

MOVEMENT MANAGEMENT SYSTEM, MOVEMENT MANAGEMENT METHOD, AND PROGRAM

Technical Field

[0001] The present disclosure generally relates to a movement management system, a movement management method, and a program. More particularly, the present disclosure relates to a movement management system, a movement management method, and a program, all of which are used to control an autonomous mobile robot.

Background Art

[0002] Patent Literature 1 discloses a robot including a moving mechanism, a shooting unit, a marker recognition unit, and a movement control unit. The shooting unit captures an image of the surrounding space. The marker recognition unit recognizes a predetermined marker included in the captured image generated by the shooting unit. The movement control unit controls the movement by the moving mechanism based on the marker thus recognized.

[0003] As can be seen, the robot of Patent Literature 1 is configured to control its own movement by recognizing the captured image. However, if the robot of Patent Literature 1 has insufficient ability to recognize the captured image, then the robot would be unable to control its own movement accurately. For example, such a robot could not recognize the presence of a transparent obstacle made of glass, for example. In that case, it could be impossible to restrict the robot's movement to an area where such an obstacle is present.

Citation List

Patent Literature

[0004] Patent Literature 1: WO 2019/240208 A1

Summary of Invention

[0005] An object of the present disclosure is to provide a movement management system, a movement management method, and a program, all of which contribute to restricting the operation of a robot more accurately.

[0006] A movement management system according to an aspect of the present disclosure

includes a positioner, a generator, and a notification processor. The positioner determines the location of a robot based on a beacon signal received at a scanner installed in a facility. The beacon signal is transmitted from a robot beacon built in the robot moving autonomously. The generator generates movement guidance information. The notification processor transmits the movement guidance information to the robot. The movement guidance information includes: location information about the location of the robot that has been determined by the positioner; and restriction information about a range of a restricted area where an operation of the robot is restricted in the facility.

[0007] A movement management method according to another aspect of the present disclosure includes a positioning step, a generation step, and a notification step. The positioning step includes determining the location of a robot based on a beacon signal received at a scanner installed in a facility. The beacon signal is transmitted from a robot beacon built in the robot moving autonomously. The generation step includes generating movement guidance information. The notification step includes transmitting the movement guidance information to the robot. The movement guidance information includes: location information about the location of the robot that has been determined in the positioning step; and restriction information about a range of a restricted area where an operation of the robot is restricted in the facility.

[0008] A program according to still another aspect of the present disclosure is designed to cause one or more processors of a computer system to perform the movement management method described above.

Brief Description of Drawings

[0009] FIG. 1 is a block diagram illustrating a movement management system according to an exemplary embodiment and devices for use along with the movement management system;

FIG. 2 is a plan view of a facility where the movement management system is used; and

FIG. 3 is a sequence chart showing an exemplary operation of the movement management system.

Description of Embodiments

[0010] A movement management system, movement management method, and program according to an exemplary embodiment will now be described with reference to the accompanying drawings. Note that the 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. 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.

[0011] (Embodiment)

(Overview)

A movement management system 1 (refer to FIG. 1) according to this embodiment controls the movement of a robot 2 in a facility F1 (refer to FIG. 2). The movement management system 1 is ready to communicate with the robot 2. The movement management system 1 controls the movement of the robot 2 by communicating with the robot 2. As used herein, the phrase “ready to communicate” refers to the ability to transmit and receive signals either directly or indirectly via, for example, a network or a relay by any appropriate wired or wireless communication method.

[0012] Examples of the “facility” as used herein include dwelling houses, stores, office buildings, factories, warehouses, shopping malls, libraries, art museums, museums, amusement facilities, theme parks, public parks, airports, railway stations, ballparks, hotels, and hospitals. Alternatively, the “facility” may also be a moving vehicle such as a watercraft or a railway train. Furthermore, the “facility” may be an indoor facility or an outdoor facility, whichever is appropriate.

[0013] As shown in FIG. 1, the movement management system 1 according to this embodiment includes a positioner 131, a generator 132, and a notification processor 133. The positioner 131 determines the location of the robot 2 based on a beacon signal B2 received at a scanner 3 installed in the facility F1. The beacon signal B2 is transmitted from a robot beacon 23 built in the robot 2 moving autonomously. The generator 132 generates movement guidance information. The notification processor 133 transmits the movement guidance information to the robot 2. The movement guidance information includes: location information about the location of the robot 2 that has been determined by the positioner 131; and restriction information about the range of a restricted area R1 (refer to FIG. 2) where the operation of the robot 2 is restricted in the facility F1.

[0014] This embodiment enables locating the restricted area R1 with more reliability than in a situation where the robot 2 locates the restricted area R1 based on only the output of a sensor 24 built in the robot 2 itself. This enables restricting the operation of the robot 2 more accurately.

[0015] A movement management method according to this embodiment includes a positioning

step, a generation step, and a notification step. The positioning step includes determining the location of a robot 2 based on a beacon signal B2 received at a scanner 3 installed in a facility F1. The beacon signal B2 is transmitted from a robot beacon 23 built in the robot 2 moving autonomously. The generation step includes generating movement guidance information. The notification step includes transmitting the movement guidance information to the robot 2. The movement guidance information includes: location information about the location of the robot 2 that has been determined in the positioning step; and restriction information about the range of a restricted area R1 where an operation of the robot 2 is restricted in the facility F1.

