12901 but a shelf unit A12905 located right adjacent to the shelf unit A12901". Information of the shelf unit A12905 is accordingly displayed on the display unit of the mobile terminal A12901. By selecting the display object in consideration of the user's gaze in addition to the lighting in front of the mobile terminal A12901 in this way, information that more reflects the user's intension can be presented.

[2361]

The structure of the mobile terminal A12901 in Embodiment 25 is described below, with reference to FIG. 614. In FIG. 614, the same structural elements as those in Embodiment 22 are given the same reference signs as in FIG. 594. The mobile terminal A12901 includes a light reception control unit A13002, the ID storage unit A11013, a DB management unit A13003, the product information storage unit A11016, the map information storage unit A11017, the display unit A11018, the state management unit A11019, the UI unit A11020, and a gaze information storage unit A13001. The mobile terminal A12901 is connected to a server device A13004 by wireless communication.

[2362]

The behavior of the mobile terminal A12901 is described below. Upon detecting the illuminance pattern of the first light emitting unit A11007 or the second light emitting unit A11011, the light reception control unit A13002 in the mobile terminal A12901 converts the detected pattern to the ID, and stores the ID in the ID storage unit A11013. In this embodiment, the light reception control unit A13002 detects the illuminance pattern of the first light emitting unit A11007 or the second light emitting unit A11011. Accordingly, the ID stored in the ID storage unit A11013 is the same as the ID stored in the first ID storage unit A11004 or the second ID storage unit A11008. The light reception control unit A13002 also detects gaze

classification information indicating which of front, right, and left the user's gaze is classified as, by an internal light reception function in the light reception control unit A13002. The light reception control unit A13002 stores the detected classification result in the gaze information storage unit A13001.

[2363]

The flow of the DB management unit A13003 is described below. In this embodiment, SA11801 in FIG. 602 in Embodiment 22 is given in greater detail. The detailed flow of SA11801 is described below. FIG. 616 is a flowchart of when inquiring of a server in Embodiment 25. The DB management unit A13003 reads the ID from the ID storage unit A11013, and also reads the gaze classification information from the gaze information storage unit A13001. The DB management unit A13003 then requests the server device A11015 to transmit the product information. Here, the DB management unit A13003 transmits the ID of the base light to the server device A11015, and also transmits the gaze classification information stored in the gaze information storage unit A13001 to the server device A11015 (SA13201). The server device A11015 holds a DB as illustrated in FIG. 615. The server device A11015 first searches a column A13102 for the received ID (SA13202). In the case where the corresponding row is found, the server device A11015 extracts a shelf identifier from the row (SA13203). Here, the server device A11015 refers to a column A13101 in the case where the gaze classification information is "front", a column A13103 in the case where the gaze classification information is "left", and a column A13014 in the case where the gaze classification information is "right" (SA13203). Through such reference, the server device A11015 obtains the shelf identifier in the corresponding row (SA13205). The server device A11015 then searches the column A13101 for the obtained shelf identifier (SA13208), and notifies the DB management unit A13003 in the mobile terminal A12901 of shelf information A13105 in the corresponding row (SA13209). In the case where the received ID is detected in the column A13102 but no shelf identifier can be extracted from the ID and the gaze

classification information (SA13206), the server device A11015 notifies the DB management unit A13003 in the mobile terminal A12901 of shelf information A13105 in the row in which the received ID is found (SA13207). In the case where the received ID is not detected in the column A13102 (SA13203), the server device A11015 notifies the DB management unit A13003 in the mobile terminal A12901 that there is no corresponding ID (SA13204). For example, in the case where the ID is "200" and the gaze classification information is "right", the ID "200" is found in the first row in the lighting ID column A13102. Since the right adjacent shelf identifier A13104 in the first row is "101", the shelf information A13105 in the row in which the shelf identifier A13101 is "101", i.e. shelf information 2, is transmitted to the mobile terminal A12901.

[2364]

After this, the DB management unit A13003 in the mobile terminal A12901 stores the obtained product information in the product information storage unit A11016. The DB management unit A13003 sets the validity flag A11301 in the map information storage unit A11017 to FALSE, the validity flag in the product information storage unit A11016 to TRUE, and the abnormality flag A11601 to FALSE. If the ID transmitted to the server device A11015 is an invalid ID not related to any ceiling light or base light, the DB management unit A13003 sets the validity flag A11301 in the map information storage unit A11017 to FALSE, the validity flag in the product information storage unit A11016 to FALSE, and the abnormality flag A11601 to TRUE.

[2365]

[Embodiment 26]

This embodiment specifically defines the structure of the light reception control unit A11012 based on Embodiment 25. FIG. 617 is a block diagram of a light reception control unit in Embodiment 26. The light reception control unit A11012 in Embodiment 26 includes: the first light receiving unit A12501; the second light receiving unit A12502; the selector A12503 that selects which of the two light receiving units is to operate; the acceleration detection unit A12504

that supplies information necessary for the selection process in the selector A12503; the received light signal storage unit A12505 that stores a received light signal obtained from the first light receiving unit A12501 or the second light receiving unit A12502 via the selector A12503; the decoding unit A12506 that reads the received light signal from the received light signal storage unit A12505, performs a decoding process to generate an ID, and stores the generated ID in the ID storage unit A11013; and the threshold storage unit A12507 that stores beforehand a first threshold and a second threshold for the selector A12503 to determine, from obtained acceleration, whether or not the mobile terminal A11011 including the light reception control unit A11012 is horizontal to the ground. The light reception control unit A11012 in Embodiment 26 further includes a gaze detection unit A13301 that receives a video signal from the light receiving unit A12501, detects the gaze position of the user, and stores gaze classification information in the gaze information storage unit A13001. In this embodiment, the light receiving unit A12501 is a video capture device such as a camera device.

