

DESCRIPTION

Title of Invention

ENTRY/EXIT MANAGEMENT SYSTEM, ENTRY/EXIT MANAGEMENT METHOD, AND PROGRAM

Technical Field

[0001] The present disclosure generally relates to entry/exit management systems, entry/exit management methods, and programs and more specifically relates to an entry/exit management system, an entry/exit management method, and a program which control a security gate.

Background Art

[0002] Patent Literature 1 describes a control system (an entry/exit management system) that controls opening-closing of a security gate which is provided in a facility in which a plurality of mobile robots travel autonomously. When receiving a passing-through reservation signals of the plurality of mobile robots, the control system allows the plurality of mobile robots to consecutively pass through a gate of the security gate while the security gate opens the gate once.

[0003] At an installation place of the security gate, humans or robots which are about to pass through the security gate may be crowded together, which may cause traffic congestion.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2022-124531 A

Summary of Invention

[0005] It is an object of the present disclosure to provide an entry/exit management system, an

entry/exit management method, and a program which are configured to mitigate traffic congestion at an installation place of a security gate.

[0006] An entry/exit management system according to an aspect includes a management unit and a human sensing unit. The management unit is configured to control a security gate. A plurality of autonomous robots and a human are to pass through the security gate. The plurality of autonomous robots includes a first robot and a second robot. The human sensing unit is configured to determine, based on an output of a sensor configured to sense the human staying in a sensing area at an installation place of the security gate, presence or absence of the human in the sensing area. The management unit is configured to, when the entry/exit management system receives a passage request requesting passage through the security gate from the first robot, determine whether or not there is a passage conflict between the first robot and the second robot and determine, based on a determination result by the human sensing unit, whether or not there is a passage conflict between the first robot and the human. A state where there is the passage conflict between the first robot and the second robot is a state where around the same time that the first robot is about to pass through the security gate, the second robot is also about to pass through the security gate. A state where there is the passage conflict between the first robot and the human is a state where around the same time that the first robot is about to pass through the security gate, the human is also about to pass through the security gate. The management unit is configured to, when there is no passage conflict between the first robot and the second robot and there is no passage conflict between the first robot and the human, cause the security gate to permit the first robot to pass through.

[0007] An entry/exit management method according to an aspect includes a management step and a human sensing step. The management step includes controlling a security gate. A plurality of autonomous robots and a human are to pass through the security gate. The plurality of autonomous robots includes a first robot and a second robot. The human sensing step includes determining, based on an output of a sensor configured to sense the human staying in a sensing

area at an installation place of the security gate, presence or absence of the human in the sensing area. The management step includes: determining, when receiving a passage request requesting passage through the security gate from the first robot, whether or not there is a passage conflict between the first robot and the second robot; and determining, based on a determination result in the human sensing step, whether or not there is a passage conflict between the first robot and the human. A state where there is the passage conflict between the first robot and the second robot is a state where around the same time that the first robot is about to pass through the security gate, the second robot is also about to pass through the security gate. A state where there is the passage conflict between the first robot and the human is a state where around the same time that the first robot is about to pass through the security gate, the human is also about to pass through the security gate. The management step includes causing, when there is no passage conflict between the first robot and the second robot and there is no passage conflict between the first robot and the human, the security gate to permit the first robot to pass through.

[0008] A program according to an aspect of the present disclosure is a program for causing one or more processors of a computer system to execute the entry/exit management method.

Brief Description of Drawings

[0009] [FIG. 1] FIG. 1 is a block diagram of a robot system including an entry/exit management system according to a first embodiment;

[FIG. 2] FIG. 2 is a perspective view schematically illustrating a security gate used together with the entry/exit management system and a situation around the security gate;

[FIG. 3] FIG. 3 is a prediction data of a congestion degree obtained by the entry/exit management system;

[FIG. 4] FIG. 4 is a flowchart illustrating processing by the entry/exit management system;

[FIG. 5] FIG. 5 is a plan view schematically illustrating a security gate used together with

the entry/exit management system and a situation around the security gate according to a second embodiment;

[FIG. 6] FIG. 6 is a flowchart illustrating processing by the entry/exit management system; and

[FIG. 7] FIG. 7 is a flowchart illustrating processing by an entry/exit management system according to a third embodiment.

Description of Embodiments

[0010] In embodiments described below, an entry/exit management system 1, an entry/exit management method, and a program of the present disclosure will be described with reference to the drawings. Note that the embodiments described below are mere examples of various embodiments of the present disclosure. Various modifications may be made to the following embodiments depending on design and the like as long as the object of the present disclosure is achieved. Moreover, the embodiments including variations thereof described below may be implemented accordingly in combination. Moreover, figures described in the following embodiments are schematic views, and therefore, the ratio of sizes and the ratio of thicknesses of components in the drawings do not necessarily reflect actual dimensional ratios.

[0011] (First Embodiment)

(Overview)

As shown in FIG. 1, the entry/exit management system 1 communicates with a security gate 3 and a plurality of autonomous robots 5 (hereinafter referred to also as robots 5). The security gate 3 is to permit humans H1 (see FIG. 2) and the robots 5 which are successfully authenticated to pass through the security gate 3.

[0012] A direction in which a human H1 or robot 5 travels when the human H1 or robot 5 passes through the security gate 3 is referred to as a front/rear direction. The human H1 or robot 5 travels from an area 71 (see FIG. 2) in front of the security gate 3 through the security gate 3 to an area

72 (see FIG. 2) behind the security gate 3. Moreover, the human H1 or robot 5 travels from the area 72 behind the security gate 3 through the security gate 3 to the area 71 in front of the security gate 3.

[0013] The area 71 and the area 72 are included in a sensing area 70 which is described later.

[0014] In the following description, traveling from the area 71 to the area 72 is referred to as “entry”, and traveling from the area 72 to the area 71 is referred to as “exit”. The entry/exit management system 1 manages at least one of the entry or the exit. That is, when the human H1 or robot 5 is successfully authenticated, the entry/exit management system 1 causes the security gate 3 to permit the human H1 or robot 5 thus successfully authenticated to pass through (to enter or exit). Specifically, when the human H1 or robot 5 is successfully authenticated, the entry/exit management system 1 causes a gate 31 of the security gate 3 to open. This allows the human H1 or robot 5 to pass through the security gate 3.

[0015] In the present disclosure, any one robot 5 of the plurality of robots 5 is referred to as a first robot 5A, and a robot(s) 5 other than the first robot 5A of the plurality of robots 5 is referred to as a second robot 5B. In FIGS. 1 and 2, a specific robot 5 is denoted by reference sign “5A”, but any robot 5 may be deemed to be the first robot 5A. The configuration of the first robot 5A may be the same as, or may be different from, the configuration of the second robot 5B.

[0016] When the first robot 5A (i.e., any one robot 5 of the plurality of robots 5) is about to pass through the security gate 3, the entry/exit management system 1 determines whether or not to permit the first robot 5A to pass through the security gate 3.

[0017] As shown in FIG. 1, the entry/exit management system 1 includes a management unit 111 and a human sensing unit 112. The management unit 111 controls the security gate 3. The plurality of autonomous robots 5 and a human H1 are to pass through the security gate 3. The plurality of autonomous robots 5 include the first robot 5A and the second robot 5B. The human sensing unit 112 determines, based on an output of a sensor 2 for sensing the human H1 staying in the sensing area 70 at the installation place of the security gate 3, the presence or absence of the

human H1 in the sensing area 70. When the entry/exit management system 1 receives a passage request requesting passage through the security gate 3 from the first robot 5A, the management unit 111 determines whether or not there is a passage conflict between the first robot 5A and the second robot 5B, and based on a determination result by the human sensing unit 112, the management unit 111 determines whether or not there is a passage conflict between the first robot 5A and the human H1. A state where there is the passage conflict between the first robot 5A and the second robot 5B refers to a state where around the same time that the first robot 5A is about to pass through the security gate 3, the second robot 5B is also about to pass through the security gate 3. A state where there is the passage conflict between the first robot 5A and the human H1 refers to a state where around the same time that the first robot 5A is about to pass through the security gate 3, the human H1 is also about to pass through the security gate 3. When there is no passage conflict between the first robot 5A and the second robot 5B, and there is no passage conflict between the first robot 5A and the human H1, the management unit 111 causes the security gate 3 to permit the first robot 5A to pass through.