[0016] Optionally, the movement management method may also be implemented as a program. A program according to this embodiment is designed to cause one or more processors of a computer system to perform the movement management method described above. The program may be stored in a non-transitory storage medium readable for the computer system.

[0017] (Details)

(1) Overall configuration

Next, a movement management system 1 according to this embodiment and various devices for use along with the movement management system 1 will be described in further detail.

[0018] As shown in FIG. 1, the movement management system 1 may be used along with, for example, one or more (e.g., two in FIG. 1) robots 2, one or more (e.g., three in FIG. 1) scanners 3, one or more (e.g., two in FIG. 1) facility beacons 4, a hub 5, a relay 6, and a mobile communications device 7.

[0019] The hub 5 relays communications between the movement management system 1 and the plurality of scanners 3. An output signal of the movement management system 1 is branched by the hub 5 and transmitted to the plurality of scanners 3.

[0020] Also, the hub 5 is a power over Ethernet (PoE) hub and is electrically connected to the plurality of scanners 3 via a local area network (LAN) cable. The hub 5 supplies power to the plurality of scanners 3.

[0021] The relay 6 relays communications between the movement management system 1 and the plurality of robots 2. In addition, the relay 6 also relays communications between the movement management system 1 and the plurality of facility beacons 4. The relay 6 may be implemented as, for example, a Wi-Fi (R) router. The relay 6 communicates with the plurality of robots 2 and the plurality of facility beacons 4 via wireless communication using radio waves, for example.

[0022] Furthermore, each of the plurality of robots 2 includes a robot beacon 23 which transmits a beacon signal B2. Each of the plurality of facility beacons 4 transmits a beacon signal B4. These beacon signals B2, B4 are radio wave signals. Each of the plurality of scanners 3 receives

the beacon signal B2, B4 and measures the received signal strength indicator (RSSI) of the beacon signal B2, B4 thus received.

[0023] (2) Movement management system

The movement management system 1 includes a communications unit 11, a storage unit 12, and a processing unit 13.

[0024] The communications unit 11 includes a communications interface device. The communications unit 11 is ready to communicate with the plurality of robots 2, the plurality of scanners 3, and the plurality of facility beacons 4 via the communications interface device. The communications unit 11 acquires, from the plurality of scanners 3, information about the RSSI of the beacon signals B2, B4 and identification information of the sources of the beacon signals B2, B4.

[0025] The storage unit 12 is a storage device implemented as, for example, a hard disk drive (HDD) or a solid-state drive (SSD). The storage unit 12 stores, for example, map information of the facility F1 and information about the locations of the plurality of scanners 3.

[0026] The processing unit 13 includes a computer system including one or more processors and a memory. At least some functions of the processing unit 13 are performed by making the processor of the computer system execute a program stored in the memory of the computer system. 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 such as a memory card.

[0027] The processing unit 13 includes the positioner 131, the generator 132, and the notification processor 133. Note that the positioner 131, the generator 132, and the notification processor 133 only represent respective functions to be performed by the processing unit 13 and do not necessarily have a substantive configuration.

[0028] The positioner 131 determines the location of the source of the beacon signal B2, B4 based on information about the RSSI of the beacon signal B2, B4. For example, if the positioner 131 determines the location of a robot 2 as the source of the beacon signal B2, then the plurality of scanners 3 measure the RSSI of the beacon signal B2 received. In addition, the beacon signal B2 includes the identification information of the robot 2 as the source. Each of the plurality of scanners 3 transmits a first signal including information about the RSSI of the beacon signal B2, the identification information of the source, and the identification information of its own (i.e., the scanner 3 itself) to the movement management system 1. The communications unit 11 of the movement management system 1 receives the first signal. The positioner 131 determines, based on the RSSI measured by three or more scanners 3 belonging to the plurality of scanners 3, the

distances between the robot 2 as the source and the three or more scanners 3. The positioner 131 further determines the location of the robot 2 by three-point positioning technique using these distances.

[0029] If the positioner 131 determines the location of a facility beacon 4 as the source of the beacon signal B4, then the plurality of scanners 3 measure the RSSI of the beacon signal B4 received. In addition, the beacon signal B4 includes the identification information of the facility beacon 4 as the source. Each of the plurality of scanners 3 transmits a second signal including information about the RSSI of the beacon signal B4, the identification information of the source, and the identification information of its own (i.e., the scanner 3 itself) to the movement management system 1. The communications unit 11 of the movement management system 1 receives the second signal. The positioner 131 determines, based on the RSSI measured by three or more scanners 3 belonging to the plurality of scanners 3, the distances between the facility beacon 4 as the source and the three or more scanners 3. The positioner 131 further determines the location of the facility beacon 4 by the three-point positioning technique using these distances.

[0030] The generator 132 generates movement guidance information. The notification processor 133 transmits the movement guidance information to the robot 2. More specifically, the notification processor 133 controls the communications unit 11 to make the communications unit 11 transmit the movement guidance information.

