

DESCRIPTION

Title of Invention

SECURITY SYSTEM, CONTROL METHOD, AND PROGRAM

Technical Field

[0001] The present disclosure generally relates to a security system, a control method, and a program, and more particularly relates to a security system, a control method, and a program, all of which are configured to control a security gate.

Background Art

[0002] Patent Literature 1 discloses an entry/exit control device (security system) for controlling the locking and unlocking of a door installed in a predetermined facility. More particularly, on receiving door identification information from a robot control device, the entry/exit control device determines, by referring to a door management table, whether or not the door, indicated by the door identification information, is allowed to be unlocked to let a robot pass through the door. When the entry/exit control device determines that the door be allowed to be unlocked, the entry/exit control device not only unlocks the door but also notifies the robot control device that the door has been unlocked.

Citation List

Patent Literature

[0003] Patent Literature 1: JP 2021-107108 A

Summary of Invention

[0004] In view of the foregoing background, it is therefore an object of the present disclosure to provide a security system, a control method, and a program, all of which allow for mitigating a reduction in security caused by careless opening of a security gate.

[0005] A security system according to an aspect of the present disclosure includes a first communication unit, a second communication unit, and a control unit. The first communication unit is configured to receive a door open request signal from a robot. The second communication unit is configured to receive, from a human detection device for detecting a person, a signal

representing a detection result of the person. The control unit is configured to control a security gate. The control unit is configured to determine, based on the detection result of the person, whether a condition is appropriate for opening the security gate or is inappropriate for opening the security gate. The control unit is configured to open the security gate upon the first communication unit receiving the door open request signal from the robot when the condition is appropriate for opening the security gate. The control unit is configured to keep the security gate closed upon the first communication unit receiving the door open request signal from the robot when the condition is inappropriate for opening the security gate..

[0006] A control method according to another aspect of the present disclosure is a control method for a security gate. The control method includes a first communication step, a second communication step, and a control step. The first communication step includes receiving a door open request signal from a robot. The second communication step includes receiving, from a human detection device for detecting a person, a signal representing a detection result of the person. The control step includes controlling the security gate. The control step includes determining, based on the detection result of the person, whether a condition is appropriate for opening the security gate or is inappropriate for opening the security gate. The control step includes opening the security gate upon the door open request signal being received from the robot when the condition is appropriate for opening the security gate. The control step includes keeping the security gate closed upon the door open request signal being received from the robot when the condition is inappropriate for opening the security gate.

[0007] A program according to still another aspect of the present disclosure is a program readable for a computer system. The program is designed to cause one or more processors of the computer system to perform the control method described above.

Brief Description of Drawings

[0008] [FIG. 1] FIG. 1 is a block diagram of a robot system including a security system according to an exemplary embodiment;

[FIG. 2] FIG. 2 is a schematic representation illustrating a security gate used together with the security system and its surroundings;

[FIG. 3] FIG. 3 is a flowchart showing the procedure of the security system;

[FIG. 4] FIG. 4 is a schematic representation illustrating the security gate used together with the security system and its surroundings; and

[FIG. 5] FIG. 5 is a schematic representation illustrating the security gate used together with the security system and its surroundings.

Description of Embodiments

[0009] (Embodiment)

A security system 1, control method, and program according to an exemplary embodiment will now be described with reference to the accompanying drawings. Note that the exemplary embodiment to be described below is only an exemplary one of various embodiments of the present disclosure and should not be construed as limiting. Rather, the exemplary embodiment may be readily modified in various manners depending on a design choice or any other factor without departing from the scope of the present disclosure. Note that the drawings to be referred to in the following description of embodiments are all schematic representations. Thus, the ratio of the dimensions (including thicknesses) of respective constituent elements illustrated on the drawings does not always reflect their actual dimensional ratio.

[0010] (Overview)

As shown in FIG. 1, the security system 1 communicates with a security gate 31 and a plurality of robots 5. The security system 1 permits persons 6 (refer to FIG. 2) who have been successfully authenticated and the robots 5 that have been successfully authenticated to pass through the security gate 31.

[0011] A traveling direction of the person 6 or the robot 5 when the person 6 or the robot 5 passes through the security gate 31 will be hereinafter referred to as a “rightward/leftward direction.” The person 6 or the robot 5 moves, via the security gate 31, from a first area 7A (refer to FIG. 2) on the left of the security gate 31 to a second area 7B (refer to FIG. 2) on the right of the security gate 31. In the same way, the person 6 or the robot 5 moves, via the security gate 31, from the second area 7B on the right of the security gate 31 to the first area 7A on the left of the security gate 31. The security gate 31 serves as a partition between the first area 7A and the second area 7B.

[0012] In the following description, moving from the first area 7A to the second area 7B will be hereinafter referred to as an “entry” and moving from the second area 7B to the first area 7A will be hereinafter referred to as an “exit.” The security system 1 manages at least one of the entry or the exit. That is to say, when the person 6 or the robot 5 is successfully authenticated, the security system 1 causes the security gate 31 to permit the person 6 who has been successfully authenticated or the robot 5 that has been successfully authenticated to pass through the security gate 31 (entry or exit). Specifically, when the person 6 or the robot 5 is successfully authenticated, the security system 1 opens the security gate 31. This allows the person 6 or the robot 5 to pass through the security gate 31.

[0013] More particularly, in each of the first area 7A and the second area 7B, the person 6 is detected by a human detection device 2. When the robot 5 is successfully authenticated, the security system 1 determines, based on a detection result obtained by the human detection device 2, whether the security system 1 opens the security gate 31 or keeps the security gate 31 closed.

[0014] As shown in FIG. 1, the security system 1 according to this embodiment includes a first communication unit 11, a second communication unit 12, and a control unit 14. The first communication unit 11 receives a door open request signal from the robot 5. The second communication unit 12 receives, from each of the human detection devices 2 for detecting the person 6, a signal representing a detection result of the person 6. The control unit 14 controls the security gate 31. The control unit 14 determines, based on the detection result of the person 6, whether or not a condition is appropriate for opening the security gate 31. The control unit 14 opens the security gate 31 upon the first communication unit 11 receives the door open request signal from the robot 5 when the condition is appropriate for opening the security gate 31. The control unit 14 keeps the security gate 31 closed upon the first communication unit 11 receives the door open request signal from the robot 5 when the condition is inappropriate for opening the security gate 31.

[0015] The configuration described above allows for reducing the chances, for example, that the person 6 who does not have a right to pass through pass through the security gate 31 due to the security gate 31 that is carelessly opened when the robot 5 transmits the door open request signal. In addition, the configuration allows for reducing the chances that the security gate 31 is carelessly opened when the robot 5 transmits the door open request signal, which also reduces the chances that the robot 5 stops at a position in which the robot 5 interrupts the security gate 31 from closing when the robots 5 detects the person 6 around the security gate 31, for example. This allows for reducing the chances that the security gate 31 remains open. In this manner, the configuration described above allows for mitigating a reduction in security caused by careless opening of the security gate 31.

[0016] Also, the same function as the security system 1 may be implemented as a control method for the security gate 31. The control method according to this embodiment includes a first communication step, a second communication step, and a control step. The first communication step includes receiving a door open request signal from a robot 5. The second communication step includes receiving, from a human detection device 2 for detecting a person 6, a signal representing a detection result of the person 6. The control step includes controlling the security gate 31. The control step includes determining, based on the detection result of the person 6, whether or not a condition is appropriate for opening the security gate 31. The control step

includes opening the security gate 31 upon the door open request signal being transmitted from the robot 5 when the condition is appropriate for opening the security gate 31. The control step includes keeping the security gate 31 closed upon the door open request signal being transmitted from the robot 5 when the condition is inappropriate for opening the security gate 31.