[2366]

[Embodiment 27]

This embodiment specifically defines the structure of the light reception control unit A11012 based on Embodiment 25. FIG. 618 is a block diagram of a light reception control unit in Embodiment 27. The light reception control unit A11012 in Embodiment 26 includes: the first light receiving unit A12501; the second light receiving unit A12502; the selector A12503 that selects which of the two light receiving units is to operate; the acceleration detection unit A12504 that supplies information necessary for the selection process in the selector A12503; the received light signal storage unit A12505 that stores a received light signal obtained from the first light receiving unit A12501 or the second light receiving unit A12502 via the selector A12503; the decoding unit A12506 that reads the received light signal from the received light signal storage unit A12505, performs a decoding process to generate an ID, and stores the

generated ID in the ID storage unit A11013; and the threshold storage unit A12507 that stores beforehand a first threshold and a second threshold for the selector A12503 to determine, from obtained acceleration, whether or not the mobile terminal A11011 including the light reception control unit A11012 is horizontal to the ground. The light reception control unit A11012 in Embodiment 27 further includes: an imaging unit A13401; and a gaze detection unit A13402 that receives a video signal from the imaging unit A13401, detects the gaze position of the user, and stores gaze classification information in the gaze information storage unit A13001. In this embodiment, the imaging unit A13401 is a video capture device such as a camera device, and the light receiving unit 12501 is a sensor device such as an illuminance sensor.

[2367]

According to the embodiment described above, information that more reflects the user's current position and intention can be presented according to the orientation of the mobile terminal.

[2368]

[Embodiment 28]

FIG. 619 is a diagram for describing a use case in Embodiment 28. An embodiment of using a reception unit 1028 that employs a modulation scheme such as PPM, FDM, FSK, or frequency allocation according to the present invention is described below, with reference to FIG. 619.

[2369]

Light emission operation by a light emitter is described first. In a light emitter 1003 such as a lighting device or a TV monitor attached to a ceiling or a wall, an authentication ID generation unit 1010 generates an authentication ID, using a random number generation unit 1012 changing per time period. For the light emitter ID and authentication ID 1004, in the case where there is no interrupt (1011), it is determined that there is no "transmission data string" transmitted from a mobile terminal 1020. Accordingly, a light emitting unit 1016 such as an LED continuously or intermittently outputs a light signal including: (1) the light emitter

ID; (2) the authentication ID; and (3) a transmission data string flag = 0 which is an identifier for identifying whether or not there is a transmission data string 1009 transmitted from an electronic device 1040 via a mobile terminal 1003.

[2370]

The transmitted light emission signal is received by a photosensor 1041 in the electronic device 1040 (Step 1042). In Step S1043, whether or not the authentication ID and the device ID of the electronic device 1040 are valid is determined. In the case of Yes, whether or not the transmission data string flag is 1 is checked (Step 1051). Only in the case of Yes, the data of the transmission data string, e.g. a user command for applying a cooking recipe or the like, is executed (Step 1045).

[2371]

A mechanism of light transmission by the electronic device 1040 using the light modulation scheme according to the present invention is described below. The electronic device 1040 transmits the device ID, the authentication ID for authenticating the device, and the ID of the light emitter 1003 received by the electronic device 1040 as mentioned above, i.e. the ID of the light emitter 1003 the successful reception of which is ensured, for example using an LED backlight unit 1050 of a display unit 1047 (Step 1046).

[2372]

The light signal according to the present invention is transmitted from the display unit 1047 such as a liquid crystal display of a microwave or a POS device, by PPM, FDM, or FSK at a modulation frequency of 60 Hz or more without flicker. Accordingly, ordinary consumers are unaware of the transmission of the light signal. It is therefore possible to produce independent display such as a microwave menu on the display unit.

[2373]

(Method of detecting the ID of the light emitter 1003 receivable by the electronic device 1040)

The user who intends to use the microwave or the like receives a light signal from the light emitter 1003 by an in camera unit 1017

of a mobile terminal, thus receiving the light emitter ID and the light emitter authentication ID in a reception unit 1027 via an in camera processing unit 1026. As the light emitter ID receivable by the electronic device 1040, a light emitter ID corresponding to the position, which is recorded in the mobile terminal or a cloud 1032 with position information using Wi-Fi or mobile reception such as 3G, may be detected (Step 1025).

[2374]

When the user points an out camera 1019 of the mobile terminal 1020 at the display unit 1047 of the microwave 1040 or the like, the light signal 1048 according to the present invention can be demodulated using a MOS camera. Increasing the shutter speed enables faster data reception. A reception unit 1028 receives the device ID of the electronic device 1040, the authentication ID, a service ID, or a service provision cloud URL or device status converted from the service ID.

[2375]

In Step 1029, the mobile terminal 1020 connects to the external cloud 1032 using the URL received or held inside via a 3G/Wi-Fi communication unit 1031, and transmits the service ID and the device ID. In the cloud 1032, a database 1033 is searched for data corresponding to each of the device ID and the service ID. The data is then transmitted to the mobile terminal 1020. Video data, command buttons, and the like are displayed on the screen of the mobile terminal based on this data. Upon viewing the display, the user inputs a desired command by an input method of pressing a button on the screen or the like (Step 1030). In the case of Yes (input), a transmission unit 1024 transmits a transmission data string including the device ID of the electronic device 1040, the device authentication ID, the light emitter ID, the light emitter authentication ID, and the user command in Step 1030, via a BTLE (Bluetooth Low Energy) transmission and reception unit 1021.

[2376]

The light emitter 1003 receives the transmission data string by a reception unit 1007 in a BTLE transmission and reception unit 1004.

When the interrupt processing unit 1011 detects that the transmission data string is received (Yes), data "(transmission data string) + ID + (transmission data flag = 1)" is modulated by the modulation unit according to the present invention and transmitted by light from the light emitting unit 1016 such as an LED. In the case of No, the light emitter ID and the like are continuously transmitted.