[0031] (3) Movement guidance information

As described above, the movement guidance information includes the location information acquired by the positioner 131 about the location of the robot 2 and restriction information about the range of a restricted area R1 (refer to FIG. 2) where the operation of the robot 2 is restricted in the facility F1. On receiving the movement guidance information, the robot 2 updates the information about the restricted area R1. The robot 2 moves autonomously while imposing specified restriction on its own operation in the restricted area R1.

[0032] In this embodiment, the restriction on the operation of the robot 2 in the restricted area R1 includes allowing no access to the restricted area R1 to the robot 2. In other words, the robot 2 moves autonomously while avoiding access to the restricted area R1. The robot 2 may store the map information of the facility F1 in advance, for example. On acquiring the movement guidance information, the robot 2 extracts restriction information included in the movement guidance information. Thereafter, the robot 2 associates information about the range of the restricted area R1 (i.e., the restriction information) with the map information. In this manner, the information about the restricted area R1 which is stored in the robot 2 is updated.

[0033] Note that the restriction on the operation of the robot 2 in the restricted area R1 is not

limited to allowing no access to the restricted area R1 to the robot 2. For example, the restriction on the operation may include instructing the robot 2 to slow down while passing through the restricted area R1. Alternatively, the restriction on the operation may include instructing the robot 2 to stop moving temporarily before entering the restricted area R1, for example. Still alternatively, the restriction on the operation may include instructing the robot 2 to issue an alert by emitting a sound, for example, before entering the restricted area R1. Yet alternatively, the restriction on the operation may include instructing, if the robot 2 has entered the restricted area R1, the robot 2 to leave the restricted area R1.

[0034] The restricted area R1 may include a predetermined area.

[0035] The restricted area R1 may include an area which has been determined in accordance with an operating command entered by the user. For example, the mobile communications device 7 communicating with the movement management system 1 may include a user interface 72. In that case, the restricted area R1 may be determined in accordance with an operating command entered by the user via the user interface 72, and information about the restricted area R1 thus determined may be transmitted to the movement management system 1. Alternatively, the movement management system 1 may include the user interface 72.

[0036] The positioner 131 may determine the location of a facility beacon 4. The generator 132 may regard an area corresponding to the location of the facility beacon 4 which has been determined by the positioner 131 as a part of the restricted area R1. The area corresponding to the location of the facility beacon 4 may include, for example, the location of the facility beacon 4 and its surrounding locations.

[0037] As can be seen, the positioner 131 determines the location of a facility beacon 4, which is attached to a target 8 (refer to FIG. 2) present in the facility F1, based on the beacon signal B4 transmitted from the facility beacon 4 and received at the scanner 3. The target 8 may be either one of objects 81–83 installed in the facility F1 or a person 84 present in the facility F1. The generator 132 may regard an area corresponding to the location of the facility beacon 4 which has been determined by the positioner 131 as a part of the restricted area R1.

[0038] The object as the target 8 may be, for example, an obstacle to the movement of the robot 2. More specifically, the object as the target 8 may be a piece of fixtures such as a shelf, a desk, or a table. The object as the target 8 may be, for example, an object having no self-propelled capability. The target 8 may be an object which is movable when carried by either a person or a carrier (such as the robot 2 or a forklift).

[0039] Alternatively, the object as the target 8 may also be, for example, a “No Access” sign. Examples of such signs include road cones and signboards. The sign may be either a sign

indicating that no access is allowed for humans or a sign indicating that no access is allowed for robots 2, whichever is appropriate.

[0040] If the target 8 is an object, then the phrase “attaching the facility beacon 4 to the target 8” may mean, for example, mounting the facility beacon 4 to the target 8. Also, the facility beacon 4 does not have to be fixed to the target 8 but may be, for example, just put on the target 8. In addition, the facility beacon 4 does not have to be in contact with the target 8. Alternatively, the facility beacon 4 may be, for example, mounted on the ceiling of the place where the target 8 is installed or put on the floor around the target 8.

[0041] Still alternatively, the target 8 may also be the ceiling, floor, wall, or any other component of the facility F1. That is to say, the facility beacon 4 may be installed on either the floor of the place, to which no access is allowed to the robot 2, or on the ceiling, wall, or any other building component surrounding the place.

[0042] If the target 8 is a person, then the phrase “attaching the facility beacon 4 to the target 8” means, for example, that the person carries the facility beacon 4 with him or her.

[0043] The relationship between the location of the facility beacon 4 and the range of the restricted area R1 (hereinafter referred to as a “location-range relationship”) may be determined by, for example, an operating command entered by the user via the user interface 72. Optionally, the location-range relationship may be determined on an individual basis with respect to each facility beacon 4. For example, as for a facility beacon 4 attached to an object 81 (refer to FIG. 2), a relatively small area surrounding the facility beacon 4 may be defined as the restricted area R1. On the other hand, as for a facility beacon 4 attached to another object 82 (refer to FIG. 2), a relatively large area surrounding the facility beacon 4 may be defined as the restricted area R1.