[0017] The control method described above may be implemented as a program. The program according to this embodiment is a program readable for a computer system and makes one or more processors of the computer system execute the control method described above. The program may be stored in a non-transitory storage medium which is readable for the computer system.

[0018] (Details)

(1) Overall Configuration

As shown in FIG. 1, a security system 1 is included in a robot system X1. The robot system X1 includes the security system 1, a plurality of (e.g., two in the example illustrated in FIG. 1) human detection devices 2, a gate system 3, a robot server 4, and a plurality of (e.g., three in the example illustrated in FIG. 1) robots 5.

[0019] The plurality of human detection devices 2 and the gate system 3 are installed in a facility. Examples of the facilities include a multi-family dwelling house, a shop, an office building, a factory, a warehouse, a commercial complex, a library, an art museum, a museum, a leisure facility, a theme park, a public park, an airport, a railway station, a ballpark, a hotel, and a hospital. Alternatively, the facility may also be a moving vehicle such as a ship and a rail train. Optionally, the facility may be an indoor facility or may be an outdoor facility, whichever is appropriate.

[0020] The security system 1 and the robot server 4 may be installed in the facility or may be installed in a place different from the facility, whichever is appropriate.

[0021] The plurality of robots 5 move autonomously in the facility and perform a task. The plurality of robots 5 move autonomously along a movement route notified to the plurality of robots 5 by the robot server 4, for example. Examples of the tasks include delivery, cleaning, a security patrol, and an equipment inspection.

[0022] (2) Human Detection Device

Each of the human detection devices 2 detects the person 6. The human detection device 2 includes, for example, a camera. The camera captures a space around the security gate 31 to generate a captured image. Generating the captured image corresponds to detecting the person 6. The camera transmits the captured image to the security system 1. The camera may be, for example, a visible light camera or an infrared camera, whichever is appropriate.

[0023] Each of the human detection devices 2 preferably detects the person 6 one or more times per second.

[0024] A human detection device 2A belonging to the two human detection devices 2 detects a person 6A present in the first area 7A. The other human detection device 2B belonging to the two human detection devices 2 detects a person 6B present in the second area 7B.

[0025] (3) Security System

As shown in FIGS. 1 and 2, the gate system 3 includes the security gate 31, two readers 32, a drive device 33, a pass sensor 34, and a notifying unit 35.

[0026] As used in the present disclosure, the “security gate 31” is configured to be controlled to allow the person 6 who has been successfully authenticated to pass therethrough, whereas the “security gate 31” is configured to be controlled not to allow the person 6 who has not been successfully authenticated to pass therethrough. Also, the security gate 31 may allow the robot 5 to pass therethrough. The security gate 31 is switched between a pass preventing state (pass disallowing state) and a pass allowing state. The pass preventing state is a state of preventing the person 6 and the robot 5 from passing through the security gate 31. The pass allowing state is a state in which the person 6 and the robot 5 may pass through the security gate 31.

[0027] The security gate 31 includes: an opening part (doorway) provided through a wall serving as a partition between two spaces; and a door for opening and closing the opening part, for example. The door is, for example, a sliding door. The person 6 and the robot 5 may pass through the opening part when the door is in a position different from the opening part.

[0028] In this embodiment, a closed state corresponds to the pass preventing state and an open state corresponds to the pass allowing state. That is to say, the security gate 31 is switched between the closed state and the open state. A state in which the door of the security gate 31 blocks the opening part connecting the first area 7A and the second area 7B corresponds to the closed state. Meanwhile, a state in which the door of the security gate 31 is in a position different from the opening part and the opening part is left open corresponds to the open state.

[0029] A reader 32A belonging to the two readers 32 is installed in the first area 7A. The other reader 32B belonging to the two readers 32 is installed in the second area 7B. Each of the readers 32 reads information, which includes identification information, from a device that the person 6 carries. Examples of the devices include an RFID tag, an IC card, a magnetic card, a cellular phone such as a smartphone, and a wearable device. Alternatively, the device may also be a member such as a card with a barcode (one-dimensional barcode or two-dimensional barcode). Each of the readers 32 may be configured to read the information from the device in a contactless manner or may be configured to read the information from the device in contact manner, whichever is appropriate.

[0030] The drive device 33 includes, for example, a motor. The drive device 33 drives the

security gate 31. Thus, the drive device 33 switches the open and closed state of the security gate 31.

[0031] The pass sensor 34 detects the person 6 who passes through the security gate 31. The pass sensor 34 is, for example, a photoelectric sensor. The photoelectric sensor is, for example, a through-beam photoelectric sensor and includes a light emitter for emitting light and a photodetector for receiving light emitted from the light emitter. The photoelectric sensor detects the presence or absence of the person 6 who passes through the security gate 31 based on the amount of light received by the photodetector.

[0032] The notifying unit 35 notifies the person 6 that it is prohibited to pass through the security gate 31 when the robot 5 is passing through the security gate 31. The notifying unit 35 makes a sign denoting “no passage,” for example. Specifically, the notifying unit 35 includes a projector for projecting a mark (e.g., a “no entry” mark of the traffic sign) denoting “no passage” on the ground in the entry area of the security gate 31. Alternatively, the notifying unit 35 includes a display for showing a mark (e.g., a “no entry” mark of the traffic sign) denoting “no passage.” Still alternatively, the notifying unit 35 includes a light source for emitting light (e.g., light in red) representing “no passage.”

[0033] Optionally, the notifying unit 35 may output sound (which may include voice) representing “no passage.” Specifically, the notifying unit 35 may include a buzzer for outputting a beep sound representing “no passage.” Alternatively, the notifying unit 35 may include a loudspeaker for outputting voice expressing “no passage” by telling, for example, “robot is passing through the gate, and please wait a moment.”

[0034] (4) Robot Server

The robot server 4 manages operation of the plurality of robots 5. The robot server 4 obtains location information of each of the plurality of robots 5, for example. In addition, the robot server 4 notifies the plurality of robots 5 of the respective movement routes, for example. Each of the robots 5 travels along the movement route notified to each of the robots 5 by the robot server 4 while circumventing an obstacle (the person 6 or an object) present on the movement route.

[0035] Optionally, the robot server 4 may relay communication between the plurality of robots 5 and the security system 1.

[0036] (5) Robot

Each of the robots 5 includes a processing unit 51, a storage unit 52, a communication unit 53, a sensing unit 54, a traveling device 55, and a power supply unit 56.

[0037] The robot 5 includes a computer system including one or more processors and a memory.

The one or more processors of the computer system execute a program stored in the memory of the computer system, and thus at least a part of a function of the robot 5 is performed. The program may be stored in the memory. Alternatively, the program may also be downloaded via a telecommunications line such as the Internet or distributed after having been stored in a non-transitory storage medium (e.g., a memory card) readable for the computer system.

[0038] The processing unit 51 includes the one or more processors of the computer system described above. The processing unit 51 executes the program to perform a predetermined function. The processing unit 51 controls the storage unit 52, the communication unit 53, the sensing unit 54, the traveling device 55, and the power supply unit 56.

[0039] The storage unit 52 is a storage device implemented as, for example, a hard disk drive (HDD) or a solid state drive (SSD). The storage unit 52 stores information. For example, the storage unit 52 stores the robot's 5 own identification information and map information of the facility where the robot 5 travels. The storage unit 52 also stores information about the movement route of the robot 5 obtained from the robot server 4.