[2377]

Since the electronic device 1040 has already confirmed, through actual reception, that the signal from the light emitter 1003 is receivable, the reception can be reliably performed.

[2378]

In this case, the light emitter ID is included in the transmission data string, so that the interrupt processing unit 1011 recognizes that the electronic device as the transmission target is present in the light irradiation range of the light emitter of the ID. Therefore, the signal is transmitted only from the light emitter situated within the very narrow range where the electronic device is present, without transmitting the signal from other light emitters. The radio space can be efficiently used in this way.

[2379]

In the case where this scheme is not employed, since a Bluetooth signal reaches far, a light signal will end up being transmitted from a light emitter at a different position from the electronic device. While one light emitter is emitting light, light transmission to another electronic device is impossible or is interfered with. Such a problem can be effectively solved by this scheme.

[2380]

The following describes electronic device malfunction prevention.

[2381]

In Step 1042, the photosensor 1041 receives the light signal. Since the light emitter ID is checked first, a light emission signal of another light emitter ID can be removed and so malfunctions are

reduced.

[2382]

In the present invention, the transmission data string 1009 includes the device ID and the device authentication ID of the electronic device that is to receive the signal. In Step 1043, whether or not the device authentication ID and the device ID belong to the electronic device 1040 is checked, thus preventing any malfunction. A malfunction of a microwave or the like caused by erroneously processing a signal transmitted to another electronic device 1040a can be avoided, too.

[2383]

The following describes user command execution error prevention.

[2384]

In Step 1044, when the transmission flag is 1, it is determined that there is a user command. When the transmission flag is 0, the process is stopped. When the transmission flag is 1, after the device ID and the authentication ID in the user data string are authenticated, the transmission data string of the user command and the like is executed. For example, a recipe is extracted and displayed on the screen. When the user presses the corresponding button, the operation of the recipe such as 600 w for 3 minutes, 200 w for 1 minutes, and steaming for 2 minutes can be started without an error.

[2385]

When the user command is executed, electromagnetic noise of 2.4 GHz is generated in the microwave. To reduce this, in the case of operating according to instructions through the smartphone via Bluetooth or Wi-Fi, an intermittent drive unit 1061 intermittently stops microwave output, e.g. for about 100 ms in 2 seconds. Communication by Bluetooth, Wi-Fi 802.11n, etc. is possible during this period. If the microwave is not stopped, a stop instruction from the smartphone to the light emitter 1003 by BTLE is interfered with. In the present invention, on the other hand, transmission can be performed without any interference, with it being possible to stop the microwave or change the recipe by a light emission signal.

[2386]

In this embodiment, by merely adding the photosensor 1041 which costs only several yen per unit to the electronic device including the display unit, bidirectional communication with the smartphone in interaction with the cloud can be realized. This has an advantageous effect of turning a low-cost home appliance into a smart home appliance. Though the home appliance is used in this embodiment, the same advantageous effects can be achieved with a POS terminal including a display unit, an electronic price board in a supermarket, a personal computer, etc.

[2387]

In this embodiment, the light emitter ID can be received only from the lighting device situated above the electronic device. Since the reception area is narrow, a small zone ID of Wi-Fi or the like is defined for each light emitter, and the ID is assigned to the position in each zone, thereby reducing the number of digits of the light emitter ID. In such a case, since the number of digits of the light emitter ID transmitted by PPM, FSK, or FDM according to the present invention is reduced, it is possible to receive a light signal from a small light source, obtain an ID at high speed, receive data from a distant light source, etc.

[2388]

[Embodiment 29]

When receiving a visible light ID from a visible light transmitter, it takes time until the visible light ID is received, and so the user needs to wait for the visible light ID reception for a certain period of time. Besides, there is a possibility that the visible light ID reception fails. These problems occur because a uniquely identifiable visible light ID has a long bit string length. The problems are especially frequent in a visible light transmitter that employs the frequency modulation scheme.

[2389]

In this embodiment, an area in which a mobile terminal is currently present is specified, and a part of a visible light ID is obtained beforehand. As a result, upon visible light ID reception,

the area in which the mobile terminal is currently present according to the user is detected, and a light emitter from which the visible light ID is to be obtained can be limited to a device intended by the user.

[2390]

Not only the explicit user operation such as the current area of the mobile terminal but also the orientation of the housing of the mobile terminal may be detected to automatically limit the light emitter from which the visible light ID is to be obtained, or to determine which of a plurality of cameras included in the mobile terminal is to be used. Thus, the user's implicit intension can be reflected, too.

[2391]

This embodiment is described in detail below.

[2392]

FIG. 620 is a diagram illustrating a structure of a system according to the present invention. In FIG. 620, visible light emitted from a visible light transmitter (B0120) is received using a front camera (B0106) or a back camera (B0107) in a mobile terminal (B0101), and the visible light is converted to a visible light ID in visible light ID reception means (B0105).

[2393]

The area in which the mobile terminal (B0101) held by the user is currently present is used as information for selecting the visible light ID. To obtain the area in which the mobile terminal is currently present, sensing data obtained from sensing means (B0103) in the mobile terminal (B0101) is used. Through the use of the sensing data obtained from the sensing means (B0103), area detection means (B0102) detects information related to the area in which the mobile terminal is currently present.

[2394]

Inquiry ID generation means (B0104) inquires of an area ID information server (B0141) via communication means (B0108), for the ID of the area in which the mobile terminal held by the user is currently present and that is specified by the area detection means

(B0102). The area ID information server (B0141) receives the area-related information from the mobile terminal (B0101). The area-related information is passed to area information determination means (B0143) via communication means (B0142). The area information determination means (B0143) determines the area ID by comparing information held in area ID information holding means (B0144) and the area-related information received from the mobile terminal (B0101), and transmits the area ID to the mobile terminal (B0101) via the communication means (B0142).