[0018] With this configuration, when there is no passage conflict, passage of the first robot 5A is permitted, and therefore, it is possible to reduce the possibility that the first robot 5A obstructs passage of the human H1 or the second robot 5B. Thus, the traffic congestion at the installation place of the security gate 3 can be mitigated. In particular, it is possible to reduce the possibility that the first robot 5A obstructs the passage of the human H1 when the travel speed of the first robot 5A passing through the security gate 3 is lower than the travel speed of the human H1.

[0019] Further, a similar function to the entry/exit management system 1 is implementable by the entry/exit management method. The entry/exit management method of the present embodiment includes a management step and a human sensing step. The management step includes controlling the security gate 3. The plurality of autonomous robots 5 and the human H1 are to pass through the security gate 3. The plurality of autonomous robots 5 include the first robot 5A and the second robot 5B. The human sensing step includes determining, based on an

output of a sensor 2 for sensing the human H1 staying in the sensing area 70 at the installation place of the security gate 3, the presence or absence of the human H1 in the sensing area 70. The management step includes: determining, when receiving a passage request requesting passage through the security gate 3 from the first robot 5A, whether or not there is a passage conflict between the first robot 5A and the second robot 5B, and determining, based on a determination result in the human sensing step, whether or not there is a passage conflict between the first robot 5A and the human H1. A state where there is the passage conflict between the first robot 5A and the second robot 5B refers to a state where around the same time that the first robot 5A is about to pass through the security gate 3, the second robot 5B is also about to pass through the security gate 3. A state where there is the passage conflict between the first robot 5A and the human H1 refers to a state where around the same time that the first robot 5A is about to pass through the security gate 3, the human H1 is also about to pass through the security gate 3. The management step includes, when there is no passage conflict between the first robot 5A and the second robot 5B, and there is no passage conflict between the first robot 5A and the human H1, causing the security gate 3 to permit the first robot 5A to pass through.

[0020] Furthermore, the entry/exit management method is implementable by a program. A program of the present embodiment is a program for causing one or more processors of a computer system to execute the entry/exit management method. The program may be stored in a non-transitory recording medium readable in a computer system.

[0021] (Details)

(1) Overall Structure

As shown in FIG. 1, the entry/exit management system 1 is included in a robot system X1. The robot system X1 includes the entry/exit management system 1, the sensor 2, the security gate 3, a robot control server 4, and a plurality of (in FIG. 1, three) robots 5.

[0022] The sensor 2 and the security gate 3 are installed in a facility. Examples of the facility includes multiple dwelling houses, retail establishments, office buildings, factories, warehouses,

commercial complexes, libraries, art museums, museums, play centers, theme parks, parks, airports, railroad stations, ballparks, hotels, and hospitals. Otherwise, the facility may be, for example, a moving vehicle such as a marine vessel or a rail vehicle. Moreover, the facility may be an indoor facility or an outdoor facility.

[0023] The entry/exit management system 1 and the robot control server 4 may be installed in the facility or may be installed in a place different from the facility.

[0024] The plurality of robots 5 autonomously travel in the facility to carry out tasks. The plurality of robots 5 autonomously travel, for example, along a travel route notified by the robot control server 4. Examples of the task include delivery, cleaning, a security patrol, and facility inspection.

[0025] (2) Sensor

The sensor 2 senses the human H1. The sensor 2 is, for example, a camera 20. The camera 20 captures the sensing area 70 by visible light and generates a captured image. The camera 20 transmits the captured image to the entry/exit management system 1.

[0026] The sensor 2 preferably senses the human H1 with a frequency higher than once per second.

[0027] (3) Security Gate

As shown in FIGS. 1 and 2, the security gate 3 includes two bodies 30, the gate 31, two readers 32, a driving device 33, a passage sensor 34, and a notifier 35.

[0028] Each of the two bodies 30 is in the shape of a rectangular parallelepiped. The two bodies 30 are fixed to a floor surface. The two bodies 30 face each other. A space between the two bodies 30 is a path through which a human H1 or robot 5 passes.

[0029] The gate 31 (door) includes two flaps 311. The two flaps 311 correspond to the two bodies 30 on a one-to-one basis. Each flap 311 is fixed to a corresponding one of the bodies 30. Each flap 311 is turnable with its connection part to a corresponding one of the bodies 30 as a supporting point.

[0030] The security gate 3 is switched between a passage restriction state (impassable state) and a passable state. The passage restriction state is a state where passage of the human H1 and the robots 5 through the security gate 3 is restricted. The passable state is a state where the security gate 3 is passable for the human H1 and the robots 5.

[0031] In the present embodiment, a closed state corresponds to the passage restriction state, and an open state corresponds to the passable state. That is, the security gate 3 is switched between the closed state and the open state. As shown in FIG. 2, a state where each flap 311 protrudes from a corresponding one of the bodies 30 to close at least part of the path between the two bodies 30 by the two flaps 311 corresponds to the closed state. Moreover, a state where each flap 311 is housed in a corresponding one of the bodies 30 corresponds to the open state.

[0032] The two readers 32 are mounted on the two respective bodies 30. Each readers 32 reads information including identification information from a device 6 carried by a human H1. The device 6 is, for example, an IC tag, an IC card, a magnetic card, a mobile phone such as a smartphone, or a wearable computer. Moreover, the device 6 may be a member such as a card provided with a barcode (one-dimensional barcode or two-dimensional barcode). Each reader 32 may be configured to read information from the device 6 in a non-contact manner or may be configured to read information from the device 6 in a contact manner.

[0033] The driving device 33 includes, for example, a motor. The driving device 33 drives the two flaps 311 of the gate 31. Thus, the driving device 33 switches the security gate 3 between the closed state and the open state.

[0034] The passage sensor 34 is configured to sense the human H1 and the robots 5 which pass through the security gate 3. The passage sensor 34 is, for example, a photoelectric sensor. The photoelectric sensor is, for example, a transmission-type photoelectric sensor and includes a floodlight which outputs light to the path between the two bodies 30 and a photoreceiver which receives the light output from the floodlight. The photoelectric sensor senses the presence or absence of an object passing through the path on the basis of the quantity of light

received by the photoreceiver.

[0035] The notifier 35 notifies the human H1 that the human H1 is prohibited from passing through the security gate 3 when one of the robots 5 passes through the security gate 3. The notifier 35 performs, for example, a display indicating the prohibition of passage. Specifically, the notifier 35 includes a projector which projects a symbol (e.g., no entry mark of road traffic signs) showing the prohibition of passage on the floor surface on an entry side of the security gate 3. In another example, the notifier 35 includes a display which displays a symbol (e.g., no entry mark of road traffic signs) showing the prohibition of passage. In another example, the notifier 35 includes a light source which emits light (e.g., red light) indicating the prohibition of passage.

[0036] Note that the notifier 35 may output a sound (which can include voice) indicating the prohibition of passage. Specifically, the notifier 35 may include a buzzer that outputs a beep sound indicating the prohibition of passage. In another example, the notifier 35 may include a loudspeaker which outputs a voice (e.g., saying, “A robot is passing through the gate. Please wait.”) indicating the prohibition of passage.

[0037] (4) Robot Control Server

The robot control server 4 manages the operation of the plurality of robots 5. The robot control server 4 acquires, for example, location information on each of the plurality of robots 5. Moreover, the robot control server 4 notifies each of the plurality of robots 5 of, for example, a travel route. Each robot 5 runs along the travel route notified by the robot control server 4 while avoiding an obstacle(s) (the human(s) H1 or an item(s)) on the travel route.

[0038] Moreover, the robot control server 4 may relay communication the entry/exit management system 1 and between the plurality of robots 5.

[0039] (5) Robot

In the present embodiment, description is given assuming that the plurality of robots 5 have the same configuration. Each robot 5 includes a processing unit 51, a storage 52, a communication unit 53, a sensor unit 54, a travel device 55, and a power supply unit 56.