[0040] The communication unit 53 includes a communication interface device. The robot 5 is configured to communicate with the security system 1 and the robot server 4 via the communication unit 53. As used herein, the phrase "to be configured to communicate" means being able to transmit and receive signals either directly or indirectly via a network or a repeater, for example, by an appropriate wired or wireless communication method. Particularly, the robot 5 according to this embodiment communicates wirelessly with the security system 1 and the robot server 4.

[0041] The sensing unit 54 includes one or more sensors for detecting the surroundings. Each of the one or more sensors is implemented as at least one of, for example, a camera, a laser rangefinder, an infrared sensor, or a pressure sensor. The camera is, for example, a visible light camera or an infrared camera. The laser rangefinder is, for example, a Lidar (Light Detection and Ranging). For example, the robot 5 stops traveling when its sensing unit 54 detects an obstacle (the person 6 or an object) within a predetermined range (e.g., within a circle having a radius of 1 m and centered at the robot 5).

[0042] The traveling device 55 includes, for causing the robot 5 to travel, a motor and a driving wheel, for example. The motor rotates the driving wheel, thus the robot 5 travels along the ground.

[0043] The power supply unit 56 supplies electric power required for operation of the robot 5. The power supply unit 56 includes, for example, a battery.

[0044] (6) Security System

The security system 1 includes a first communication unit 11, a second communication unit 12, a third communication unit 13, a control unit 14, a storage unit 15, and an operating unit 16.

[0045] The security system 1 includes a computer system including one or more processors and a memory. The one or more processors of the computer system execute a program stored in the memory of the computer system, and thus at least a part of a function of the security system 1 is performed. The program may be stored in the memory. Alternatively, the program may also be downloaded via a telecommunications line such as the Internet or distributed after having been stored in a non-transitory storage medium (e.g., a memory card) readable for the computer system.

[0046] The control unit 14 includes the one or more processors of the computer system described above. The control unit 14 executes the program to perform a predetermined function. The control unit 14 controls the first communication unit 11, the second communication unit 12, the third communication unit 13, and the storage unit 15.

[0047] The storage unit 15 is a storage device implemented as, for example, a hard disk drive (HDD) or a solid state drive (SSD). The storage unit 15 stores information. For example, the storage unit 15 stores the identification information of each of the plurality of robots 5 and the identification information of the device that the person 6 carries.

[0048] The operating unit 16 accepts an operating command entered by a user. The operating unit 16 includes at least one of a button, a key switch, or a pointing device, for example. Examples of the pointing devices include a mouse, a touch panel (touchscreen), a pen tablet, a touchpad, a trackpad, a trackball, a joypad, and a joystick.

[0049] The first communication unit 11 includes a first communication interface device. The security system 1 is configured to communicate with the robot server 4 and the plurality of robots 5 via the first communication unit 11. That is to say, the control unit 14 performs processing for communicating with the plurality of robots 5 via the first communication unit 11.

[0050] The second communication unit 12 includes a second communication interface device. The security system 1 is configured to communicate with the plurality of human detection devices 2 via the second communication unit 12. That is to say, the control unit 14 performs processing for communicating with the plurality of human detection devices 2 via the second communication unit 12.

[0051] The third communication unit 13 includes a third communication interface device. The security system 1 is configured to communicate with the gate system 3 via the third communication unit 13. That is to say, the control unit 14 performs processing for communicating with the gate system 3 via the third communication unit 13.

[0052] When the reader 32 of the gate system 3 reads the identification information from the device that the person 6 carries, the gate system 3 transmits a signal including the identification information thus read to the security system 1. The storage unit 15 of the security system 1 stores, in advance, the identification information associated with the person 6 who is permitted to pass through the security gate 31. Thus, the control unit 14 of the security system 1 is able to identify, by reference to information stored in the storage unit 15, whether or not the identification information read by the reader 32 is associated with permission for passing through the security gate 31. In this manner, the control unit 14 authenticates the person's 6 identity.

[0053] When the identification information read by the reader 32 is associated with the permission for passing through the security gate 31, the security gate 31 will be in the open state. After the pass sensor 34 detects that the person 6 has passed through the security gate 31, the security gate 31 will be in the closed state.

[0054] (7) Exemplary Operation

An exemplary operation of the security system 1 will be described with reference to FIG. 3. Note that the flowchart shown in FIG. 3 shows only an exemplary procedure and should not be construed as limiting. Optionally, the processing steps shown in FIG. 3 may be performed in a different order from the illustrated one as needed, some of the processing steps shown in FIG. 3 may be omitted as appropriate, and/or an additional processing step may be performed as needed. In this example, the robots 5 is supposed to move from the first area 7A to the second area 7B.

[0055] Information including the identification information is read, by the reader 32, from the device that the person 6 carries. When this identification information is associated with the permission for passing through the security gate 31 (if the answer is Yes in Step ST1), the control unit 14 of the security system 1 opens the security gate 31 (in Step ST2). After the pass sensor 34 detects that the person 6 has passed through the security gate 31 (if the answer is Yes in Step ST3), the control unit 14 closes the security gate 31 (in Step ST4).

[0056] Each of the plurality of robots 5 transmits a door open request signal to the security system 1 when the robot 5 approaches the security gate 31. The door open request signal includes the identification information, as authentication information, of the corresponding robot 5. When the door open request signal does not include valid authentication information, the security system 1 does not allow the corresponding robot 5 to pass through the security gate 31. In the following description, the door open request signal is supposed to include the valid authentication information.

[0057] In one example, a stop area 73A (refer to FIG. 2) is set near to the security gate 31. The robot 5 transmits the door open request signal to the security system 1 upon arriving at the stop

area 73A. The information about the location of the stop area 73A is included in the map information, stored in the storage unit 52 of the robot 5, of the facility.

[0058] When the first communication unit 11 receives the door open request signal transmitted from the robot 5 (if the answer is Yes in Step ST5), the control unit 14 of the security system 1 determines the current condition of the surroundings of the security gate 31 (in Step ST6).

[0059] When the current condition is appropriate for opening the security gate 31 (if the answer is Yes in Step ST7), the control unit 14 opens the security gate 31 (in Step ST9) and notifies the robot 5 that the security gate 31 has been opened. When notified, the robot 5 starts to move to pass through the security gate 31.

[0060] In contrast, when the current condition is inappropriate for opening the security gate 31 (if the answer is No in Step ST7), the control unit 14 keeps the security gate 31 closed. In this case, the control unit 14 outputs a retreat command to the robot 5 (in Step ST8). On receiving the retreat command, the robot 5 moves to a retreat area 72A (refer to FIG. 2) located at a distance from the security gate 31. The distance from the security gate 31 to the retreat area 72A is longer than the distance from the security gate 31 to the stop area 73A. In this manner, the control unit 14 outputs the retreat command to make the robot 5 move away from the security gate 31 if the condition is inappropriate for opening the security gate 31 when the first communication unit 11 receives the door open request signal from the robot 5.

[0061] The robot 5 repeatedly transmits the door open request signal until the robot 5 is notified that the security gate 31 is opened, and thus Steps ST5–ST7 are performed repeatedly.

[0062] After a predetermined time has passed since the control unit 14 opened the security gate 31 in response to the door open request signal (if the answer is Yes in Step ST10), the control unit 14 closes the security gate 31 (in Step ST4).

[0063] The predetermined time is stored in the storage unit 15 in advance. Alternatively, the predetermined time is decided based on one or more control parameters stored in the storage unit 15 in advance. The one or more control parameters to decide the predetermined time will be described later.