[0044] Optionally, the restricted areas R1 may have different shapes for one target 8 and another target 8, for example. For instance, in the example illustrated in FIG. 2, as for the facility beacon 4 attached to the object 83, an area covering the facility beacon 4 which is elongate in one direction is defined as the restricted area R1. On the other hand, as for the facility beacon 4 attached to a person 84, a circular area centered around the facility beacon 4 is defined as the restricted area R1.

[0045] Optionally, the dimensions (including the width, length, and height) of the restricted area R1, the shape of the restricted area R1, and other parameters thereof may be determined in accordance with a command entered by the user via the user interface 72.

[0046] As described above, the beacon signal B4 transmitted from a facility beacon 4 includes identification information of the facility beacon 4. The movement management system 1 acquires this identification information via the scanner 3. Then, the generator 132 may acquire the attribute information of the target 8 based on this identification information and determine, in

accordance with this attribute information, the restriction on the operation of the robot 2 in the restricted area R1. Specifically, the storage unit 12 of the movement management system 1 stores in advance the correspondence between the identification information of the facility beacon 4 and the attribute information of the target 8. The generator 132 reads out, on acquiring the identification information, corresponding attribute information from the storage unit 12.

[0047] The attribute information may include, for example, information indicating whether the target 8 is a person or an object. Also, determining the restriction on the operation according to the attribute information includes changing the location-range relationship according to the attribute information, for example. That is to say, the location-range relationship may be changed depending on whether the target 8 is a person or an object. For example, if the target 8 is a person, a range located within a first distance from the person may be defined as the restricted area R1. On the other hand, if the target 8 is an object, a range located within a second distance from the object may be defined as the restricted area R1. The first distance may be longer than the second distance. In another example, the robot 2 may slow down or stop moving when approaching a person but does not have to slow down or stop moving when approaching an object.

[0048] Furthermore, if the target 8 is a person, then the attribute information may include information about his or her age, for example. On the other hand, if the target 8 is an object, then the attribute information may include information about at least one of the type or dimensions of the object, for example.

[0049] Optionally, the movement guidance information may include information about the restriction on a time slot basis on the operation of the robot 2 in the restricted area R1. That is to say, the restriction on the operation of the robot 2 in the restricted area R1 may vary from one time slot to another. For example, in one restricted area R1, no access may be allowed before noon, but access may be allowed in the afternoon. In other words, no access to one restricted area R1 may be allowed before noon, but the restricted area R1 may be eliminated in the afternoon. In another example, no access to one restricted area R1 may be allowed before noon and access to the restricted area R1 may be allowed in the afternoon only on the condition that the robot 2 slows down while passing through the area R1.

[0050] For example, the storage unit 12 of the movement management system 1 may store information about the restriction on the time slot basis. The generator 132 may generate, by reference to this information, movement guidance information that varies from one time slot to another.

[0051] Optionally, the movement guidance information may include information about restriction on a purpose of operation basis on the operation of the robot 2 in the restricted area R1.

That is to say, the restriction on the operation of the robot 2 in the restricted area R1 may vary from one purpose of operation of the robot 2 to another. In one example, access to one restricted area R1 may be allowed only for the purpose of inspecting the facility F1 but no access to the restricted area R1 may be allowed for any other purposes. In another example, access to one restricted area R1 may be allowed for the purpose of inspecting the facility F1 but access to the restricted area R1 for other purposes is allowed only on the condition that the robot 2 slows down.

[0052] For example, the storage unit 12 of the movement management system 1 may store information about the restriction on a purpose of operation basis in association with the identification information of each robot 2. The generator 132 may generate, by reference to this information, movement guidance information that varies from one purpose of operation of each robot 2 to another. Optionally, information about the purpose of operation may be transmitted from the robot 2 to the movement management system 1. Alternatively, the purpose of operation of each robot 2 may be determined in accordance with an operating command entered by the user via the user interface 72.

[0053] (4) Robot

Next, a configuration for the robot 2 will be described with reference to FIG. 1.

[0054] The robot 2 includes a communications unit 21, a storage unit 22, a robot beacon 23, a sensor 24, a processing unit 25, and a moving mechanism 26.

[0055] The communications unit 21 includes a communications interface device. The communications unit 21 may communicate with the movement management system 1 via the communications interface device.

[0056] The storage unit 22 is a storage device implemented as, for example, a hard disk drive (HDD) or a solid-state drive (SSD). The storage unit 22 stores, for example, identification information of its own device (i.e., the robot 2 itself) and map information of the facility F1.

[0057] The robot beacon 23 transmits the beacon signal B2.

[0058] The sensor 24 acquires information about the movement of the robot 2. The information about the movement of the robot 2 includes, for example, information about detection of an obstacle. The sensor 24 includes a camera, for example. The camera captures an image of the surroundings of the robot 2.

[0059] The processing unit 25 includes a computer system including one or more processors and a memory. The processing unit 25 performs overall control on the robot 2. For example, the processing unit 25 determines a migration route by reference to the movement guidance information provided by the movement management system 1. In addition, the processing unit 25 controls the operation of the moving mechanism 26 to cause the robot 2 to travel along the

migration route.

[0060] In addition, the processing unit 25 analyzes the image captured by the camera of the sensor 24, thereby detecting an obstacle. The processing unit 25 instructs the robot 2 to move in such a manner as to avoid contact with the obstacle detected by the processing unit 25 and avoid access to the restricted area R1 specified by the movement management system 1.