[2395]

The inquiry ID generation means (B0104) generates an inquiry ID by combining the area ID received from the area ID information server (B0141) and the visible light ID received using the visible light ID reception means (B0105), and requests the communication means (B0108) to obtain information corresponding to the visible light ID, thereby obtaining information corresponding to the ID from an ID correspondence information conversion server (B0111) via a public network (B0130).

[2396]

In the case where the ID obtained by combining the area ID and the visible light ID does not satisfy a predetermined inquiry ID condition, the inquiry ID generation means (B0104) generates an ID for interpolating the insufficient part of the inquiry ID using interpolation ID generation means (B0110). The interpolation ID generation means (B0110) generates the interpolation ID according to detection of the orientation of the mobile terminal (B0101) using the sensing means (B0103) or based on a user attribute in user information holding means B0151.

[2397]

When communication means (B0112) in the ID correspondence information conversion server (B0111) receives the information obtainment request from the communication means (B0108) in the mobile terminal (B0101), conversion information determination means (B0113) obtains visible light ID correspondence information corresponding to the received visible

light ID from ID correspondence information holding means B0114.
[2398]

The ID correspondence information holding means (B0114) passes the obtained visible light ID correspondence information to the communication means (B0112). The communication means (B0112) transmits the visible light ID correspondence information to the mobile terminal (B0101) via the public network (B0130).
[2399]

FIG. 621 is a flowchart of an area detection process for the mobile terminal (B0101).
[2400]

In Step SB0201, the process starts. In Step SB0202, the area detection means (B0102) is started and monitors notification from the sensing means (B0103), to prepare the calculation of the area in which the mobile terminal (B0101) is present. In Step SB0203, whether or not the area detection means (B0102) has detected the area in which the mobile terminal is present is determined. In the case of No, the determination is performed again. In the case of Yes, the process proceeds to Step SB0204. In Step SB0204, the area detection means (B0102) passes the detected area information of the mobile terminal to the inquiry ID generation means (B0104). In Step SB0205, the inquiry ID generation means (B0104) transmits the area information received from the area detection means (B0102), to the area ID information server (B0141). The process then proceeds to Step SB0206 (1).
[2401]

FIG. 622 is a flowchart of a process in the area ID information server (B0411) in the case where the mobile terminal (B0101) requests the area ID information.
[2402]

The process proceeds from Step SB0206 (1) to Step SB0301, and whether or not the communication means (B0412) in the area ID information server (B0411) has received the detected area information of the mobile terminal (B0101) is determined. In the case of No, the determination is performed again. In the case of Yes,

the process proceeds to Step SB0302, and the communication means (B0412) passes the received area information to the area information determination means (B0413). In Step SB0303, the area information determination means (B0413) inquires of the area ID information holding means (B0414) for the ID corresponding to the notified area information. In Step SB0304, whether or not information matching the notified area information is present in a table illustrated in FIG. 637 in the area ID information holding means (B0414) is determined. In the case of Yes, the process proceeds to Step SB0305. In Step SB0305, the area ID information holding means (B0414) notifies the area information determination means (B0413) of the corresponding area ID in the table illustrated in FIG. 637. In Step SB0306, the area information determination means (B0413) generates ID correspondence information notification, and passes the notification to the communication means (B0412). The process then proceeds to Step SB0307. In the case of No in Step SB0304, the process proceeds to Step SB0308, and the area ID information holding means (B0414) notifies the area information determination means (B0413) that the information is not present in the table. In Step SB0309, the area information determination means (B0413) generates ID correspondence information unavailable notification, and passes the notification to the communication means (B0412). The process then proceeds to Step SB0307. In Step SB0307, the communication means (B0412) returns the ID information received from the area information determination means (B0413), to the mobile terminal (B0101) requesting the area ID. The process then proceeds to Step SB0308 (2).

[2403]

FIG. 623 is a flowchart of a process when the mobile terminal (B0101) receives the area ID information from the area ID information server (B0411).

[2404]

The process proceeds from Step SB0308 (2) to Step SB0401, and the communication means (B0108) passes the area ID

information received from the area ID information server (B0411), to the inquiry ID generation means (B0104). In Step SB0402, the inquiry ID generation means (B0104) holds the area ID information until new area information is provided from the area detection means (B0102). The process then proceeds to Step SB0403 (3).

[2405]

FIG. 624 is a flowchart of a process when the mobile terminal (B0101) receives an ID from the visible light transmitter (B0120).

[2406]

The process proceeds from Step SB0403 (3) to Step SB0501, and the visible light ID reception means (B0105) increases the shutter speed of the camera used for visible light ID reception, and waits for input from the camera. In Step SB0502, whether or not the inquiry ID generation means (B0104) has received visible light ID reception notification from the visible light ID reception means (B0105) is determined. In the case of No, the process returns to Step SB0501. In the case of Yes, the process proceeds to Step SB0503, and whether or not the received visible light ID has all bits (128 bits) is determined. In the case of Yes, the process proceeds to Step SB0506 (4). In the case of No, the process proceeds to Step SB0504, and whether or not the combination of the received visible light ID and the area ID information received from the area ID information server (B0141) has all bits (128 bits) is determined. In the case of No, the process proceeds to Step SB0507 (5). In the case of Yes, the process proceeds to Step SB0505, and the inquiry ID generation means (B0104) generates an ID by combining the held area ID information and the received visible light ID. In the case of Yes, the process proceeds to Step SB0506 (4).

[2407]

FIG. 625 is a flowchart of a process when the mobile terminal (B0101) requests the visible light ID correspondence information.