[0064] In Step ST9, the control unit 14 causes the notifying unit 35 of the gate system 3 to provide a notification indicating that any person 6 is prohibited from passing through the security gate 31. Thereafter, the control unit 14 causes the notifying unit 35 to stop providing the notification when the control unit 14 closes the security gate 31 in Step ST4.

[0065] (8) Determination of Condition

As described above, in Step ST6, the control unit 14 determines whether or not the current condition is appropriate for opening the security gate 31. This will now be described in detail.

[0066] (8.1) First Example

First, suppose a situation in which a robot 5 and a person 6A are present in the first area 7A as shown in FIG. 2 and this robot 5 transmits the door open request signal. In this situation, it is also supposed that no person 6B is present in the second area 7B. In addition, the second area 7B is supposed to be more strictly restricted to enter (i.e., an area having a higher security level) than the first area 7A.

[0067] The human detection device 2A includes a camera and captures the first area 7A to generate a captured image. The captured image is transmitted to the security system 1. The control unit 14 obtains the location of the person 6A present in the first area 7A based on the captured image serving as a detection result obtained by the human detection device 2A. More particularly, the control unit 14 calculates the location of the person 6A by analyzing the captured image.

[0068] The control unit 14 determines whether or not the person 6A is able to pass through the security gate 31 within the period from the time when the control unit 14 opens the security gate 31 in response to the door open request signal received from the robot 5 to the time when the control unit 14 closes the security gate 31. More particularly, the control unit 14 determines, based on the location of the person 6A, the movement speed of the person 6A, and duration required from the time when the control unit 14 opens the security gate 31 to the time when the control unit 14 closes the security gate 31 after the robot 5 passes through the security gate 31, whether or not the person 6A is able to pass through the security gate 31 within the period from the time when the control unit 14 opens the security gate 31 in response to the door open request signal received from the robot 5 to the time when the control unit 14 closes the security gate 31. If the control unit 14 determines that the person 6A be unable to pass through the security gate 31 within the period described above (if the answer is Yes in Step ST7), then the control unit 14 opens the security gate 31. On the other hand, if the control unit 14 determines that the person 6A be able to pass through the security gate 31 within the period described above (if the answer is No in Step ST7), then the control unit 14 keeps the security gate 31 closed.

[0069] The control unit 14 determines whether or not the condition is appropriate for opening the security gate 31 based on the detection result of the person 6A and the plurality of control parameters determined in advance. More particularly, the control unit 14 obtains the location of the person 6A based on the detection result of the person 6A. Examples of the plurality of control parameters are to be shown in table 1.

[0070] [Table 1]

Sign	Description
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Td	Time required to open security gate 31
Vr	Movement speed of robot 5
To	Preparation time for robot 5 to actually start to move since robot 5 received movement instruction
Hrsec	Safe stopping distance of robot 5 (robot 5 stops when distance between robot 5 and obstacle reduces to less than safe stopping distance)
Hrsize	Dimension of robot 5
Xr0	Distance between security gate 31 and robot 5 when security gate 31 opens
Xr1	Distance between security gate 31 and robot 5 when security gate 31 closes
Hr	Movement distance of robot 5 from time when security gate 31 opens to time when security gate 31 closes. $Hr = Xr1 - Xr0$ holds.
Tr	Time required for robot 5 to pass through security gate 31
Vh	Movement speed of person 6

[0071] A user such as an administrator of the security system 1 may set the plurality of control parameters as desired.

[0072] Also, Hh is supposed to denote the distance between the person 6A and the security gate 31. Hh is calculated by the control unit 14 based on the detection result of the person 6A.

[0073] In addition, Th is supposed to denote a time required for the person 6A to reach the security gate 31. In this case, an equation (1) holds.

$$[0074] \quad Th = Hh/Vh \quad (1)$$

An equation (2) holds as well.

$$[0075] \quad Tr = Td + To + Hr/Vr \quad (2)$$

An inequality (3) is as follows.

$$[0076] \quad Th > Tr \quad (3)$$

If the inequality (3) holds, then a situation in which the person 6A passes through the security gate 31 without the authentication by the reader 32A (so-called “tailgating”) may be prevented even the security gate 31 is opened in response to the door open request signal received from the robot 5.

[0077] Thus, the control unit 14 calculates Hh4 as a value of Hh when an equation (4) holds.

$$[0078] \quad Th = Tr \quad (4)$$

The control unit 14 determines whether or not the person 6A is present in an area 71A (refer to FIG. 2), which is located within a distance of Hh4 from the security gate 31, of the first area 7A. Specifically, the control unit 14 determines whether or not an inequality (5) holds.

$$[0079] \quad Hh < Hh4 \quad (5)$$

When the inequality (5) holds (i.e., the person 6A is present in the area 71A), the control

unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the inequality (5) does not hold (i.e., the person 6A is not present in the area 71A), the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0080] In other words, the control unit 14 determines that the condition be appropriate for opening the security gate 31 when the person 6A is located at a distance equal to or greater than a predetermined distance (Hh4) measured from the security gate 31. Conversely, the control unit 14 determines that the condition be inappropriate for opening the security gate 31 when the person 6A is located at a distance less than the predetermined distance measured from the security gate 31. The plurality of control parameters include a control parameter for setting the predetermined distance. Optionally, the plurality of control parameters may include the predetermined distance. That is to say, Hh4 that denotes the predetermined distance may be set by the user as desired.

[0081] Note that a situation in which no person 6A is present in the area 71A corresponds to a situation in which the person 6A is located at a distance equal to or greater than the predetermined distance (Hh4) measured from the security gate 31.

[0082] The control unit 14 accepts a change in the plurality of control parameters. Thus, changing the plurality of control parameters allows for changing a condition under which the control unit 14 opens the security gate 31. Specifically, the range of the area 71A (refer to FIG. 2), which is located within a distance of Hh4 from the security gate 31, may be changed.

[0083] For example, the user may change the plurality of control parameters by operating the operating unit 16.

[0084] (8.2) Second Example

Next, suppose a situation in which a person 6B is present in the second area 7B and a robot 5 is present in the first area 7A as shown in FIG. 2 and this robot 5 transmits the door open request signal. In this situation, it is also supposed that no person 6A is present in the first area 7A. In addition, the second area 7B is supposed to have a higher security level than the first area 7A.

[0085] The human detection device 2B includes a camera and captures the second area 7B to generate a captured image. The captured image is transmitted to the security system 1. The control unit 14 obtains the location of the person 6B present in the second area 7B based on the captured image serving as a detection result obtained by the human detection device 2B. More particularly, the control unit 14 calculates the location of the person 6B by analyzing the captured image.

[0086] The control unit 14 determines whether or not a situation, in which the robot 5 is required

to stop while passing through the security gate 31 due to the presence of the person 6B in the way of the robot 5, occurs. More particularly, the control unit 14 determines, based on the location of the person 6B, whether or not a situation, in which the robot 5 is required to stop while passing through the security gate 31 due to the presence of the person 6B in the way of the robot 5, occurs. When the control unit 14 determines that the situation, in which the robot 5 is required to stop while passing through the security gate 31 due to the presence of the person 6B in the way of the robot 5, does not occur (if the answer is Yes in Step ST7), the control unit 14 opens the security gate 31. Conversely, when the control unit 14 determines that the situation, in which the robot 5 is required to stop while passing through the security gate 31 due to the presence of the person 6B in the way of the robot 5, occurs (if the answer is No in Step ST7), the control unit 14 keeps the security gate 31 closed.