[0040] Moreover, each robot 5 includes a computer system including one or more processors and a memory element. The processor(s) of the computer system executes a program stored in the memory element of the computer system, thereby implementing at least some functions of each robot 5. The program may be stored in the memory element, may be provided over a telecommunications network such as the Internet, or may be provided as a non-transitory recording medium (e.g., a memory card) which is readable by the computer system and in which the program has been stored.

[0041] The processing unit 51 includes one or more processors of the computer system. The processing unit 51 executes a program, thereby implementing a predetermined function. The processing unit 51 controls the storage 52, the communication unit 53, the sensor unit 54, the travel device 55, and the power supply unit 56.

[0042] The storage 52 is a storage device including, for example, a hard disk drive (HDD) or a solid-state drive (SSD). The storage 52 stores information. For example, the storage 52 stores: identification information on a device (robot 5) in which the storage 52 is included; and map information on the facility in which the robot 5 runs. Moreover, the storage 52 stores information indicating the travel route of the robot 5 acquired from the robot control server 4.

[0043] The communication unit 53 includes a communication interface device. Each robot 5 is configured to communicate via the communication unit 53 with the entry/exit management system 1 and the robot control server 4. As used in the present disclosure, “be configured to communicate” means being capable of directly, or indirectly via a network, a relay, or the like, transmitting and receiving a signal based on an appropriate communication scheme of wired communication or wireless communication. In particular, the robots 5 of the present embodiment perform wireless communication with the entry/exit management system 1 and the robot control server 4.

[0044] The sensor unit 54 includes one or more sensors as components for sensing a surrounding situation. The one or more sensors are, for example, at least one of cameras, laser distance meters,

infrared sensors, or pressure sensors. The camera is, for example, a visible light camera or an infrared camera. The laser distance meter is, for example, Light Detection and Ranging (Lidar).

[0045] The travel device 55 includes, as components for causing the robot 5 to run, for example, a motor and a drive wheel. The motor rotates the drive wheel, and thereby, the robot 5 runs on the ground.

[0046] The power supply unit 56 supplies electric power necessary for operation of the robot 5. The power supply unit 56 includes, for example, a battery.

[0047] (6) Entry/Exit Management System

The entry/exit management system 1 includes a processing unit 11, a storage 12, and a communication unit 13.

[0048] Moreover, the entry/exit management system 1 includes a computer system including one or more processors and a memory element. The processor(s) of the computer system executes a program stored in the memory element of the computer system, thereby implementing at least some functions of the entry/exit management system 1. The program may be stored in the memory element, may be provided over a telecommunications network such as the Internet, or may be provided as a non-transitory recording medium (e.g., a memory card) which is readable by the computer system and in which the program has been stored.

[0049] The processing unit 11 includes one or more processors of the computer system. The processing unit 11 executes a program, thereby implementing a predetermined function. The processing unit 11 controls the storage 12 and the communication unit 13.

[0050] Moreover, the processing unit 11 includes a management unit 111 and a human sensing unit 112. Note that the management unit 111 and the human sensing unit 112 merely represent functions implemented by the processing unit 11 and do not necessarily represent tangible components.

[0051] The management unit 111 controls the security gate 3. More specifically, the management unit 111 makes a determination based on information acquired from each of the

plurality of robots 5 and the security gate 3, and based on a result of the determination, the management unit 111 gives an instruction to the security gate 3 to cause the security gate 3 to be in the closed state or the open state.

[0052] The human sensing unit 112 determines, based on the output of the sensor 2, the presence or absence of the human H1 in the sensing area 70. Moreover, the human sensing unit 112 identifies, based on the output of the sensor 2, the number of humans H1 in the sensing area 70. More specifically, the human sensing unit 112 analyzes a captured image generated by the camera 20 as the sensor 2, thereby determining the presence or absence of the one or more humans H1 in the sensing area 70 and further identifying the number of humans H1 in the sensing area 70.

[0053] The sensing area 70 may be adjacent to the security gate 3 or may be apart from the security gate 3 to some extent.

[0054] The human sensing unit 112 identifies the number of humans H1 in the sensing area 70, for example, at regular intervals. Thus, the human sensing unit 112 identifies the number of humans H1 in the sensing area 70 in each of a plurality of time slots in a day. The human sensing unit 112 stores the number of humans H1 in the sensing area 70 in the storage 12 together with date and time data. In the present embodiment, the congestion degree of the human H1 in the sensing area 70 is represented by the number of humans H1 in the sensing area 70.

[0055] In the following description, simply saying the “congestion degree” means the congestion degree of the human H1 in the sensing area 70.

[0056] The storage 12 stores, for example, the congestion degree for every defined time period (e.g., 30 minutes) for a plurality of days. The human sensing unit 112 statistically obtains, based on the congestion degree for each of the defined time periods for the plurality of days, a predicted value of the congestion degree for each time slot. Specifically, the human sensing unit 112 uses an average value of congestion degrees of the same time slots from the plurality of days as the predicted value of the congestion degree of the time slot.

[0057] For example, it is assumed that the congestion degree of a time slot from 7:00 to 7:30 on

day 1 is 2, the congestion degree of a time slot from 7:00 to 7:30 on day 2 is 4, and the congestion degree of a time slot from 7:00 to 7:30 on day 3 is 4. In this case, the congestion degree, obtained from these pieces of data, of the time slot from 7:00 to 7:30 on any given day is 3.3 which is an average value of 2, 4, and 4.

[0058] FIG. 3 shows an example of the prediction data of the congestion degree obtained as described above. The prediction data of FIG. 3 includes a predicted value of a congestion degree for every 30 minutes on any given day.

[0059] Thus, the management unit 111 obtains, based on a past congestion degree of the human H1 in the sensing area 70, a predicted value of a current congestion degree of the human H1 in the sensing area 70. Then, the management unit 111 determines, based on the predicted value, whether or not to permit the first robot 5A to pass through the security gate 3 when there is a passage conflict between the first robot 5A and the human H1 or the second robot 5B, which will be described later in detail.

[0060] The storage 12 is a storage device including, for example, a hard disk drive (HDD) or a solid-state drive (SSD). The storage 12 stores information. For example, the storage 12 stores the identification information on each of the plurality of robots 5 and identification information on the device 6.

[0061] The communication unit 13 includes a communication interface device. The entry/exit management system 1 is configured to communicate via the communication unit 13 with the sensor 2, the security gate 3, the robot control server 4, and the plurality of robots 5.

[0062] When one of the readers 32 of the security gate 3 reads the identification information from the device 6 carried by the human H1, the security gate 3 transmits a signal including the identification information thus read to the entry/exit management system 1. The storage 12 of the entry/exit management system 1 stores in advance the identification information corresponding to the human H1 permitted to pass through the security gate 3. Thus, the management unit 111 of the entry/exit management system 1 refers to the information stored in the storage 12, and

thereby, the management unit 111 can identify whether or not the identification information read by the reader 32 is associated with permission for passage through the security gate 3. In this way, the management unit 111 authenticates the human H1.

[0063] When the identification information read by the reader 32 is associated with the permission for the passage through the security gate 3, the security gate 3 enters the open state. Thereafter, when the passage sensor 34 senses that the human H1 has passed through the security gate 3, the security gate 3 enters the closed state.

[0064] (7) Operation Example

When coming close to the security gate 3, each of the plurality of robots 5 transmits a request signal representing a passage request to the entry/exit management system 1. The request signal includes identification information as authentication information on the robot 5. If the request signal includes no correct authentication information (e.g., includes no authentication information that matches authentication information stored in the storage 12 in advance), the entry/exit management system 1 does not permit the robot 5 to pass through the security gate 3. The following description is based on the provision that the request signal includes the correct authentication information.

[0065] A timing at which the robot 5 transmits the request signal may be a timing at which the robot 5 enters the sensing area 70 or may be a timing before the robot 5 enters the sensing area 70 or after the robot 5 enters the sensing area 70. For example, a stop area is set at a predetermined location which is in the sensing area 70 and which is near the security gate 3, and the robot 5 transmits the request signal when arriving at the stop area. Information indicating the location of the stop area is included in the map information on the facility stored in the storage 52 of the robot 5.