[2408]

The process proceeds from Step SB0506 (4) to Step SB0601, and the inquiry ID generation means (B0104) passes an information obtainment request to the communication means (B0108), for

obtainment of information related to the notified visible light ID. In Step SB0602, the communication means (B0108) requests the ID correspondence information obtainment from the server, via the public network (B0130). The process then proceeds to Step SB0603 (6).

[2409]

FIG. 626 is a flowchart of a process in the case where the ID correspondence information server (B0111) receives the ID correspondence information request from the mobile terminal (B0101).

[2410]

The process proceeds from Step SB0603 (6) to Step SB0702, and whether or not the communication means (B0112) in the ID correspondence information server (B0111) has received the ID correspondence information request is determined. In the case of No, the determination is performed again. In the case of Yes, the process proceeds to Step SB0703, and the communication means (B0112) notifies the conversion information determination means (B0113) of the received ID. In Step SB0704, the conversion information determination means (B0113) inquires of the ID correspondence information holding means (B0114) for the information corresponding to the notified ID. In Step SB0705, whether or not the notified ID is present in the table illustrated in FIG. 629 in the ID correspondence information holding means (B0114) is determined. In the case of Yes, the process proceeds to Step SB0706, and the ID correspondence information holding means (B0114) notifies the conversion information determination means (B0113) of the data of the corresponding row in the table illustrated in FIG. 629. In Step SB0707, the conversion information determination means (B0113) generates ID correspondence information notification, and passes the notification to the communication means (B0112). The process then proceeds to Step SB0708. In the case of No in Step SB0702, the process proceeds to Step SB0709, and the ID correspondence information holding means (B0114) notifies the conversion information determination means

(B0113) that the information is not present in the table. In Step SB0710, the conversion information determination means (B0113) generates ID correspondence information unavailable notification, and passes the notification to the communication means (B0112). The process then proceeds to Step SB0708. In Step SB0708, the communication means (B0112) returns the information received from the conversion information determination means (B0113), to the mobile terminal (B0101) requesting the ID correspondence information. The process then proceeds to Step SB0711 (7).

[2411]

FIG. 627 is a flowchart of a process when the mobile terminal (B0101) receives a short ID from the visible light transmitter (B0120).

[2412]

The process proceeds from Step SB0507 (5) to Step SB0801, and the inquiry ID generation means (B0104) inquires of the visible light ID reception means (B0105) whether the received ID is obtained by the front camera (B0106) or the back camera (B0107). In Step SB0802, the visible light ID reception means (B0105) responds to the inquiry ID generation means (B0104) whether the received ID is obtained by the front camera (B0106) or the back camera (B0107). In Step SB0803, the inquiry ID generation means (B0104) requests the interpolation ID generation means (B0110) to provide the interpolation ID added to the received ID. In Step SB0804, the interpolation ID generation means (B0110) generates the interpolation ID using the sensing data received from the sensing means (B0103) or the information held in the user information holding means (B0151), and passes the interpolation ID to the inquiry ID generation means (B0104). In Step SB0805, the inquiry ID generation means (B0104) generates an ID by combining the held area ID information, the received visible light ID, and the interpolation ID. The process then proceeds to Step SB0506 (4).

[2413]

FIG. 628 is a flowchart of a process upon display by the mobile terminal (B0101).

[2414]

The process proceeds from Step SB0711 (7) to Step SB0901, and the communication means (B0108) in the mobile terminal (B0101) receives the ID correspondence information from the server via the public network (B0130). In Step SB0902, the communication means (B0108) in the mobile terminal (B0101) passes the received ID correspondence information to the inquiry ID generation means (B0104). In Step SB0903, the inquiry ID generation means (B0104) notifies the display means (B0109) of the reception of the visible light ID. In Step SB0904, the display means (B0109) performs display for the possible part in the received notification. In Step SB0905, the process ends.

[2415]

FIG. 629 is a flowchart of a process in which the interpolation ID generation means (B0110) generates the interpolation ID based on the user attribute. A table of user attributes illustrated in FIG. 635 and a correspondence table between interpolation IDs and user attributes illustrated in FIG. 636 are used in this process.

[2416]

In Step B1001, the process starts. In Step B1002, the interpolation ID generation means (B0110) reads all user attributes held in the user information holding means (B0151). In Step B1003, the interpolation ID generation means (B0110) extracts the correspondence table between interpolation IDs and user attributes held therein, to select the interpolation ID (in the case where the interpolation ID generation means does not hold the table, the interpolation ID generation means may read the table from an external server via a network). In Step B1004, the interpolation ID generation means (B0110) checks the corresponding interpolation ID defined in the table, for each of one or more user attributes read from the user information holding means (B0151). In Step B1005, whether or not the corresponding interpolation ID has been checked for all user attributes read from the user attribute holding means (B0151) is determined. In the case of No, the process returns to Step B1004. In the case of Yes, the process proceeds to Step B1006,

and the interpolation ID generation means (B0110) determines the interpolation ID that corresponds to the most user attributes as the interpolation ID suitable for the user using the mobile terminal, and passes the interpolation ID to the inquiry ID means. In Step B1007, the process ends.

[2417]

FIG. 630 is a flowchart of a process in which the interpolation ID generation means (B0110) specifies the position of the visible light transmitter (B0120) based on the sensing means and the receiving camera. The specification of the position of the visible light transmitter in a situation illustrated in FIG. 632 is assumed in this flowchart.

[2418]

In Step B1101, the process starts. In Step B1102, the interpolation ID generation means (B0110) estimates the tilt of the mobile terminal in the X, Y, and Z axis directions when the mobile terminal receives the ID from the visible light transmitter (B0120), from the values of the accelerometer, the gyroscope, and the geomagnetic sensor received from the sensing means. In Step B1103, the interpolation ID generation means (B0110) extracts the information of whether the visible light ID is received by the front camera or the back camera of the mobile terminal, when receiving the visible light ID from the inquiry ID generation means (B0104). In Step B1104, the interpolation ID generation means (B0110) specifies the position of the visible light transmitter (B0120), based on the tilt of the mobile terminal estimated in Step B1102 and the ID receiving camera information extracted in Step B1103. The process then proceeds to Step B1105 (8).