[0061] The moving mechanism 26 is a driving unit for driving the robot 2. The moving mechanism 26 includes, for example, a wheel and a motor. The robot 2 is caused to move by making the motor turn the wheel.

[0062] (5) Scanners

The plurality of scanners 3 may be installed, for example, on the ceiling of the facility F1. Each of the scanners 3 receives the beacon signal B2 transmitted from any of the robots 2 and the beacon signal B4 transmitted from any of the facility beacons 4 and measures the RSSI of the beacon signals B2, B4. In addition, each scanner 3 transmits the RSSI thus measured, the identification information of the source included in the beacon signals B2, B4, and the identification information of its own (i.e., the scanner 3 itself) to the movement management system 1.

[0063] (6) Facility beacons

In the facility F1, a plurality of facility beacons 4 are used. For example, in FIG. 2, one facility beacon 4 is attached to an object 81, another facility beacon 4 is attached to an object 82, and still another facility beacon 4 is attached to an object 83. Yet another facility beacon 4 is carried by the person 84 with him or her.

[0064] Each of the plurality of facility beacons 4 transmits the beacon signal B4.

[0065] The facility beacon 4 may be, for example, a dedicated terminal having only the capability of transmitting the beacon signal B4, or a cellphone such as a smartphone or a wearable terminal, whichever is appropriate.

[0066] (7) Mobile communications device

As shown in FIG. 1, the mobile communications device 7 includes a communications unit 71 and the user interface 72.

[0067] The communications unit 71 includes a communications interface device. The communications unit 71 may communicate with the movement management system 1 via the communications interface device.

[0068] The user interface 72 accepts an operating command entered by the user. The user interface 72 may include, for example, at least one member selected from the group consisting of a button, a mouse, a touchpad, a touchscreen panel, and a touchscreen panel display.

[0069] In accordance with the operating command entered by the user via the user interface 72, the restricted area R1 is determined and information about the restricted area R1 thus determined is transmitted by the communications unit 71 to the movement management system 1.

[0070] (8) Exemplary operation

(8.1) Basic example

Next, an exemplary operation of the robot 2 under the control of the movement management system 1 will be described with reference to FIGS. 2 and 3. In the following description, no access to the restricted area R1 is supposed to be allowed to the robot 2. Also, in the following description, the robot 2 is supposed to move to its destination G1.

[0071] The robot 2 transmits a beacon signal B2 (in Step ST1). A plurality of facility beacons 4 (only one of which is shown in FIG. 3) transmit beacon signals B4 (in Step ST2). For example, the robot 2 and the plurality of facility beacons 4 may transmit the beacon signals B2, B4 at predetermined time intervals.

[0072] A plurality of scanners 3 (only one of which is shown in FIG. 3) receive the beacon signals B2, B4 to measure their received signal strength indicators (RSSI) (in Step ST3). Furthermore, the scanners 3 each transmit signals (i.e., a first signal and a second signal) including the RSSI, the identification information of the source included in the beacon signals B2, B4, and the identification information of its own (i.e., the scanner 3 itself) to the movement management system 1 (in Step ST4). In accordance with the first signal and the second signal, the positioner 131 of the movement management system 1 determines the respective locations of the robot 2 and the plurality of facility beacons 4 (in Step ST5).

[0073] The generator 132 determines the restricted area R1 based on the respective locations of the plurality of facility beacons 4 that have been determined by the positioner 131 (in Step ST6). More specifically, the generator 132 regards locations corresponding to the respective locations of facility beacons 4 as parts of the restricted area R1. The restricted area R1 may further include, for example, a predetermined area and an area that has been determined in accordance with an operating command entered by the user via the user interface 72.

[0074] The notification processor 133 transmits the movement guidance information to the robot 2 (in Step ST7). The movement guidance information includes location information about the location of the robot 2 that has been determined by the positioner 131. The movement guidance information further includes restriction information about the range of the restricted area R1.

[0075] The robot 2 receives the movement guidance information. The processing unit 25 of the robot 2 determines the migration route in accordance with the movement guidance information (in Step ST8). The robot 2 travels along the migration route (in Step ST9).

[0076] FIG. 2 shows an exemplary migration route 100 determined by the processing unit 25. More specifically, the processing unit 25 creates such a migration route that leads to the destination G1 while bypassing the restricted area R1.

[0077] Even if the target 8 is present on a passageway, it does not necessarily mean that the robot 2 is not allowed to pass through the passageway. It may be determined based on the dimensions of the restricted area R1 corresponding to the target 8 and other factors whether the robot 2 is allowed to pass through the passageway or not. In FIG. 2, a passageway which is wide enough for the robot 2 to pass through is ensured beside the restricted area R1 corresponding to the object 81 (as the target 8), and therefore, the robot 2 creates a migration route which passes beside the object 81.

[0078] In this embodiment, the map information of the facility F1 is stored in advance in the storage unit 22 of the robot 2. Alternatively, the map information may be transmitted from the movement management system 1 to the robot 2.