[0066] When receiving the request signal representing the passage request, the entry/exit management system 1 determines whether or not to permit the robot 5, which has transmitted the passage request, to pass through the security gate 3. The processing performed by the entry/exit

management system 1 when any one robot 5, that is, the first robot 5A, of the plurality of robots 5 transmits the passage request will be described below with reference to FIG. 4.

[0067] The management unit 111 of the entry/exit management system 1 acquires prediction data of a congestion degree from the human sensing unit 112 (step ST1). The prediction data of the congestion degree is data including a predicted value of a congestion degree for every defined time period, for example, as shown in FIG. 3.

[0068] If the entry/exit management system 1 receives the passage request from the first robot 5A (step ST2: Yes), the management unit 111 determines whether or not there is the passage conflict.

[0069] First of all, the passage conflict between the first robot 5A and the human H1 will be described. If the human sensing unit 112 determines that the one or more humans H1 (even one human) are present in the sensing area 70 when the entry/exit management system 1 receives the passage request from the first robot 5A, the management unit 111 determines that there is the passage conflict between the first robot 5A and the human H1.

[0070] Next, the passage conflict between the first robot 5A and the second robot 5B will be described. If the entry/exit management system 1 receives a passage request from the second robot 5B around the same time that the entry/exit management system 1 receives the passage request from the first robot 5A, the management unit 111 determines that there is the passage conflict between the first robot 5A and the second robot 5B. As used herein, “around the same time” means such a timing of the passage request that when each of the first robot 5A and the second robot 5B is about to pass through the security gate 3 immediately after transmitting the passage request, one of the first robot 5A and the second robot 5B obstructs the passage of the other of the first robot 5A and the second robot 5B through the security gate 3. When each of the first robot 5A and the second robot 5B transmits the passage request within approximately the same order of amount of time as that required for each of the first robot 5A and the second robot 5B to pass through the security gate 3, this can be said to be around the same time. As a specific

example, an upper limit time is assumed to be 5 to 10 seconds, and when each of the first robot 5A and the second robot 5B transmits the passage request within the upper limit time, this can be said to be around the same time.

[0071] If there is at least one of the passage conflict between the first robot 5A and the human H1 or the passage conflict between the first robot 5A and the second robot 5B (step ST3: Yes), the management unit 111 compares the predicted value of the congestion degree with a predetermined value (step ST4). In the present embodiment, the congestion degree is represented by the number of humans H1 in the sensing area 70.

[0072] In the example shown in FIG. 3, the predicted value of the congestion degree is larger than or equal to a predetermined value Th1 in a time slot from 8:00 to 15:00 and is smaller than the predetermined value Th1 in the other time slots. Thus, when the first robot 5A transmits the passage request in the time slot from 8:00 to 15:00, the predicted value of the congestion degree is larger than or equal to the predetermined value, and the determining in step ST4 results in “Yes”.

[0073] If the predicted value of the congestion degree is larger than or equal to the predetermined value (step ST4: Yes), the management unit 111 notifies the first robot 5A that the first robot 5A is not permitted to pass through the security gate 3 (i.e., notifies the first robot 5A of the passage prohibition) (step ST5). In this case, the management unit 111 does not perform control such that the security gate 3 enters the open state to allow the passage of the first robot 5A. Thus, when the congestion degree (here, the predicted value of the congestion degree) of the human H1 (the number of humans staying) in the sensing area 70 is higher than or equal to the predetermined value, the management unit 111 prohibits the first robot 5A from passing through the security gate 3. When the first robot 5A is prohibited from passing through the security gate 3, the first robot 5A waits, for example, near the security gate 3, and each time a defined time period elapses, the first robot 5A retransmits the request signal representing the passage request.

[0074] If the predicted value of the congestion degree is smaller than the predetermined value (step ST4: No), the management unit 111 notifies the first robot 5A that the first robot 5A is

permitted to pass through the security gate 3 (step ST6). When receiving the notification, the first robot 5A travels to the security gate 3. Here, the entry/exit management system 1 determines whether or not the first robot 5A comes close to the security gate 3 (step ST7).

[0075] In step ST7, the entry/exit management system 1 may determine that the first robot 5A comes close to the security gate 3 when receiving an approach notification signal, which is output from the first robot 5A when the first robot 5A comes close to the security gate 3. Alternatively, the entry/exit management system 1 may determine, based on the output of the sensor 2, or an output of a sensor disposed at the security gate 3, whether or not the first robot 5A comes close to the security gate 3.

[0076] If the first robot 5A comes close to the security gate 3 (step ST7: Yes), the management unit 111 causes the security gate 3 to enter the open state to allow the first robot 5A to pass through the security gate 3 (step ST8). Then, the management unit 111 causes the notifier 35 of the security gate 3 to notify the human H1 that the human H1 is prohibited from passing through the security gate 3 (step ST9). Thus, the management unit 111 notifies the human H1 of the passage prohibition through the security gate 3 by using the notifier 35 when the management unit 111 causes the security gate 3 to permit the first robot 5A to pass through.

[0077] Thereafter, if the passage sensor 34 senses that the first robot 5A has passed through the security gate 3 (step ST10: Yes), the management unit 111 causes the security gate 3 to enter the closed state (step ST11) and causes the notifier 35 to end the notification (step ST12).

[0078] When the passage of the first robot 5A is permitted in step ST6, if a human H1 is authenticated by one of the readers 32 of the security gate 3 before the first robot 5A comes close to the security gate 3, the human H1 is allowed to pass through the security gate 3. That is, permitting the passage of the first robot 5A in the step ST6 is not processing that gives priority to the passage of the first robot 5A over the passage of the human H1 but is processing that allows the first robot 5A and the human H1 authenticated to pass through on a first come, first served basis.

[0079] Moreover, when the passage of the first robot 5A is permitted in step ST6, if the second robot 5B permitted to pass through comes close to the security gate 3 before the first robot 5A comes close to the security gate 3, the second robot 5B is allowed to pass through the security gate 3. That is, permitting the passage of the first robot 5A in step ST6 is not processing that gives priority to the passage of the first robot 5A over the passage of the second robot 5B but is processing that allows the first robot 5A and the second robot 5B permitted to pass through, to pass through on a first come, first served basis.

[0080] When the passage of the first robot 5A is not permitted in step ST5, if a human H1 is authenticated by one of the readers 32 of the security gate 3, the human H1 is allowed to pass through the security gate 3. That is, not permitting the passage of the first robot 5A in step ST5 is processing that gives priority to the passage of the human H1 over the passage of the first robot 5A.

[0081] (Variation of First Embodiment)

Variations of the first embodiment are enumerated below. The variations described below may be accordingly combined with each other. In the following description, the configuration of the first embodiment described above is referred to as a basic example.

[0082] The sensor 2 is not limited to the camera 20 (visible light camera) which captures an image by visible light. For example, in the facility, an infrared camera which captures an image by an infrared ray may be installed as the sensor 2. Alternatively, in the facility, an object sensor may be installed as the sensor 2. The object sensor detects an object which passes through a path connected to the security gate 3. The object sensor may be, for example, a pressure sensor installed on a floor of the path. The object sensor may be, for example, a photoelectric sensor that senses the presence or absence of an object passing through a path by outputting light to the path. The object sensor may be, for example, an ultrasonic sensor that senses the presence/absence of an object passing through a path by an ultrasonic echo.

[0083] In the facility, a plurality of sensors 2 may be installed. The plurality of sensors 2 may

include a plurality of types of sensors. For example, the plurality of sensors 2 may include one or more cameras 20 and one or more object sensors.

[0084] The sensor 2 may be included in the robot 5. The sensor 2 may be, for example, a camera included, as a component of the sensor unit 54, in the robot 5. In the case of the robot 5 including the sensor 2, the sensor 2 senses the human H1 staying in the sensing area 70 when the robot 5 comes close to the sensing area 70.