[0087] The control unit 14 determines whether or not the condition is appropriate for opening the security gate 31 based on the detection result of the person 6B and the plurality of control parameters determined in advance. More particularly, the control unit 14 obtains the location of the person 6B based on the detection result of the person 6B. Examples of the plurality of control parameters are as shown in table 1.

[0088] As in the first example, the control unit 14 calculates Hh that denotes the distance between the person 6B and the security gate 31.

[0089] The control unit 14 determines whether or not the condition is appropriate for opening the security gate 31 based on Hh, Hrsec that denotes the safe stopping distance of the robot 5, and Hrsize that denotes the dimensions of the robot 5. More particularly, the control unit 14 determines whether or not the person 6B is present in an area 74B (refer to FIG. 2), which is located within a distance of Hrsec + Hrsize from the security gate 31, of the second area 7B. Specifically, the control unit 14 determines whether or not an inequality (6) holds.

[0090] $Hh < Hrsec + Hrsize$ (6)

A situation in which the inequality (6) holds corresponds to the situation, in which the robot 5 is required to stop while passing through the security gate 31 due to the presence of the person 6B in the way of the robot 5, occurs. Keeping the security gate 31 closed when the inequality (6) holds reduces the chances that the robot 5 stops, when the robots 5 detects the person 6 around the security gate 31, at a position in which the robot 5 interrupts the security gate 31 from closing. This reduces the chances that the security gate 31 remains open.

[0091] When the inequality (6) holds (i.e., the person 6B is present in the area 74B), the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the inequality (6) does not hold (i.e., the person 6B is not present in the area

74B), the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0092] In other words, the control unit 14 determines that the condition be appropriate for opening the security gate 31 when the person 6B is located at a distance equal to or greater than a predetermined distance ($Hrsec + Hrsz$) measured from the security gate 31. Conversely, the control unit 14 determines that the condition be inappropriate for opening the security gate 31 when the person 6B is located at a distance less than the predetermined distance measured from the security gate 31. The plurality of control parameters include a control parameter for setting the predetermined distance. Optionally, the plurality of control parameters may include the predetermined distance.

[0093] The control unit 14 accepts a change in the plurality of control parameters. Thus, changing the plurality of control parameters allows for changing a condition under which the control unit 14 opens the security gate 31. Specifically, the range of the area 74B (refer to FIG. 2), which is located within a distance of $Hrsec + Hrsz$ from the security gate 31, may be changed.

[0094] For example, the user may change the plurality of control parameters by operating the operating unit 16.

[0095] (8.3) Third Example

Next, suppose a situation in which a person 6B is present in the second area 7B and a robot 5 and a person 6A are present in the first area 7A as shown in FIG. 2. In this situation, it is also supposed that this robot 5 transmits the door open request signal. In addition, the second area 7B is supposed to have a higher security level than the first area 7A.

[0096] In this case, the control unit 14 determines that the condition be appropriate for opening the security gate 31 when the control unit 14 determines that the condition be appropriate for opening the security gate 31 in both the first example and the second example. Conversely, the control unit 14 determines that the condition be inappropriate for opening the security gate 31 when the control unit 14 determines that at least one of the condition in the first example or the condition in the second example be inappropriate for opening the security gate 31.

[0097] That is to say, when the person 6 is present in at least one of the area 71A or the area 74B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the person 6 is present neither in the area 71A nor in the area 74B, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0098] (8.4) Fourth Example

In the first to third examples, the determination of condition, performed by the control unit 14 when the robot 5 moves from the first area 7A to the second area 7B, is described.

[0099] In the following fourth example, the determination of condition performed by the control unit 14 when the robot 5 moves from the second area 7B to the first area 7A will be described with reference to FIG. 4. Note that the second area 7B is supposed to have a higher security level than the first area 7A.

[0100] The control unit 14 determines whether or not the person 6A is present in the area 71A (refer to FIG. 4), which is located within a distance of Hh_4 measured from the security gate 31, of the first area 7A. This is determined by the same method as in the first example, and therefore, the description thereof will be omitted as appropriate here.

[0101] Specifically, when the inequality (5) holds (i.e., the person 6A is present in the area 71A), the control unit 14 determines that the condition be inappropriate for opening the security gate 31. In other words, when the person 6A is located at a distance less than the predetermined distance measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0102] The control unit 14 determines whether or not the person 6A is present in the area 74A (refer to FIG. 4), which is located within a distance of $Hr_{sec} + Hr_{size}$ measured from the security gate 31, of the first area 7A. Specifically, the control unit 14 determines whether or not the inequality (6), where Hh denotes the distance between the person 6A and the security gate 31, holds. When the inequality (6) holds (i.e., the person 6A is present in the area 74A), the control unit 14 determines that the condition be inappropriate for opening the security gate 31. In other words, when the person 6A is located at a distance less than the predetermined distance measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0103] The control unit 14 determines that the condition be appropriate for opening the security gate 31 when the person 6A is in neither of the areas 71A, 74A.

[0104] Note that when the area 74A is encompassed by the area 71A as shown in FIG. 4, the determination based on the inequality (6) may be omitted. In this case, when the person 6A is present in the area 71A, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when no person 6A is present in the area 71A, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0105] In addition, when the area 71A is encompassed by the area 74A, the determination based on the inequality (5) may be omitted. In this case, when the person 6A is present in the area 74A, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when no person 6A is present in the area 74A, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0106] Also, when the condition is inappropriate for opening the security gate 31, the control unit 14 outputs a retreat command to the robot 5. On receiving the retreat command, the robot 5 moves to a retreat area 72B (refer to FIG. 4) located at a distance from the security gate 31.

[0107] (8.5) Fifth Example

In the first to fourth examples, the determination of condition performed by the control unit 14 is described in a situation in which the second area 7B is supposed to have a higher security level than the first area 7A. Thus, the person 6B is supposed to be allowed to move, through the security gate 31, from the second area 7B to the first area 7A without the authentication by the reader 32B when the security gate 31 is opened in response to the door open request signal transmitted from the robot 5.

[0108] In the fifth and sixth examples described below with reference to FIG. 5 relates to the determination of condition in a situation in which the person 6B is not allowed to move, through the security gate 31, from the second area 7B to the first area 7A without the authentication by the reader 32B when the security gate 31 is opened in response to the door open request signal transmitted from the robot 5. In the fifth example, the robot 5 is supposed to be present in the first area 7A.

[0109] When the person 6A is present in the area 71A, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. In other words, when the person 6A is located at a distance less than the predetermined distance measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0110] An area 71B is located, in the second area 7B, within a distance of $Hh4$ measured from the security gate 31. When the person 6B is present in the area 71B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. In other words, when the person 6B is located at a distance less than the predetermined distance measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0111] The control unit 14 determines whether or not the person 6B is present in the area 74B, which is located within a distance of $Hrsec + Hrsize$ measured from the security gate 31, of the second area 7B. Specifically, when the person 6B is present in the area 74B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0112] The control unit 14 determines that the condition be appropriate for opening the security gate 31 when the person 6 is present in none of the areas 71A, 71B, and 74B.

[0113] Note that when the area 74B is encompassed by the area 71B as shown in FIG. 5, the determination based on the presence or absence of the person 6 in the area 74B may be omitted.