[0079] The map information includes three-dimensional model data such as the building information modeling (BIM) data about the facility F1. Thus, the map information includes information about the regions through which the robot 2 cannot pass (such as the walls, columns, and steps of the facility F1). The robot 2 creates a migration route to avoid not only the restricted area R1 but also those regions through which the robot 2 cannot pass as well. That is to say, the robot 2 creates the migration route by reference to the map information of the facility F1, the location information of its own (i.e., the robot 2 itself) extracted from the movement guidance information, and the restriction information about the range of the restricted area R1.

[0080] As described above, the robot 2 and the plurality of facility beacons 4 transmit the beacon signals B2, B4 at predetermined time intervals, thus having the series of processing steps ST1–ST9 performed repeatedly. Thus, the movement management system 1 updates the restricted area R1 and the location information of the robot 2 at predetermined time intervals (e.g., every second). Meanwhile, the robot 2 updates its migration route at predetermined time intervals (e.g., every second). This allows the migration route to be updated according to the movement of the robot 2. In addition, as the targets 8 (i.e., the person 84 and the objects 81–83) to which the facility beacons 4 are attached move, the restricted areas R1 also move accordingly. This allows the robot 2 to be controlled according to the current locations of the targets 8.

[0081] Also, if the robot 2 includes the sensor 24, then the robot 2 may travel to avoid not only the restricted area R1 but also the obstacle detected by the sensor 24 as well. This embodiment allows, even if there is any obstacle that cannot be detected by the sensor 24 but the place where the obstacle is installed is included in the restricted area R1, the robot 2 to avoid the obstacle. In

addition, it is difficult for the sensor 24 to recognize a no access area where no obstacles are present but through which the robot 2 should not pass. Nevertheless, defining the no access area as a part of the restricted area R1 allows the robot 2 to avoid the no access area.

[0082] (8.2) First variation

In the example illustrated in FIG. 2, only one robot 2 is present. However, this is only an example and should not be construed as limiting. Alternatively, there may be a plurality of robots 2. Supposing an arbitrary one of the plurality of robots 2 is a first robot and another one of the plurality of robots 2, other than the first robot, is a second robot, the generator 132 may regard an area corresponding to the location of the second robot as a part of the restricted area R1 where the operation of the first robot is restricted. The area corresponding to the location of the second robot may include, for example, the location of the second robot and its surroundings.

[0083] (8.3) Second variation

If the robot 2 is operating for the purpose of cleaning the facility F1, then the robot 2 sequentially moves to one of uncleaned areas to another while avoiding access to the restricted area R1.

[0084] In this case, the facility beacon 4 is attached to an object 83 present at the entrance of a room 92 and its corresponding restricted area R1 is defined to close the entrance of the room 92 as shown in FIG. 2. This allows no access to the room 92 to the robot 2. On the other hand, no facility beacon 4 is installed at the entrance of a room 91. Thus, the robot 2 accesses the room 91 to clean the room 91. As can be seen, installing the object 83, to which the facility beacon 4 is attached, at an appropriate place enables managing the movement of the robot 2 even without making complicated settings. In addition, the management mode of the movement of the robot 2 may be changed by causing the object 83 to move along with the facility beacon 4.

[0085] (8.4) Third variation

In the basic example described above, the robot 2 determines its own migration route. Alternatively, the generator 132 of the movement management system 1 may determine the migration route for the robot 2. In that case, the notification processor 133 transmits movement guidance information, including route instruction information instructing the robot 2 on a migration route, to the robot 2. In response, the robot 2 extracts the migration route from the route instruction information and travels along the migration route.

[0086] In addition, the movement guidance information transmitted from the movement management system 1 to the robot 2 may include an instruction about the operation of the robot 2. For example, if the robot 2 has already accessed, or is going to access, the restricted area R1, then the movement management system 1 may instruct the robot 2 to change its traveling direction

using the movement guidance information.

[0087] (Other variations of embodiment)

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. Alternatively, the variations to be described below may also be adopted as appropriate in combination with any of the variations described above.

[0088] The restricted area R1 may include a first restricted area and a second restricted area. The restriction on the operation of the robot 2 in the first restricted area may be different from the restriction on the operation of the robot 2 in the second restricted area. For example, the second restricted area may be defined to surround the first restricted area, no access to the first restricted area may be allowed to the robot 2, and the robot 2 that has accessed the second restricted area may be instructed to leave the restricted area R1.

[0089] Two devices that communicate with each other via wired communication in the exemplary embodiment described above may also wirelessly communicate with each other. Conversely, two devices that communicate with each other via wireless communication in the exemplary embodiment described above may also communicate with each other via wired communication.

[0090] The positioner 131 determines the locations of the sources of the beacon signals B2, B4 based on the RSSI of the beacon signals B2, B4. In this case, the technique by which the positioner 131 determines the locations of the sources does not have to be the three-point positioning technique. For example, if the beacon signal B2 transmitted from one robot 2 is received at a particular scanner 3, then the positioner 131 may determine that the robot 2 be located within the area surrounding the particular scanner 3.

[0091] The positioner 131 may determine the locations of the sources of the beacon signals B2, B4 based on the respective phases of the beacon signals B2, B4, instead of the RSSI of the beacon signals B2, B4.