[0085] In the case of the robot 5 including the sensor 2, a sensing result by the sensor 2 may be transmitted to the entry/exit management system 1, and the human sensing unit 112 of the entry/exit management system 1 may determine, based on the sensing result by the sensor 2, the presence or absence of the human H1 in the sensing area 70. Alternatively, the robot 5 may include the sensor 2 and the human sensing unit 112, and the human sensing unit 112 of the robot 5 may determine, based on the sensing result by the sensor 2, the presence or absence of the human H1 in the sensing area 70.

[0086] In the basic example, the congestion degree is represented by the number of humans H1 in the sensing area 70. In contrast, the congestion degree may be a value obtained by dividing the number of humans H1 in the sensing area 70 by the area of the sensing area 70. Alternatively, the congestion degree may be an area occupied by the one or more humans H1 present in the sensing area 70. Still alternatively, the congestion degree may be a value obtained by dividing the area occupied by the one or more humans H1 present in the sensing area 70 by the area of the sensing area 70.

[0087] In the basic example, the management unit 111 obtains, based on a past congestion degree, a predicted value of a current congestion degree and determines, based on the predicted value, whether or not to permit the first robot 5A to pass through the security gate 3 when there is the passage conflict between the first robot 5A and the human H1 or one of the second robots 5B. In contrast, the management unit 111 may determine, based on an actually measured value of the current congestion degree (i.e., congestion degree at an immediately preceding time point),

whether or not the first robot 5A is permitted to pass through the security gate 3 when there is the passage conflict between the first robot 5A and the human H1 or one of the second robots 5B.

[0088] If one of the second robots 5B is present in the sensing area 70 when the entry/exit management system 1 receives the passage request from the first robot 5A, the management unit 111 may determine that there is the passage conflict between the first robot 5A and the second robot 5B. The management unit 111 determines the presence or absence of the one of the second robots 5B, for example, on the basis of the signal output from the second robot 5B or the output of the sensor 2.

[0089] The security gate 3 of the basic example enters the open state only when allowing the human H1 or robot 5 to pass through. In contrast, the security gate 3 may be in the open state in a normal mode and may be configured to enter the closed state when the human H1 or robot 5 which is not permitted to pass through the security gate 3 comes close to the security gate 3.

[0090] The gate 31 of the security gate 3 of the basic example includes the flaps 311 which are turnable with respect to the body 30. In contrast, the security gate 3 may be an automatic door including a sliding door as the gate 31 which automatically opens and closes in accordance with an authentication result of the human H1 or robot 5. A state where the sliding door closes the exit/entrance corresponds to the closed state, and a state where the sliding door opens the exit/entrance corresponds to the open state.

[0091] The security gate 3 of the basic example drives the gate 31 to switch between the open state and the closed state, thereby allowing a target (the human H1 or robot 5) to pass through in the open state and not allowing the target to pass through in the closed state. In contrast, the security gate 3 may include, as the gate 31, an arm which is manually rotatable, and the arm may be switched between an unlocked state and a locked state, thereby allowing the target to pass through in the unlocked state of the arm and not allowing the target to pass through in the locked state of the arm (passage restriction).

[0092] A plurality of security gates 3 may be installed on one site. When the first robot 5A

transmits a passage request requesting passage through a given security gate 3 of the plurality of security gates 3, if there is no passage conflict at the given security gate 3, the management unit 111 may cause the given security gate 3 to permit the first robot 5A to pass through. Alternatively, when the first robot 5A transmits the passage request, if there is no passage conflict at any one security gate 3 of the plurality of security gates 3, the management unit 111 may cause the one security gate 3 to permit the first robot 5A to pass through, and may notify the first robot 5A of the one security gate 3 through which the first robot 5A is permitted to pass.

[0093] The entry/exit management system 1 determines, based on the presence or absence, and the congestion degree, of the human H1 in the sensing area 70, whether or not to permit the first robot 5A to pass through the security gate 3. In the basic example, the sensing area 70 includes the area 71 in front of the security gate 3 and the area 72 behind the security gate 3. In contrast, one of the area 71 in front of the security gate 3 and the area 72 behind the security gate 3 does not have to be included in the sensing area 70. In particular, when the security gate 3 is one-way, an area at which an object arrives after passing through the security gate is preferably not included in the sensing area 70. For example, when the human H1 and the robots 5 are able to travel through the security gate 3 from the area 71 to the area 72 but are not able to travel from the area 72 to the area 71, the area 72 is preferably not included in the sensing area 70.

[0094] The security gate 3 may be configured to authenticate only one of passage from the area 71 to the area 72 and passage from the area 72 to the area 71. That is, the security gate 3 may permit the passage of the human H1 and the robots 5 successfully authenticated in one direction and may permit the passage of the human H1 and the robots 5 in the other direction without authentication.

[0095] The sensing area 70 may include a path between the two bodies 30 of the security gate 3.

[0096] The management unit 111 may be configured to identify a human H1 such as staff stationed near the security gate 3 (hereinafter referred to as stationed staff) such that the presence or absence of the stationed staff is not used for the determination of the passage conflict. The

management unit 111 may determine the sensing area 70, for example, such that the sensing area 70 does not include a position where the stationed staff stays. Moreover, the management unit 111 may perform face authentication of the human H1 in the captured image generated by the camera 20 to distinguish the stationed staff.

[0097] The flowchart shown in FIG. 4 is a mere example of the entry/exit management method according to the present disclosure, and the order of steps may accordingly be changed, or a step(s) may accordingly be added or omitted. For example, step ST1 of acquiring the prediction data of the congestion degree does not have to be executed each time but may be executed once a day, for example. Moreover, for example, when the first robot 5A is prohibited from passing through a given security gate 3 in step ST5, the first robot 5A or the robot control server 4 may search for a travel route not passing through the given security gate 3.

[0098] If there is no passage conflict (step ST3: No), the management unit 111 may give priority to the passage of the first robot 5A over the passage of a human H1 and may prohibit the passage of the human H1 (see step ST9).

[0099] The entry/exit management system 1 or a subject that carries out the entry/exit management method in the present disclosure includes a computer system. The computer system may include a processor and a memory element as principal hardware components thereof. The processor executes a program stored in the memory of the computer system, thereby implementing at least some of functions as the entry/exit management system 1 or the subject that carries out the entry/exit management method in the present disclosure. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded over a telecommunications network 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 include 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 integrated 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 memory elements. 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.

[0100] Moreover, in the embodiment, a plurality of functions integrated in one device may be distributed in a plurality of devices. For example, a device including the human sensing unit 112 may be provided separate from a device including the management unit 111. Further, at least some functions of the entry/exit management system 1 may be implemented by, for example, a server or cloud (cloud computing).

[0101] In contrast, in the embodiment, a plurality of functions distributed in a plurality of devices may be integrated in one device. For example, a plurality of functions distributed in the security gate 3 and the entry/exit management system 1 may be integrated in one device. That is, at least some functions of the entry/exit management system 1 may be included in the security gate 3. For example, the function of authenticating the human H1 may be included in the security gate 3. When the function of authenticating the human H1 is included in the security gate 3, it is not essential that the entry/exit management system 1 manages at least one of entry/exit of the human H1 into/from the security gate 3. Thus, the entry/exit management system 1 manages at least one of the entry or the exit of the robots 5 into or from the security gate 3.

[0102] (Second Embodiment)

With reference to FIGS. 5 and 6, an entry/exit management system 1 and an entry/exit management method according to a second embodiment will be described below. Components similar to those of the first embodiment are denoted by the same reference signs as those in the first embodiment, and the description thereof will be omitted.

[0103] In the present embodiment, a management unit 111 predicts, based on the number of humans staying in a predetermined place 80, the congestion degree of the human H1 in a sensing area 70. The human H1 in the predetermined place 80 is able to travel to a place where a security gate 3 is installed. In FIG. 5, the predetermined place 80 includes a place 81 and a place 82. The management unit 111 determines, based on the predicted congestion degree of the human H1 in the sensing area 70, whether or not a first robot 5A is permitted to pass through a security gate 3 when there is a passage conflict between the first robot 5A and the human H1 or a second robot 5B. This will be described in further detail below.