[2419]

FIG. 631 is a flowchart of a process in which the interpolation ID generation means (B0110) generates the interpolation ID based on the position of the visible light transmitter.

[2420]

The process proceeds from Step B1105 (8) to Step B1201, and the interpolation ID generation means (B0110) extracts the

correspondence table between interpolation IDs and visible light transmitter positions held therein, to select the interpolation ID corresponding to the position of the visible light transmitter (B0120) (in the case where the interpolation ID generation means does not hold the table, the interpolation ID generation means may read the table from an external server or the like via a network). In Step B1202, the interpolation ID generation means (B0110) obtains the interpolation ID corresponding to the specified position of the visible light transmitter (B0120) from the table, and passes the interpolation ID to the inquiry ID means. In Step B1203, the process ends.

[2421]

FIGS. 632, 633, and 634 are diagrams illustrating in detail the case where the interpolation ID generation means (B0110) generates the interpolation ID based on the position of the visible light transmitter as illustrated in the flowcharts in FIGS. 630 and 631.

[2422]

FIG. 632 is a diagram illustrating visible light transmitters (B0120) around the user using the mobile terminal (B0101).

[2423]

The visible light transmitters include: a visible light transmitter B1302 such as a lighting installed on the ceiling; a visible light transmitter B1303 such as a signage installed in front of the user; a visible light transmitter B1304 such as a signage installed behind the user; and a visible light transmitter B1305 such as a lighting installed on the floor.

[2424]

Which of the visible light transmitters B1302, B1303, B1304, and B1305 the received ID is transmitted from is specified using the tilt angle R (B1301) of the mobile terminal (B0101) and the information of whether the camera receiving the visible light ID is the front camera (B0106) or the back camera (B0107).

[2425]

FIG. 633 is a diagram illustrating an example in which the interpolation ID generation means (B0110) specifies the position of

the visible light transmitter (B0120) based on the orientation of the housing detected using the sensing means (B0103) and the information of whether the camera receiving the visible light ID is the front camera (B0106) or the back camera (B0107).

[2426]

The mobile terminal (B0101) detects the orientation of the housing by the sensing means (B0103), and receives visible light (B1101) only by one of the front camera (B0106) and the back camera (B0107). This reduces inadequate operation induced by reflected light and the like, and also saves power. For example, the following control is performed: only the front camera (B0106) is activated in the case where the housing of the mobile terminal (B0101) is tilted at 45 degrees or more as indicated by an angle B1102; and only the back camera (B0107) is activated in the case where the housing of the mobile terminal is tilted at less than 45 degrees as indicated by an angle B1403.

[2427]

FIG. 634 is a diagram illustrating an example of a table used by the interpolation ID generation means (B0110) to select the interpolation ID based on the device position.

[2428]

A column B1501 indicates the camera used. A column B1502 indicates the tilt angle R (B1301) of the mobile terminal (B0101) illustrated in FIG. 632. A column B1503 indicates the position of the visible light transmitter (B1503) estimated based on the information of B1502 and B1503.

[2429]

Take a row B1504 for example. The visible light ID is received using the front camera, and the angle of the mobile terminal is in the range from 315 degrees to 360 degrees or from 0 degree to 45 degrees. The device position is accordingly determined as the visible light transmitter 1304 illustrated in FIG. 632, which is installed behind the user using the mobile terminal (B0101). The interpolation ID in this case is specified as "IC1".

[2430]

FIG. 635 is a diagram illustrating an example of the user attribute table held in the user information holding means (B0151).

[2431]

A column B1601 indicates the attribute name such as name or sex representing user information, and a column B1602 indicates the attribute value of the user corresponding to the attribute name.

[2432]

FIG. 636 is a diagram illustrating an example of the table used by the interpolation ID generation means (B0110) to select the interpolation ID based on the user attribute.

[2433]

A column B1701 indicates the interpolation ID, and a column B1702 indicates the user attribute used when selecting the interpolation ID. The interpolation ID generation means (B0110) determines, using the user information illustrated in FIG. 635, whether or not the condition indicated in B1702 is met, and selects the interpolation ID.

[2434]

For example, in the user information illustrated in FIG. 635, the sex B1603 is male, the membership rank B1604 is premium, and the age is 35. Hence, the interpolation ID "1B1" in FIG. 636 is selected.

[2435]

FIG. 637 is a diagram illustrating an example of the data table held in the visible light ID correspondence information data holding means (B0114). A column B1801 indicates the ID generated by the inquiry ID generation means (B0110) in the mobile terminal (B0101), and is a 128-bit string including the visible light ID which the mobile terminal (B0101) receives from the visible light transmitter (B0120). A column B1802 indicates the visible light ID correspondence information, which is information corresponding to the visible light ID such as an URL that corresponds to the inquiry ID B1801.

[2436]

FIG. 638 is a diagram illustrating an example of the area ID information table held in the area ID information server (B0141).

[2437]

As a wireless LAN access point identifier (B1103), for example, an identifier SSID of an access point or an identifier ESSID formed by combining a plurality of specific wireless LAN access points is used for wireless LAN access point identification. Store information is information the mobile terminal (B0101) receives from a Wi-Fi access point or a Bluetooth communication device installed in the store upon entering the store.

[2438]

FIG. 639 is a diagram illustrating a use case in this embodiment.

[2439]

In step 1, the user visits a store. In step 2, the user takes out the mobile terminal (B0101) on a specific sales floor in the store. In step 3, the user displays information received from the ID correspondence information conversion server, on the screen of the mobile terminal (B0101).