[0092] The sensor 24 does not have to be configured to shoot the obstacle using a camera. Alternatively, the sensor 24 may include, for example, an ultrasonic sensor, an infrared sensor, or a light detection and ranging (LiDAR) sensor to detect the obstacle.

[0093] In the exemplary embodiment described above, the movement management system 1 communicates with the robots 2 via a communication path different from the communication path through which the movement management system 1 communicates with the scanners 3 as shown in FIG. 1. Alternatively, the scanners 3 may relay the communications between the movement management system 1 and the robots 2.

[0094] The number of the robots 2 used and the number of the scanners 3 installed do not have to be the ones adopted in the exemplary embodiment described above but may each be one or more.

[0095] The number of the facility beacons 4 installed does not have to be the one adopted in the exemplary embodiment described above but may also be one. Also, the facility beacons 4 are not essential constituent elements.

[0096] The hub 5, the relay 6, and the mobile communications device 7 are not essential constituent elements, either.

[0097] The movement management system 1 according to the present disclosure or the agent that performs the movement management method according to the present disclosure includes a computer system. The computer system includes a processor and a memory as principal hardware components thereof. The computer system performs at least some functions of the movement management system 1 according to the present disclosure or serves as the agent that performs the movement management method 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 “very-large-scale integrated circuit (VLSI),” and an “ultra-large-scale integrated circuit (ULSI).” Optionally, a field-programmable gate array (FPGA) 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. Those 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.

[0098] Also, in the embodiment described above, the plurality of functions of the movement management system 1 are aggregated in a single device. However, this is not an essential

configuration for the movement management system 1. Alternatively, those constituent elements of the movement management system 1 may be distributed in multiple devices. Still alternatively, at least some functions of the movement management system 1 (e.g., at least some functions of the generator 132) may be implemented as a server or a cloud computing system as well.

[0099] Optionally, the movement management system 1 may further include at least one robot 2. In that case, a device including the communications unit 11, the storage unit 12, and the processing unit 13 of the movement management system 1 (hereinafter referred to as a “basic device”) is provided separately from the robot 2. That is to say, the plurality of constituent elements of the movement management system 1 are distributed in multiple devices. The robot 2 includes a sensor 24 for recognizing an obstacle.

[0100] Optionally, the movement management system 1 may further include at least one scanner 3. In that case, the basic device of the movement management system 1 is provided separately from the scanner 3.

[0101] (Recapitulation)

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

[0102] A movement management system (1) according to a first aspect includes a positioner (131), a generator (132), and a notification processor (133). The positioner (131) determines the location of a robot (2) based on a beacon signal (B2) received at a scanner (3) installed in a facility (F1). The beacon signal (B2) is transmitted from a robot beacon (23) built in the robot (2) moving autonomously. The generator (132) generates movement guidance information. The notification processor (133) transmits the movement guidance information to the robot (2). The movement guidance information includes: location information about the location of the robot (2) that has been determined by the positioner (131); and restriction information about a range of a restricted area (R1) where an operation of the robot (2) is restricted in the facility (F1).

[0103] This configuration enables locating the restricted area (R1) with more reliability than in a situation where the robot (2) locates the restricted area (R1) based on only the output of a sensor (24) built in the robot (2) itself. This enables restricting the operation of the robot (2) more accurately.

[0104] In a movement management system (1) according to a second aspect, which may be implemented in conjunction with the first aspect, the positioner (131) determines the location of a facility beacon (4) based on a beacon signal (B4) transmitted from the facility beacon (4) and received at the scanner (3). The facility beacon (4) is attached to a target (8) present in the facility (F1). The target (8) is either an object installed in the facility (F1), or a person present in the

facility (F1). The generator (132) regards an area corresponding to the location of the facility beacon (4) determined by the positioner (131) as a part of the restricted area (R1).

[0105] This configuration allows, even if the target (8) moves along with the facility beacon (4), the positioner (131) to determine the location of the target (8) and allows the generator (132) to newly set the restricted area (R1).

[0106] In a movement management system (1) according to a third aspect, which may be implemented in conjunction with the second aspect, the beacon signal (B4) transmitted from the facility beacon (4) includes identification information of the facility beacon (4). The generator (132) acquires attribute information of the target (8) based on the identification information and determines, according to the attribute information, how the operation of the robot (2) is restricted in the restricted area (R1).

[0107] This configuration allows the robot (2) to operate in accordance with the attribute information.

[0108] In a movement management system (1) according to a fourth aspect, which may be implemented in conjunction with any one of the first to third aspects, restriction on the operation of the robot (2) in the restricted area (R1) includes allowing no access to the restricted area (R1) to the robot (2).

[0109] This configuration may reduce the chances of causing an event such as collision of the robot (2) against an obstacle.

[0110] In a movement management system (1) according to a fifth aspect, which may be implemented in conjunction with any one of the first to fourth aspects, the movement guidance information includes information about restriction on a time slot basis on the operation of the robot (2) in the restricted area (R1).

[0111] This configuration allows the operation of the robot (2) to be restricted on a time slot basis.