[0104] The security gate 3 is installed in a path between the place 81 and the place 82. The sensing area 70 is present in the path between the place 81 and the place 82. Of the sensing area 70, an area 71 is located between the place 81 and the security gate 3, and an area 72 is located between the security gate 3 and the place 82.

[0105] In a facility, a sensor 91 for sensing a human H1 staying in the place 81 and a sensor 92 for sensing a human H1 staying in the place 82 are installed. The sensors 91 and 92 are components of a robot system X1. The sensors 91 and 92 are, for example, cameras 90. A human sensing unit 112 of the entry/exit management system 1 analyzes captured images generated by the cameras 90, thereby identifying the number of humans H1 in each of the places 81 and 82.

[0106] Note that the sensors 91 and 92 are not limited to the cameras 90 (visible light cameras) in a similar manner that the sensor 2 is not limited to the camera 20 (a visible light camera). For example, the sensors 91 and 92 may be infrared cameras or object sensors.

[0107] A path in which one human H1 coming from a place other than the place 81 or 82 and another human H1 coming from the place 81 or 82 can get together is provided neither between the place 81 and the sensing area 70 nor between the place 82 and the sensing area 70. The human H1 has to pass through the place 81 or 82 to go to the sensing area 70. However, a path where a small number of humans H1 can get together, for example, an exit/entrance for staff only, may be provided between the place 81 and the sensing area 70 or between the place 82 and the sensing area 70.

[0108] The management unit 111 collects history data on the number of humans staying in each of the places 81 and 82 and the sensing area 70. Based on the history data, the management unit 111 statistically obtains a ratio of the number of humans H1 having traveled to the sensing area 70 after a predetermined time to the number of humans H1 who stayed in the places 81 and 82.

[0109] The ratio of the number of humans H1 having traveled to the sensing area 70 after the predetermined time to the number of humans H1 who stayed in the place 81 is hereinafter referred to as a “transfer ratio from the place 81 to the sensing area 70”. Moreover, the ratio of the number of humans H1 having traveled to the sensing area 70 after the predetermined time to the number of humans H1 who stayed in the place 82 is referred to as “transfer ratio from the place 82 to the sensing area 70”. Further, when the “transfer ratio from the place 81 to the sensing area 70” and “transfer ratio from the place 82 to the sensing area 70” are not particularly distinguished from each other, they are also referred to as a “transfer ratio”.

[0110] A standard travel time from the place 81 to the sensing area 70 and a standard travel time from the place 82 to the sensing area 70 are determined in advance. These standard travel times may each be determined based on an actually measured required time for traveling, or times that a designer considers appropriate may be set as these standard travel times. In the following description, the standard travel time from the place 81 to the sensing area 70 is assumed to be equal to the standard travel time from the place 82 to the sensing area 70.

[0111] As a first example of calculating the transfer ratio, it is assumed that at a given time point,

the number of humans staying in the place 81 is 10, and the number of humans staying in the place 82 and the sensing area 70 is 0. Moreover, it is assumed that after a lapse of the standard travel time from the given time point, the number of humans staying in the place 81 is 0, and the number of humans staying in the sensing area 70 is 6. In this case, the percentage of the number of humans H1 having traveled to the sensing area 70 after the standard travel time to the number of humans H1 who stayed in the place 81 is 60%. In other words, the transfer ratio from the place 81 to the sensing area 70 is 60%. Thus, the management unit 111 can calculate the transfer ratio from the place 81 to the sensing area 70 and the transfer ratio from the place 82 to the sensing area 70 on the basis of the number of humans staying in each of the places 81 and 82 and the sensing area 70 at each of time points. In practice, the management unit 111 preferably calculates transfer ratios at a plurality of timings and preferably uses an average value of the transfer ratios as the transfer ratio.

[0112] As a second example of calculating the transfer ratio, an example in which the security gate 3 is one-way from the area 71 to the area 72 is considered. It is assumed that at a given time point, the number of humans staying in the place 81 is 10. Moreover, it is assumed that after a lapse of the standard travel time from the given time point, the number of humans staying in the sensing area 70 is 6. In this case, the transfer ratio from the place 81 to the sensing area 70 is 60%. Here, it is assumed that the humans H1 staying in the sensing area 70 at the given time point will all have left the sensing area 70 after a lapse of the standard travel time. Moreover, it is assumed that no human H1 travels from the place 82 to the sensing area 70. In practice, the management unit 111 preferably calculates transfer ratios at plurality of timings and preferably uses an average value of the transfer ratios as the transfer ratio.

[0113] Moreover, only a given time slot in a day, the security gate 3 may be deemed to be one-way from the area 71 to the area 72 or from the area 72 to the area 71, and the transfer ratio in this time slot may be calculated by the computation method of the second example. For example, when the security gate 3 is installed at an entrance of an office, most of a plurality of humans H1

who are to pass through the security gate 3 in a time slot in the morning are staff coming from outside, and therefore, the security gate 3 can be deemed to be one-way from the outside to the inside of the office. Moreover, accordingly, the security gate 3 may be deemed to be one-way from the area 71 to the area 72, or from the area 72 to the area 71, at all times.

[0114] The management unit 111 calculates the transfer ratio in advance. Then, the management unit 111 predicts, based on the number of humans staying in each of the places 81 and 82 and the transfer ratio, the congestion degree of the human H1 in the sensing area 70. In the present embodiment, the congestion degree is represented by the number of humans H1 in the sensing area 70.

[0115] For example, as shown in FIG. 5, the transfer ratio from the place 81 to the sensing area 70 is assumed to be 60%, and the transfer ratio from the place 82 to the sensing area 70 is assumed to be 10%. To predict the congestion degree of the human H1 in the sensing area 70 at a first time point, the management unit 111 refers to the number of humans staying in each of the places 81 and 82 at a second time point preceding the first time point by the standard travel time. For example, when at the second time point, the number of humans staying in the place 81 is 10, and the number of humans staying in the place 82 is 5, the management unit 111 predicts that the congestion degree (the number of humans staying in the sensing area 70) at the first time point is $10 \times 0.6 + 5 \times 0.1 = 6.5$.

[0116] Then, based on the congestion degree thus predicted, the management unit 111 determines whether or not to permit the first robot 5A to pass through the security gate 3 when there is the passage conflict between the first robot 5A and the human H1 or the second robot 5B. The processing performed by the entry/exit management system 1 following the prediction of the congestion degree by the management unit 111 may be similar to, for example, that in the first embodiment. That is, as shown in FIG. 4, if the predicted value of the congestion degree (predicted congestion degree) is higher than or equal to the predetermined value (step ST4: Yes), the entry/exit management system 1 does not permit the first robot 5A to pass through the security

gate 3, and if the predicted value of the congestion degree is lower than the predetermined value (step ST4: No), the entry/exit management system 1 may permit the first robot 5A to pass through the security gate 3.

[0117] With reference to FIG. 6, processing performed by the entry/exit management system 1 when the first robot 5A transmits the passage request will be described. Note that the flowchart shown in FIG. 6 is a mere example of the entry/exit management method according to the present disclosure, and the order of steps may accordingly be changed, or a step(s) may accordingly be added or omitted.

[0118] The transfer ratio is determined in advance and is stored in a storage 12. The management unit 111 acquires the transfer ratio from the storage 12 (step ST21).

[0119] Processing in steps ST22 to ST23 in FIG. 6 is similar to the processing in steps ST2 to ST3 in FIG. 4.

[0120] If the entry/exit management system 1 receives the passage request from the first robot 5A (step ST22: Yes), the management unit 111 determines whether or not there is a passage conflict (step ST23). If there is at least one of the passage conflict between the first robot 5A and the second robot 5B or the passage conflict between the first robot 5A and the human H1 (step ST23: Yes), the management unit 111 acquires the number of humans staying in each of the places 81 and 82 adjacent to the sensing area 70 (step ST24). Here, the storage 12 stores pieces of history data on the number of humans staying in the places 81 and 82. In step ST24, the management unit 111 acquires the number of humans staying in each of the places 81 and 82 at a time point preceding a time point at which the entry/exit management system 1 receives the passage request from the first robot 5A by the standard travel time.