[2440]

FIG. 640 is a diagram illustrating an example of the internal structure of the inquiry ID from the mobile terminal (B0101) to the ID correspondence information conversion server (B0111).

[2441]

The inquiry ID is an identification number for accessing specific information via the Web. In this embodiment, the bit string length of the whole inquiry ID is 128 bits.

[2442]

The internal structure of the inquiry ID includes the 120-bit ID (B2101) provided from the area ID information server (B0141), and the 8-bit ID (B2102) received from the visible light transmitter or generated from the user attribute information held in the mobile terminal. The bit string B2101 is used to specify the store or the area, and the bit string B2102 is used to specify the arbitrary location in the store or the area.

[2443]

Note that the internal structure of the inquiry ID may be a

combination other than the above, such as 110 bits + 18 bits. Moreover, the 120-bit ID (B2101) may be received from the visible light transmitter or generated from the user attribute information held in the mobile terminal, without involving the area ID information server (B0141).

[2444]

FIG. 641 is a diagram illustrating an example in which the mobile terminal (B0101) generates the inquiry ID.

[2445]

In example 1, the mobile terminal (B0101) receives all 128 bits of the inquiry ID from the visible light transmitter (B0120), without involving the area ID information server (B0141).

[2446]

In example 2, the mobile terminal (B0101) receives the 128-bit ID indicated as B2101 in FIG. 640 from the area ID information server (B0141), and the remaining 8 bits from the visible light transmitter (B0120).

[2447]

In example 3, the mobile terminal (B0101) receives the 128-bit ID indicated as B2101 in FIG. 640 from the area ID information server (B0141), receives 4 bits from the visible light transmitter (B0120), and generates the remaining 4 bits from the user attribute information and the like held in the mobile terminal.

[2448]

FIG. 642 is a diagram illustrating a detailed use case of example 2 in FIG. 641.

[2449]

Step 1 relates to the process of the mobile terminal (B0101) performed when the user visits the store. The area is specified by communication of a store GPS, Wi-Fi, Bluetooth, or sound using the mobile terminal (B0101), and the 120-bit ID from the area ID information server is requested.

[2450]

Step 2 relates to the process of the mobile terminal (B0101) performed when the user takes out the mobile terminal on the

specific sales floor in the store. After receiving the 8-bit visible light ID from the visible light transmitter (B0120), the information from the ID correspondence information conversion server (B0111) is requested using 128 bits combining the 120 bits received in step 1 and the received 8-bit visible light ID.

[2451]

In step 3, the ID correspondence information conversion server (B0111) determines the response information from the 128-bit ID received from the mobile terminal (B0101), and notifies the information. The mobile terminal (B0101) displays the information received from the ID correspondence information conversion server (B0111), on the screen.

[2452]

FIG. 643 is a diagram illustrating a detailed use case of example 3 in FIG. 641.

[2453]

Step 1 relates to the process of the mobile terminal (B0101) performed when the user visits the store. The area is specified by communication of a store GPS, Wi-Fi, Bluetooth, or sound using the mobile terminal (B0101), and the 120-bit ID from the area ID information server is requested.

[2454]

Step 2 relates to the process of the mobile terminal (B0101) performed when the user takes out the mobile terminal on the specific sales floor in the store. After receiving the 4-bit visible light ID from the visible light transmitter (B0120), the position of the visible light transmitter (B0120) is specified from the orientation of the smartphone or the like, and the 4-bit interpolation ID indicating the device position is generated.

[2455]

The information from the ID correspondence information conversion server (B0111) is requested using 128 bits combining the 120 bits received in step 1, the 4-bit visible light ID, and the 4-bit interpolation ID.

[2456]

In step 3, the ID correspondence information conversion server (B0111) determines the response information from the 128-bit ID received from the mobile terminal (B0101), and notifies the information. The mobile terminal (B0101) displays the information received from the ID correspondence information conversion server (B0111), on the screen.

[Industrial Applicability]

[2457]

The present invention is applicable to an information communication device and the like, and in particular to an information communication device and the like used for a method of communication between a mobile terminal such as a smartphone, a tablet terminal, a mobile phone, a smartwatch, or a head-mounted display and a home electric appliance such as an air conditioner, a lighting device, a rice cooker, a television, a recorder, or a projector.

[Reference Signs List]

[2458]

1101 television
1105 smartphone
1106 microwave
1107 air cleaner
1201 smartphone
1301 transmitter device
1309 transmission speed determination unit
1401 receiver device
1404 image obtaining unit
1406 blink information obtaining unit
3001a mobile terminal
3001b intercom indoor unit
3001c intercom outdoor unit
3001e delivery order server
3001f deliverer mobile terminal
4040a microwave table
4040b mobile phone table
4040c mobile phone model table

4040d user voice characteristic table
4040e user keyword voice table
4040f user owned device position table
4040h user position table
A11001 mobile terminal
A11002 first lighting device
A11003 second lighting device
A11004 first ID storage unit
A11005 first encoding unit
A11006 first illuminance pattern storage unit
A11007 first light emitting unit
A11008 second ID storage unit
A11009 second encoding unit
A11010 second illuminance pattern storage unit
A11011 second light emitting unit
A11012 light reception control unit
A11013 ID storage unit
A11014 DB management unit
A11015 server device
A11016 product information storage unit
A11017 map information storage unit
A11018 display unit
A11019 state management unit
A11020 UI unit
A12501 first light receiving unit
A12502 second light receiving unit
A12503 selector
A12504 acceleration detection unit
A12505 received light signal storage unit
A12506 decoding unit
A12507 threshold storage unit
A12701 first light receiving unit
A12702 second light receiving unit
A12703 selector
A12704 timer control unit