[0112] In a movement management system (1) according to a sixth aspect, which may be implemented in conjunction with any one of the first to fifth aspects, the movement guidance information includes information about restriction on a purpose of operation basis on the operation of the robot (2) in the restricted area (R1).

[0113] This configuration allows the operation of the robot (2) to be restricted depending on the purpose of the operation of the robot (2).

[0114] In a movement management system (1) according to a seventh aspect, which may be implemented in conjunction with any one of the first to sixth aspects, the movement guidance information includes route instruction information for use to instruct the robot (2) on a migration route.

[0115] This configuration may reduce the load placed on the robot (2) in determining the migration route.

[0116] A movement management system (1) according to an eighth aspect, which may be implemented in conjunction with any one of the first to seventh aspects, further includes the robot (2). The robot (2) includes a sensor (24) for recognizing an obstacle.

[0117] This configuration allows the robot (2) to move autonomously based on the output of the sensor (24) and the movement guidance information provided by the notification processor (133).

[0118] A movement management system (1) according to a ninth aspect, which may be implemented in conjunction with any one of the first to eighth aspects, further includes the scanner (3).

[0119] Note that the constituent elements according to the second to ninth aspects are not essential constituent elements for the movement management system (1) but may be omitted as appropriate.

[0120] A movement management method according to a tenth aspect includes a positioning step, a generation step, and a notification step. The positioning step includes determining the location of a robot (2) based on a beacon signal (B2) received at a scanner (3) installed in a facility (F1). The beacon signal (B2) is transmitted from a robot beacon (23) built in the robot (2) moving autonomously. The generation step includes generating movement guidance information. The notification step includes transmitting the movement guidance information to the robot (2). The movement guidance information includes: location information about the location of the robot (2) that has been determined in the positioning step; and restriction information about a range of a restricted area (R1) where an operation of the robot (2) is restricted in the facility (F1).

[0121] This method enables restricting the operation of the robot (2) more accurately.

[0122] A program according to an eleventh aspect is designed to cause one or more processors of a computer system to perform the movement management method according to the tenth aspect.

[0123] This program enables restricting the operation of the robot (2) more accurately.

[0124] Note that these are not the only aspects of the present disclosure but various configurations (including variations) of the movement management system (1) according to the exemplary embodiment described above may also be implemented as, for example, a movement management method, a (computer) program, or a non-transitory storage medium on which the program is stored.

Reference Signs List

[0125]	1	Movement Management System
	2	Robot
	3	Scanner
	4	Facility Beacon
	8	Target
	23	Robot Beacon
	24	Sensor
	131	Positioner
	132	Generator
	133	Notification Processor
	B2, B4	Beacon Signal
	F1	Facility
	R1	Restricted Area

CLAIMS

1. A movement management system comprising:
 - a positioner configured to determine a location of a robot based on a beacon signal transmitted from a robot beacon built in the robot and received at a scanner installed in a facility, the robot being configured to move autonomously;
 - a generator configured to generate movement guidance information; and
 - a notification processor configured to transmit the movement guidance information to the robot,

the movement guidance information including: location information about the location of the robot that has been determined by the positioner; and restriction information about a range of a restricted area where an operation of the robot is restricted in the facility.
2. The movement management system of claim 1, wherein
 - the positioner is configured to determine a location of a facility beacon based on a beacon signal transmitted from the facility beacon and received at the scanner, the facility beacon being attached to a target present in the facility,
 - the target is either an object installed in the facility, or a person present in the facility, and
 - the generator is configured to regard an area corresponding to the location of the facility beacon determined by the positioner as a part of the restricted area.
3. The movement management system of claim 2, wherein
 - the beacon signal transmitted from the facility beacon includes identification information of the facility beacon, and
 - the generator is configured to acquire attribute information of the target based on the identification information and determine, according to the attribute information, how the operation of the robot is restricted in the restricted area.
4. The movement management system of any one of claims 1 to 3, wherein
 - restriction on the operation of the robot in the restricted area includes allowing no access to the restricted area to the robot.

5. The movement management system of any one of claims 1 to 3, wherein the movement guidance information includes information about restriction on a time slot basis on the operation of the robot in the restricted area.
6. The movement management system of any one of claims 1 to 3, wherein the movement guidance information includes information about restriction on a purpose of operation basis on the operation of the robot in the restricted area.
7. The movement management system of any one of claims 1 to 3, wherein the movement guidance information includes route instruction information for use to instruct the robot on a migration route.
8. The movement management system of any one of claims 1 to 3, further comprising the robot, wherein the robot includes a sensor configured to recognize an obstacle.
9. The movement management system of any one of claims 1 to 3, further comprising the scanner.
10. A movement management method comprising:
 - a positioning step including determining a location of a robot based on a beacon signal transmitted from a robot beacon built in the robot and received at a scanner installed in a facility, the robot being configured to move autonomously;
 - a generation step including generating movement guidance information; and
 - a notification step including transmitting the movement guidance information to the robot, the movement guidance information including: location information about the location of the robot that has been determined in the positioning step; and restriction information about a range of a restricted area where an operation of the robot is restricted in the facility.
11. A program designed to cause one or more processors of a computer system to perform the movement management method of claim 10.