[0121] The management unit 111 calculates, based on the number of humans acquired in step ST24 and the transfer ratio acquired in step ST21, a predicted value of the congestion degree of the human H1 in the sensing area 70 (step ST25). That is, the management unit 111 multiplies the number of humans staying in each of the places 81 and 82 by the transfer ratio, thereby

computing the predicted value of the congestion degree.

[0122] Next, the management unit 111 compares the predicted value of the congestion degree computed in step ST25 with the predetermined value (step ST26).

[0123] If the predicted value of the congestion degree is larger than or equal to the predetermined value (step ST26: Yes), the management unit 111 notifies the first robot 5A that the first robot 5A is not permitted to pass through the security gate 3 (i.e., notifies the first robot 5A of the passage prohibition) (step ST27). Processing in step ST27 in FIG. 6 is similar to the processing in step ST5 of FIG. 4.

[0124] If the predicted value of the congestion degree is smaller than the predetermined value (step ST26: No), the management unit 111 notifies the first robot 5A that the first robot 5A is permitted to pass through the security gate 3 (step ST28). When receiving the notification, the first robot 5A travels to the security gate 3. Processing in step ST28 of FIG. 6 is similar to the processing in step ST6 of FIG. 4.

[0125] Processing in step ST28 and subsequent steps is similar to the processing in step ST6 and subsequent steps of FIG. 4.

[0126] (Third Embodiment)

With reference to FIG. 7, an entry/exit management system 1 and an entry/exit management method according to the third embodiment will be described below. Components similar to those in the first embodiment are denoted by the same reference signs as those in the first embodiment, and the description thereof is omitted.

[0127] The present embodiment is different from the first embodiment in the processing of determining whether or not to permit a first robot 5A to pass through a security gate 3 when there is a passage conflict between the first robot 5A and a human H1 or a second robot 5B. That is, in the present embodiment, a management unit 111 determines a degree of priority of the first robot 5A, and based on the degree of priority, the management unit 111 determines whether or not to permit the first robot 5A to pass through the security gate 3.

[0128] More specifically, the management unit 111 determines the degree of priority of the first robot 5A on the basis of at least one of the congestion degree of the human H1 in a sensing area 70, a task carried out by the first robot 5A, or a destination of the first robot 5A. That is, the management unit 111 determines, based on at least one of the congestion degree of the human H1 in the sensing area 70, the task carried out by the first robot 5A, or the destination of the first robot 5A, whether or not to permit the first robot 5A to pass through the security gate 3 when there is the passage conflict between the first robot 5A and the human H1 or the second robot 5B.

[0129] Moreover, in the first embodiment, when the management unit 111 permits the first robot 5A to pass through the security gate 3, the management unit 111 allows the human H1 and the first robot 5A to pass through on a first come, first served basis. In contrast, in the present embodiment, the management unit 111 may give priority to the passage of the first robot 5A over the passage of the human H1. More specifically, when there is the passage conflict between the first robot 5A and the human H1 or the second robot 5B, the management unit 111 determines, based on the degree of priority, whether priority is given to the passage of the first robot 5A over the passage of the human H1, or priority is given to the passage of the human H1 over the passage of the first robot 5A, or the human H1 and the first robot 5A are allowed to pass through on a first come, first served basis.

[0130] As an example, the task carried out by the first robot 5A is any one of “delivery”, “cleaning”, and “patrol”.

[0131] As the congestion degree, a predicted value is used in a similar manner to the first or second embodiment, but as described in variations of the first embodiment, an actually measured value of a current congestion degree (that is, congestion degree at an immediately preceding time point) may be used.

[0132] A storage 52 of each of robots 5 stores a task to be carried out by a corresponding one of the robots 5 and a destination and of the corresponding one of the robots 5. Each robot 5 is configured to notify the entry/exit management system 1 of the task and the destination.

[0133] A storage 12 stores a correspondence relationship of the congestion degree of the human H1 in the sensing area 70, the task carried out by the first robot 5A, and the destination of the first robot 5A to scores. An example of the correspondence relationship is shown in [Table 1].

[0134] [Table 1]

Parameter	Score
Congestion Degree Score	When Congestion Degree $\geq$ Predetermined Value, 1 Point When Congestion Degree $<$ Predetermined Value, 5 Points
Task Score	When Task is Delivery, 5 Points When Task is Cleaning, 3 Points When Task is Patrol, 1 Point
Destination Score	When Required Time to Destination $\geq$ 10 Minutes, 5 Points When 5 Minutes $\leq$ Required Time to Destination $<$ 10 Minutes, 3 Points When Required Time to Destination $<$ 5 Minutes, 1 Point

[0135] The higher each score is, the higher the degree of priority.

[0136] Moreover, the storage 12 stores a weight of each of a congestion degree score, a task score, and a destination score. Here, the weight is a numerical value from 1 to 3.

[0137] The management unit 111 determines the degree of priority on the basis of, for example, [Formula 1].

[0138] [Formula 1]

$$\text{Degree of Priority} = \frac{(\text{Congestion Degree Score} \times A) + (\text{Task Score} \times B) + (\text{Destination Score} \times C)}{3}$$

[0139] Here, A, B, and C are respectively the weight of the congestion degree score, the weight of the task score, and the weight of the destination score. The degree of priority is a value from 1 to 15.

[0140] The determination method of the degree of priority described so far is an example and may be modified accordingly. For example, the relationship of the congestion degree, the task, and the destination to the scores may be modified accordingly.

[0141] When there is the passage conflict between the first robot 5A and the human H1 or the second robot 5B, the management unit 111 makes a determination on the basis of the degree of

priority.

[0142] As an example, if the degree of priority is lower than 6, the management unit 111 gives priority to the passage of the human H1 over the passage of the first robot 5A. That is, in this case, the management unit 111 does not permit the passage of the first robot 5A.

[0143] Moreover, if the degree of priority is higher than or equal to 6 and lower than 10, the management unit 111 allows the human H1 and the first robot 5A to pass through on a first come, first served basis.

[0144] Moreover, if the degree of priority is higher than or equal to 10, the management unit 111 gives priority to the passage of the first robot 5A over the passage of the human H1. That is, in this case, the management unit 111 does not permit the passage of the human H1. When priority is given to the passage of the first robot 5A over the passage of the human H1, the management unit 111 causes a notifier 35 of the security gate 3 to notify the human H1 that the human H1 is prohibited from passing through the security gate 3. After the first robot 5A passes through the security gate 3, the notifier 35 stops notifying.

[0145] With reference to FIG. 7, processing performed by the entry/exit management system 1 when the first robot 5A transmits the passage request will be described. Note that the flowchart shown in FIG. 7 is a mere example of the entry/exit management method according to the present disclosure, and the order of steps may accordingly be changed, or a step(s) may accordingly be added or omitted.

[0146] The management unit 111 acquires the prediction data of the congestion degree from the human sensing unit 112 (step ST31). The management unit 111 further acquires, from the first robot 5A, information representing the task and the destination of the first robot 5A.

[0147] Processing in steps ST32 to ST33 of FIG. 7 is similar to the processing in steps ST2 to ST3 of FIG. 4.

[0148] If the entry/exit management system 1 receives the passage request from the first robot 5A (step ST32: Yes), the management unit 111 determines whether or not there is a passage conflict

(step ST33). If there is at least one of the passage conflict between the first robot 5A and the human H1 or the passage conflict between the first robot 5A and the second robot 5B (step ST33: Yes), the management unit 111 makes a determination on the basis of the degree of priority of the first robot 5A.

[0149] If the degree of priority is lower than 6 (step ST34: Yes), the management unit 111 gives priority to the passage of the human H1 over the passage of the first robot 5A (step ST35). That is, the management unit 111 notifies the first robot 5A that the first robot 5A is not permitted to pass through the security gate 3. Processing in step ST35 of FIG. 7 is similar to the processing to step ST5 of FIG. 4.

[0150] If the degree of priority is higher than or equal to 6 and lower than 10 (step ST36: Yes), the management unit 111 allows the human H1 and the first robot 5A to pass through on a first come, first served basis (step ST37). Processing in step ST37 and subsequent steps is similar to the processing in step ST6 and subsequent steps of FIG. 4.