In this case, when the person 6 is present in at least one of the area 71A or the area 71B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the person 6 is present neither in the area 71A nor in the area 71B, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0114] Also, when the area 71B is encompassed by the area 74B, the determination based on the presence or absence of the person 6B in the area 71B may be omitted. In this case, when the person 6 is present in at least one of the area 71A or the area 74B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the person 6 is present neither in the area 71A nor in the area 74B, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0115] (8.6) Sixth Example

In the following sixth example, the robot 5 is supposed to be present in the second area 7B.

[0116] When the person 6A is present in the area 71A, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. In other words, when the person 6A is located at a distance less than the predetermined distance measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0117] When the person 6B is present in the area 71B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. In other words, when the person 6B is located at a distance less than the predetermined distance measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0118] The control unit 14 determines whether or not the person 6A is present in the area 74A, which is located within a distance of $H_{rsec} + H_{rsize}$ measured from the security gate 31, of the first area 7A. Specifically, when the person 6A is present in the area 74A, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0119] When the person 6 is present in none of the areas 71A, 71B, and 74A, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0120] Note that when the area 74A is encompassed by the area 71A as shown in FIG. 5, the determination based on the presence or absence of the person 6A in the area 74A may be omitted. In this case, when the person 6 is present in at least one of the area 71A or the area 71B, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the person 6 is present neither in the area 71A nor in the area 71B, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0121] Also, when the area 71A is encompassed by the area 74A, the determination based on the

presence or absence of the person 6 in the area 71A may be omitted. In this case, when the person 6 is present in at least one of the area 71B or the area 74A, the control unit 14 determines that the condition be inappropriate for opening the security gate 31. Conversely, when the person 6 is present neither in the area 71B nor in the area 74A, the control unit 14 determines that the condition be appropriate for opening the security gate 31.

[0122] (Variations of Embodiment)

Next, variations of the exemplary embodiment will be enumerated one after another. Note that the variations to be described below may be adopted in combination as appropriate. In the following description, the configuration of the embodiment described above will be hereinafter referred to as a “basic example.”

[0123] (First Variation)

Next, a security system 1 according to a first variation will be described with reference to FIG. 5. Note that any constituent element of the first variation, having the same configuration as a counterpart of the basic example, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted herein.

[0124] A control unit 14 according to this variation includes a plurality of operation modes including a first control mode and a second control mode. The control unit 14 operates in any operation mode belonging to the plurality of operation modes. For example, the control unit 14 switches between the plurality of operation modes according to operation on the operating unit 16.

[0125] As in the basic example, when the person 6 is located at a distance less than a predetermined distance (Hh4) measured from the security gate 31, the control unit 14 determines that the condition be inappropriate for opening the security gate 31.

[0126] In the first control mode, the control unit 14 sets the predetermined distance (Hh4) at a distance greater than 0. In the second control mode, the control unit 14 sets the predetermined distance at 0.

[0127] Therefore, when the operation mode of the control unit 14 is the second control mode, processing of determining whether or not the person 6 is located at a distance less than the predetermined distance (Hh4) measured from the security gate 31 will be substantially of no effect. Thus, the robot 5 may be more likely to pass through the security gate 31. For example, when many persons 6 approach the security gate 31 and at least one person 6 stays for a long duration in an area (the area 71A or 71B) within the predetermined distance measured from the security gate 31, the robot 5 is unlikely to pass through the security gate 31 when the control unit 14 is in the first control mode. However, by switching the operation mode of the control unit 14 to the second control mode, the robot 5 is more likely to pass through the security gate 31.

[0128] Optionally, if the control unit 14 determines that a situation, in which the robot 5 is required to stop while passing through the security gate 31 due to the presence of the person 6 in the way of the robot 5, occurs even in the second control mode, then the control unit 14 may determine that the condition be inappropriate for opening the security gate 31. For example, when a destination of the robot 5 is the second area 7B and the person 6B is present in the area 74B, the control unit 14 may determine that the condition be inappropriate for opening the security gate 31. Conversely, when a destination of the robot 5 is the second area 7B and no person 6B is present in the area 74B, the control unit 14 may determine that the condition be appropriate for opening the security gate 31.

[0129] Still optionally, when the number of times that the robot 5 transmits the door open request signal reaches equal to or greater than a predetermined times, the operation mode of the control unit 14 may switch from the first control mode to the second control mode. In other words, when the control unit 14 determines, equal to or greater than the predetermined times consecutively, that the condition be inappropriate for opening the security gate 31, the operation mode of the control unit 14 may switch from the first control mode to the second control mode.

[0130] (Second Variation)

Next, a security system 1 according to a second variation will be described with reference to FIG. 5. Note that any constituent element of the second variation, having the same configuration as a counterpart of the basic example, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted herein.

[0131] A control unit 14 according to this variation changes at least one control parameter belonging to the plurality of control parameters depending on a situation in which the robot 5 is present in the first area 7A or a situation in which the robot 5 is present in the second area 7B.

[0132] When the robot 5 is present in the first area 7A, the control unit 14 makes $Hrsec + Hrsize$ greater or smaller than when the robot 5 is present in the second area 7B, for example. Thus, the dimensional ratio between the area 74A and the area 74B (refer to FIG. 5) may be adjusted.

[0133] (Third variation)

Next, a security system 1 according to a third variation will be described. Note that any constituent element of the third variation, having the same configuration as a counterpart of the basic example, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted herein.

[0134] In this variation, a value of $Hh4$ defining the area 71A of the first area 7A and a value of $Hh4$ defining the area 71B of the second area 7B are different from each other. The former will be hereinafter referred to as a "first distance" and the latter will be hereinafter referred to as a

“second distance.”

[0135] That is to say, the control unit 14 determines that the condition be appropriate for opening the security gate 31 when the person 6A, present in the first area 7A, is located at a distance equal to or greater than the first distance measured from the security gate 31 and when the person 6B, present in the second area 7B, is located at a distance equal to or greater than the second distance measured from the security gate 31.

[0136] Also, the control unit 14 determines that the condition be inappropriate for opening the security gate 31 when the person 6A, present in the first area 7A, is located at a distance less than the first distance measured from the security gate 31.

[0137] In the same way, the control unit 14 determines that the condition be inappropriate for opening the security gate 31 when the person 6B, present in the second area 7B, is located at a distance less than the second distance measured from the security gate 31.

[0138] This variation allows for adjusting the dimensional ratio between the area 71A and the area 71B (refer to FIG. 5).

[0139] (Other Variations)

Next, other variations of the exemplary embodiment will be enumerated one after another. Note that the variations to be described below may be adopted in combination as appropriate. The variations to be described below may also be adopted in combination with any of the variations described above as appropriate.

[0140] Two or three functions out of the first communication unit 11, the second communication unit 12, and the third communication unit 13 may be performed by a single device. That is to say, two or three of the first communication unit 11, the second communication unit 12, and the third communication unit 13 may be integrated with each other.

[0141] In the basic example, when the first communication unit 11 receives the door open request signal, the control unit 14 determines whether or not the condition is appropriate for opening the security gate 31. Alternatively, the control unit 14 may determine, in advance, whether or not the condition is appropriate for opening the security gate 31. Still alternatively, the control unit 14 may regularly determine whether or not the condition is appropriate for opening the security gate 31.

[0142] The human detection device 2 is not limited to have a configuration including a camera. Alternatively, the human detection device 2 may have a configuration including, for example, a pressure sensor or ultrasonic sensor for detecting the person 6. Still alternatively, the human detection device 2 may have a configuration including, for example, a beacon for detecting the person 6.

[0143] The security gate 31 is not limited to have a configuration including a sliding door. Alternatively, the security gate 31 may have a configuration including, for example, a flap which is caused to rotate on the fulcrum to switch the state of the security gate 31 between the closed state in which the flap closes the path along which the person 6 and the robot 5 pass through and the open state in which the flap is set outside the path.