A12705 received light signal storage unit
A12706 decoding unit
A12707 threshold storage unit
A13001 gaze information storage unit
A13002 light reception control unit
A13003 DB management unit
A13004 server device
A13301 gaze detection unit
A13401 imaging unit
A13402 gaze detection unit
B0101 mobile terminal
B0102 area detection means
B0103 sensing means
B0104 inquiry ID generation means
B0105 visible light ID reception means
B0106 front camera
B0107 back camera
B0108 communication means
B0109 display means
B0110 interpolation ID generation means
B0111 ID correspondence information conversion server
B0112 communication means
B0113 conversion information determination means
B0114 ID correspondence information holding means
B0120 visible light transmitter
B0130 ad hoc network temporarily established between devices or public network
B0141 area ID information server
B0142 communication means
B0143 area information determination means
B0144 area ID information holding means
B0151 user information holding means
B1301 mobile terminal angle
B1302 visible light transmitter such as a lighting installed on the ceiling

B1303 visible light transmitter such as a signage installed in front of the user

B1304 visible light transmitter such as a signage installed behind the user

B1305 visible light transmitter such as a lighting installed on the floor

B1401 light emission from visible light transmitter

B2101 ID bit string specifying an area

B2102 ID bit string specifying a specific location in the area

K10 information communication device

K11 determination unit

K12 transmission unit

K20 information communication device

K21 exposure time setting unit

K22 bright line image obtainment unit

K23 information obtainment unit

K24 door control unit

[CLAIMS]

[Claim 1]

An information communication method of transmitting a signal using a change in luminance, the information communication method comprising:

determining a pattern of the change in luminance, by modulating the signal to be transmitted; and

transmitting the signal, by a plurality of light emitters changing in luminance according to the determined pattern of the change in luminance,

wherein the plurality of light emitters are arranged on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.

[Claim 2]

The information communication method according to Claim 1,

wherein the transmitting includes

determining whether or not a level of brightness of at least one light emitter of the plurality of light emitters is less than or equal to a reference level which is predetermined brightness, and

in the transmitting, the transmission of the signal from the at least one light emitter is stopped in the case of determining that the level of brightness of the at least one light emitter is less than or equal to the reference level.

[Claim 3]

The information communication method according to Claim 1 or 2,

wherein the transmitting includes

determining whether or not a level of brightness of at least one light emitter of the plurality of light emitters is greater than or equal to a reference level which is predetermined brightness, and

in the transmitting, the transmission of the signal from the at least one light emitter is started in the case of determining that the level of brightness of the at least one light emitter is greater than or equal to the reference level.

[Claim 4]

The information communication method according to any one of Claims 1 to 3,

wherein in the determining, a first luminance change pattern corresponding to a body which is a part of the signal and a second luminance change pattern indicating a header for specifying the body are determined, and

in the transmitting, the header and the body are transmitted by the plurality of light emitters changing in luminance according to the first luminance change pattern, the second luminance change pattern, and the first luminance change pattern in the stated order.

[Claim 5]

The information communication method according to Claim 4,

wherein in the determining, a third luminance change pattern indicating an other header different from the header is determined, and

in the transmitting, the header, the body, and the other header are transmitted by the plurality of light emitters changing in luminance according to the first luminance change pattern, the second luminance change pattern, the first luminance change pattern, and the third luminance change pattern in the stated order.

[Claim 6]

The information communication method according to any one of Claims 1 to 5,

wherein in the determining:

luminance change patterns between which a timing at which a predetermined luminance value occurs is different are assigned to different signal units beforehand, to prevent two luminance change

patterns from being assigned to signal units of a same parity, the timing at which the predetermined luminance value occurs in one of the two luminance change patterns being adjacent to the timing at which the predetermined luminance value occurs in the other one of the two luminance change patterns; and

for each signal unit included in the signal, a luminance change pattern assigned to the signal unit is determined.

[Claim 7]

The information communication method according to Claim 4, further comprising:

setting an exposure time of an image sensor so that, in an image obtained by capturing at least one light emitter of the plurality of light emitters by the image sensor, bright lines corresponding to exposure lines included in the image sensor appear according to the change in luminance of the at least one light emitter;

obtaining a bright line image including the bright lines, by capturing the at least one light emitter changing in luminance by the image sensor with the set exposure time; and

obtaining information by demodulating data specified by a pattern of the bright lines included in the obtained bright line image,

wherein the obtaining of information includes:

specifying, in the pattern of the bright lines, a second part and a third part between which a first part corresponding to the second luminance change pattern is interposed in a direction perpendicular to the bright lines; and

obtaining the body by demodulating data specified by the second part and the third part, and

in the specifying, the second part and the third part are specified so that a sum of a length of the second part and a length of the third part in the direction perpendicular to the bright lines is a length associated with the body.

[Claim 8]

The information communication method according to any one

of Claims 1 to 7, further comprising

determining whether or not a flash emitted in a predetermined rhythm is received,

wherein in the transmitting, the plurality of light emitters change in higher luminance, in the case of determining that the flash is received.

[Claim 9]

The information communication method according to any one of Claims 1 to 8, further comprising

at least one light emitter of the plurality of light emitters blinking to be visible to a human eye,

wherein the at least one light emitter repeatedly alternates between the transmitting and the blinking.

[Claim 10]

An information communication device that transmits a signal using a change in luminance, the information communication device comprising:

a determination unit configured to determine a pattern of the change in luminance, by modulating the signal to be transmitted; and

a transmission unit configured to transmit the signal, by a plurality of light emitters changing in luminance according to the determined pattern of the change in luminance,

wherein the plurality of light emitters are arranged on a surface so that a non-luminance change area does not extend across the surface between the plurality of light emitters along at least one of a horizontal direction and a vertical direction of the surface, the non-luminance change area being an area in the surface outside the plurality of light emitters and not changing in luminance.