[0144] Operation of the robot 5 that has received the retreat command is not limited to move to the retreat areas 72 (refer to FIG. 2) determined in advance. Alternatively, the robot 5 that has received the retreat command only needs to move toward a direction pointing away from the security gate 31.

[0145] The control unit 14 may determine whether or not the condition is appropriate for opening the security gate 31 based on the presence or absence of the person 6 in at least one of the areas 71A, 74A, 71B, or 74B.

[0146] The number of control parameters is not limited to be greater than one but may also be one.

[0147] The agents that perform the control method for the security system 1 and the security gate 31 according to the present disclosure each include a computer system. The computer system may include a processor and a memory as principal hardware components thereof. The computer system serves as the agent that performs at least a part of the function of the control method for the security system 1 and the security gate 31 according to the present disclosure by making the processor execute a program stored in the memory of the computer system. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded through a telecommunications line or be distributed after having been recorded in some non-transitory storage medium such as a memory card, an optical disc, or a hard disk drive, any of which is readable for the computer system. The processor of the computer system may be made up of a single or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a large-scale integrated circuit (LSI). As used herein, the “integrated circuit” such as an IC or an LSI is called by a different name depending on the degree of integration thereof. Examples of the integrated circuits such as an IC or an LSI include integrated circuits called a “system LSI,” a “VLSI (very large scale integration),” and an “ULSI (ultra large scale integration).” Optionally, an FPGA (field-programmable gate array) to be programmed after an LSI has been fabricated or a reconfigurable logic device allowing the connections or circuit sections inside of an LSI to be reconfigured may also be adopted as the processor. The plurality of electronic circuits may be either integrated together on a single chip or distributed on multiple chips, whichever is appropriate. Those multiple chips may be aggregated together in a single device or

distributed in multiple devices without limitation. As used herein, the “computer system” includes a microcontroller including one or more processors and one or more memories. Thus, the microcontroller may also be implemented as a single or a plurality of electronic circuits including a semiconductor integrated circuit or a large-scale integrated circuit.

[0148] In the embodiment, the plurality of functions integrated together in a single housing may be distributed in multiple housings. For example, the plurality of functions of the security system 1 may be distributed in multiple housings.

[0149] Alternatively, in the embodiment, the plurality of functions distributed in multiple different housings may be integrated together in a single housing. For example, the plurality of functions distributed in the security system 1 and the gate system 3 may be integrated together in a single housing.

[0150] (Recapitulation)

The exemplary embodiment and its variations described above are specific implementations of the following aspects of the present disclosure.

[0151] A security system (1) according to a first aspect includes a first communication unit (11), a second communication unit (12), and a control unit (14). The first communication unit (11) is configured to receive a door open request signal from a robot (5). The second communication unit (12) is configured to receive, from a human detection device (2) for detecting a person (6), a signal representing a detection result of the person (6). The control unit (14) is configured to control a security gate (31). The control unit (14) is configured to determine, based on the detection result of the person (6), whether a condition is appropriate for opening the security gate (31) or is inappropriate for opening the security gate (31). The control unit (14) is configured to open the security gate (31) upon the first communication unit (11) receiving the door open request signal from the robot (5) when the condition is appropriate for opening the security gate (31). The control unit (14) is configured to keep the security gate (31) closed upon the first communication unit (11) receiving the door open request signal from the robot (5) when the condition is inappropriate for opening the security gate (31).

[0152] This configuration allows for reducing the chances, for example, that the person (6) who does not have a right to pass through can pass through the security gate (31) due to the security gate (31) that is carelessly opened when the robot (5) transmits the door open request signal. In addition, this configuration allows for reducing the chances that the security gate (31) is carelessly opened when the robot (5) transmits the door open request signal, which also reduces the chances that the robot (5) stops at a position in which the robot (5) interrupts the security gate (31) from closing when the robot (5) detects the person (6) around the security gate (31), for example. This

allows for reducing the chances that the security gate (31) remains open. In this manner, the configuration described above allows for mitigating a reduction in security caused by careless opening of the security gate (31).

[0153] In a security system (1) according to a second aspect, which may be implemented in conjunction with the first aspect, the control unit (14) is configured to obtain a location of the person (6) based on the detection result of the person (6). The control unit (14) is configured to determine, based on the location of the person (6), a movement speed of the person (6), and duration required from a time when the control unit (14) opens the security gate (31) to a time when the control unit (14) closes the security gate (31) after the robot (5) passes through the security gate (31), whether or not the person (6) is able to pass through the security gate (31) within a period from the time when the control unit (14) opens the security gate (31) in response to the door open request signal received from the robot (5) to the time when the control unit (14) closes the security gate (31). The control unit (14) is configured to open the security gate (31) when the control unit (14) determines that the person (6) be unable to pass through the security gate (31) within the period. The control unit (14) is configured to keep the security gate (31) closed when the control unit (14) determines that the person (6) be able to pass through the security gate (31) within the period.

[0154] This configuration allows for reducing the chances that the person (6) who does not have a right to pass through can pass through the security gate (31) due to the security gate (31) that is carelessly opened when the robot (5) transmits the door open request signal.

[0155] In a security system (1) according to a third aspect, which may be implemented in conjunction with the first or second aspect, the control unit (14) is configured to determine, based on the detection result of the person (6) and a single or a plurality of control parameters determined in advance, whether the condition is appropriate for opening the security gate (31) or is inappropriate for opening the security gate (31). The control unit (14) is configured to accept a change in the single or the plurality of control parameters.

[0156] According to this configuration, changing the single or the plurality of control parameters allows for changing a condition under which the control unit (14) opens the security gate (31).

[0157] In a security system (1) according to a fourth aspect, which may be implemented in conjunction with the third aspect, the control unit (14) is configured to obtain a location of the person (6) based on the detection result of the person (6). The control unit (14) is configured to determine that the condition be appropriate for opening the security gate (31) when the location of the person (6) is at a distance equal to or greater than a predetermined distance measured from the security gate (31). The control unit (14) is configured to determine that the condition be

inappropriate for opening the security gate (31) when the location of the person (6) is at a distance less than the predetermined distance measured from the security gate (31). The single or the plurality of control parameters include the predetermined distance or a control parameter for setting the predetermined distance.

[0158] This configuration allows for changing the predetermined distance. For example, this configuration may increase the chances that the security gate (31) opens by making the predetermined distance short in a situation in which the security gate (31) is unlikely to open in response to the door open request signal received from the robot (5) because there are many persons (6) around the security gate (31). Thus, this configuration allows for control the security gate (31) flexibly depending on, for example, the surroundings of the security gate (31).

[0159] In a security system (1) according to a fifth aspect, which may be implemented in conjunction with the fourth aspect, the control unit (14) includes a plurality of operation modes including a first control mode and a second control mode. The control unit (14) sets the predetermined distance at a distance greater than 0 in the first control mode. The control unit (14) sets the predetermined distance at 0 in the second control mode.

[0160] According to this configuration, the robot (5) may be more likely to pass through the security gate (31) when the operation mode of the control unit (14) is the second control mode.

[0161] In a security system (1) according to a sixth aspect, which may be implemented in conjunction with the fourth or fifth aspect, the security gate (31) serves as a partition between a first area (7A) and a second area (7B). The control unit (14) is configured to determine that the condition be appropriate for opening the security gate (31) when the location of the person (6), present in the first area (7A), is at a distance equal to or greater than a first distance measured from the security gate (31) and when the location of the person (6), present in the second area (7B), is at a distance equal to or greater than a second distance measured from the security gate (31). The control unit (14) is configured to determine that the condition be inappropriate for opening the security gate (31) when the location of the person (6), present in the first area (7A), is at a distance less than the first distance measured from the security gate (31). The control unit (14) is configured to determine that the condition be inappropriate for opening the security gate (31) when the location of the person (6), present in the second area (7B), is at a distance less than the second distance measured from the security gate (31). The length of the second distance is different from the length of the first distance.

[0162] According to this configuration, the control unit (14) may perform control according to the difference in the security levels between the first area (7A) and the second area (7B).

[0163] In a security system (1) according to a seventh aspect, which may be implemented in

conjunction with any one of the third to sixth aspects, the security gate (31) serves as a partition between a first area (7A) and a second area (7B). The control unit (14) is configured to change at least one control parameter belonging to the single or the plurality of control parameters depending on a situation in which the robot (5) is present in the first area (7A) or a situation in which the robot (5) is present in the second area (7B).

[0164] According to this configuration, the control unit (14) may perform control according to the difference in the security levels between the first area (7A) and the second area (7B).

[0165] In a security system (1) according to an eighth aspect, which may be implemented in conjunction with any one of the first to seventh aspects, the control unit (14) is configured to output a retreat command to make the robot (5) move away from the security gate (31) upon the first communication unit (11) receiving the door open request signal from the robot (5) when the condition is inappropriate for opening the security gate (31).

[0166] This configuration allows for reducing the chances that the robot (5) is in the way of the person (6) while waiting for the security gate (31) to be opened by the control unit (14) in response to the door open request signal.

[0167] Note that the configurations according to the aspects except for the first aspect are not essential configuration for the security system (1) but may be omitted as appropriate.

[0168] A control method according to a ninth aspect is a control method for a security gate (31). The control method includes a first communication step, a second communication step, and a control step. The first communication step includes receiving a door open request signal from a robot (5). The second communication step includes receiving, from a human detection device (2) for detecting a person (6), a signal representing a detection result of the person (6). The control step includes controlling the security gate (31). The control step includes determining, based on the detection result of the person (6), whether a condition is appropriate for opening the security gate (31) or is inappropriate for opening the security gate (31). The control step includes opening the security gate (31) upon the door open request signal being received from the robot (5) when the condition is appropriate for opening the security gate (31). The control step includes keeping the security gate (31) closed upon the door open request signal being received from the robot (5) when the condition is inappropriate for opening the security gate (31).

[0169] This configuration allows for mitigating a reduction in security caused by careless opening of the security gate (31).

[0170] A program according to a tenth aspect is a program readable for a computer system. The program is designed to cause one or more processors of the computer system to perform the control method according to the ninth aspect.

[0171] This configuration allows for mitigating a reduction in security caused by careless opening of the security gate (31).

[0172] Note that these are not the only aspects of the present disclosure but various configurations (including variations) of the security system (1) according to the exemplary embodiment described above may also be implemented as a control method, a (computer) program, or a non-transitory storage medium on which the program is stored.

Reference Signs List

[0173]	1	Security System
	2	Human Detection Device
	5	Robot
	6	Person
	7A	First Area
	7B	Second Area
	11	First Communication Unit
	12	Second Communication Unit
	14	Control Unit
	31	Security Gate

CLAIMS

[Claim 1] A security system comprising:

- a first communication unit configured to receive a door open request signal from a robot;
- a second communication unit configured to receive, from a human detection device for detecting a person, a signal representing a detection result of the person; and
- a control unit configured to control a security gate,
the control unit being configured to:
 - determine, based on the detection result of the person, whether a condition is appropriate for opening the security gate or is inappropriate for opening the security gate;
 - open the security gate upon the first communication unit receiving the door open request signal from the robot when the condition is appropriate for opening the security gate; and
 - keep the security gate closed upon the first communication unit receiving the door open request signal from the robot when the condition is inappropriate for opening the security gate.

[Claim 2] The security system of claim 1, wherein

- the control unit is configured to:
 - obtain a location of the person based on the detection result of the person;
 - determine, based on the location of the person, a movement speed of the person, and duration required from a time when the control unit opens the security gate to a time when the control unit closes the security gate after the robot passes through the security gate, whether or not the person is able to pass through the security gate within a period from the time when the control unit opens the security gate in response to the door open request signal received from the robot to the time when the control unit closes the security gate;
 - open the security gate when the control unit determines that the person be unable to pass through the security gate within the period; and
 - keep the security gate closed when the control unit determines that the person be able to pass through the security gate within the period.

[Claim 3] The security system of claim 1 or 2, wherein

- the control unit is configured to:
 - determine, based on the detection result of the person and a single or a plurality of control

parameters determined in advance, whether the condition is appropriate for opening the security gate or is inappropriate for opening the security gate; and

accept a change in the single or the plurality of control parameters.

[Claim 4] The security system of claim 3, wherein

the control unit is configured to:

obtain a location of the person based on the detection result of the person;

determine that the condition be appropriate for opening the security gate when the location of the person is at a distance equal to or greater than a predetermined distance measured from the security gate; and

determine that the condition be inappropriate for opening the security gate when the location of the person is at a distance less than the predetermined distance measured from the security gate, and

the single or the plurality of control parameters include the predetermined distance or a control parameter for setting the predetermined distance.

[Claim 5] The security system of claim 4, wherein

the control unit includes a plurality of operation modes including a first control mode and a second control mode,

the control unit sets the predetermined distance at a distance greater than 0 in the first control mode, and

the control unit sets the predetermined distance at 0 in the second control mode.

[Claim 6] The security system of claim 4 or 5, wherein

the security gate serves as a partition between a first area and a second area,

the control unit is configured to:

determine that the condition be appropriate for opening the security gate when the location of the person, present in the first area, is at a distance equal to or greater than a first distance measured from the security gate and when the location of the person, present in the second area, is at a distance equal to or greater than a second distance measured from the security gate;

determine that the condition be inappropriate for opening the security gate when the location of the person, present in the first area, is at a distance less than the first distance measured from the security gate; and

determine that the condition be inappropriate for opening the security gate when the

location of the person, present in the second area, is at a distance less than the second distance measured from the security gate, and

a length of the second distance is different from a length of the first distance.

[Claim 7] The security system of any one of claims 3 to 6, wherein

the security gate serves as a partition between a first area and a second area, and

a control unit is configured to change at least one control parameter belonging to the single or the plurality of control parameters depending on a situation in which the robot is present in the first area or a situation in which the robot is present in the second area.

[Claim 8] The security system of any one of claims 1 to 7, wherein

the control unit is configured to output a retreat command to make the robot move away from the security gate upon the first communication unit receiving the door open request signal from the robot when the condition is inappropriate for opening the security gate.

[Claim 9] A control method for a security gate, the control method comprising:

a first communication step including receiving a door open request signal from a robot;

a second communication step including receiving, from a human detection device for detecting a person, a signal representing a detection result of the person; and

a control step including controlling a security gate,

the control step including:

determining, based on the detection result of the person, whether a condition is appropriate for opening the security gate or is inappropriate for opening the security gate;

opening the security gate upon the door open request signal being transmitted from the robot when the condition is appropriate for opening the security gate; and

keeping the security gate closed upon the door open request signal being transmitted from the robot when the condition is inappropriate for opening the security gate.

[Claim 10] A program readable for a computer system, the program being designed to cause one or more processors of the computer system to perform the control method of claim 9.