[0151] If the degree of priority is higher than or equal to 10, the management unit 111 gives priority to the passage of the first robot 5A over the passage of the human H1 (step ST38). In this case, the management unit 111 causes the notifier 35 of the security gate 3 to notify the human H1 that the human H1 is prohibited from passing through the security gate 3.

[0152] If there is no passage conflict (step ST33: No), the management unit 111 allows the human H1 and the first robot 5A to pass through on a first come, first served basis (step ST37).

[0153] Note that if there is no passage conflict (step ST33: No), the management unit 111 may prioritize the passage of the first robot 5A over the passage of the human H1 (see step ST38).

[0154] (Summary)

The embodiments and the like described above disclose the following aspects.

[0155] An entry/exit management system (1) of a first aspect includes a management unit (111) and a human sensing unit (112). The management unit (111) is configured to control a security gate (3). A plurality of autonomous robots (5) and a human (H1) are to pass through the security

gate (3). The plurality of autonomous robots (5) includes a first robot (5A) and a second robot (5B). The human sensing unit (112) is configured to determine, based on an output of a sensor (2) configured to sense the human (H1) staying in a sensing area (70) at an installation place of the security gate (3), presence or absence of the human (H1) in the sensing area (70). The management unit (111) is configured to, when the entry/exit management system (1) receives a passage request requesting passage through the security gate (3) from the first robot (5A), determine whether or not there is a passage conflict between the first robot (5A) and the second robot (5B) and determine, based on a determination result by the human sensing unit (112), whether or not there is a passage conflict between the first robot (5A) and the human (H1). A state where there is the passage conflict between the first robot (5A) and the second robot (5B) is a state where around the same time that the first robot (5A) is about to pass through the security gate (3), the second robot (5B) is also about to pass through the security gate (3). A state where there is the passage conflict between the first robot (5A) and the human (H1) is a state where around the same time that the first robot (5A) is about to pass through the security gate (3), the human (H1) is also about to pass through the security gate (3). The management unit (111) is configured to, when there is no passage conflict between the first robot (5A) and the second robot (5B) and there is no passage conflict between the first robot (5A) and the human (H1), cause the security gate (3) to permit the first robot (5A) to pass through.

[0156] With this configuration, the passage of the first robot (5A) is permitted when there is no passage conflict, and therefore, the possibility that the first robot (5A) obstructs the passage of the second robot (5B) or the human (H1) can be reduced. This enables traffic congestion at the installation place of the security gate (3) to be mitigated.

[0157] In an entry/exit management system (1) of a second aspect referring to the first aspect, the management unit (111) is configured to, when the human sensing unit (112) determines the presence of the human (H1) in the sensing area (70) at reception of the passage request from the first robot (5A) by the entry/exit management system (1), determine that there is the passage

conflict between the first robot (5A) and the human (H1).

[0158] With this configuration, whether or not there is the passage conflict between the first robot (5A) and the human (H1) can be simply determined.

[0159] In an entry/exit management system (1) of a third aspect referring to the first or second aspect, the management unit (111) is configured to, when the entry/exit management system (1) receives a passage request from the second robot (5B) around the same time that the entry/exit management system (1) receives the passage request from the first robot (5A), determine that there is the passage conflict between the first robot (5A) and the second robot (5B).

[0160] With this configuration, whether or not there is the passage conflict between the first robot (5A) and the second robot (5B) can be simply determined.

[0161] In an entry/exit management system (1) of a fourth aspect referring to any one of the first to third aspects, the management unit (111) is configured to determine, based on at least one of a congestion degree of the human (H1) in the sensing area (70), a task carried out by the first robot (5A), or a destination of the first robot (5A), whether or not to permit the first robot (5A) to pass through the security gate (3) when there is the passage conflict between the first robot (5A) and the human (H1) or the second robot (5B).

[0162] With this configuration, also when there is the passage conflict, the first robot (5A) can accordingly be permitted to pass through the security gate (3). This enables the first robot (5A) to pass through the security gate (3) early.

[0163] In an entry/exit management system (1) of a fifth aspect referring to the fourth aspect, the management unit (111) is configured to obtain, based on a past congestion degree of the human (H1) in the sensing area (70), a predicted value of a current congestion degree of the human (H1) in the sensing area (70) and determine, based on the predicted value, whether or not to permit the first robot (5A) to pass through the security gate (3) when there is the passage conflict between the first robot (5A) and the human (H1) or the second robot (5B).

[0164] With this configuration, the autonomous robots (5) are prohibited from passing through

the security gate (3), for example, in a time slot in which the possibility that the sensing area (70) is crowded is high, thereby mitigating traffic congestion.

[0165] In an entry/exit management system (1) of a sixth aspect referring to the fourth or fifth aspect, the management unit (111) is configured to, when the number of humans staying in the sensing area (70) is larger than or equal to a predetermined value, prohibit the first robot (5A) from passing through the security gate (3).

[0166] This configuration enables whether the security gate (3) is passable or impassable to be determined by simple processing.

[0167] In an entry/exit management system (1) of a seventh aspect referring to any one of the fourth to sixth aspects, the human (H1) in a predetermined place (80) is able to travel to the installation place of the security gate (3), and the management unit (111) is configured to predict, based on the number of humans staying in the predetermined place (80), the congestion degree of the human (H1) in the sensing area (70). The management unit (111) is configured to determine, based on the congestion degree of the human (H1) in the sensing area (70) thus predicted, whether or not to permit the first robot (5A) to pass through the security gate (3) when there is the passage conflict between the first robot (5A) and the human (H1) or the second robot (5B).

[0168] This configuration enables congestion at the sensing area (70) to be predicted in advance.

[0169] In an entry/exit management system (1) according to an eighth aspect referring to any one of the fourth to seventh aspects, the management unit (111) is configured to determine a degree of priority of the first robot (5A) on a basis of at least one of the congestion degree of the human (H1) in the sensing area (70), a task carried out by the first robot (5A), or a destination of the first robot (5A). The management unit (111) is configured to, when there is the passage conflict between the first robot (5A) and the human (H1) or the second robot (5B), determine, based on the degree of priority, whether priority is given to passage of the first robot (5A) over passage of the human (H1), or priority is given to the passage of the human (H1) over the passage of the first robot (5A), or the human (H1) and the first robot (5A) are allowed to pass through on a first come, first served

basis.

[0170] This enables whether the security gate (3) is passable or impassable to be determined in detail.

[0171] In an entry/exit management system (1) of a ninth aspect referring to any one of the first to eighth aspects, the management unit (111) is configured to, when causing the security gate (3) to permit the first robot (5A) to pass through, notify the human (H1) that the humans (H1) is prohibited from passing through the security gate (3).

[0172] With this configuration, the human (H1) can know that the human (H1) is prohibited from passing through the security gate (3).

[0173] The configurations other than the configuration of the first aspect are not essential configurations of the entry/exit management system (1) and may accordingly be omissible.

[0174] An entry/exit management method according to a tenth aspect includes a management step and a human sensing step. The management step includes controlling a security gate (3). A plurality of autonomous robots (5) and a human (H1) are to pass through the security gate (3). The plurality of autonomous robots (5) includes a first robot (5A) and a second robot (5B). The human sensing step includes determining, based on an output of a sensor (2) configured to sense the human (H1) staying in a sensing area (70) at an installation place of the security gate (3), presence or absence of the human (H1) in the sensing area (70). The management step includes: determining, when receiving a passage request requesting passage through the security gate (3) from the first robot (5A), whether or not there is a passage conflict between the first robot (5A) and the second robot (5B); and determining, based on a determination result in the human sensing step, whether or not there is a passage conflict between the first robot (5A) and the human (H1). A state where there is the passage conflict between the first robot (5A) and the second robot (5B) is a state where around the same time that the first robot (5A) is about to pass through the security gate (3), the second robot (5B) is also about to pass through the security gate (3). A state where there is the passage conflict between the first robot (5A) and the human (H1) is a state where

around the same time that the first robot (5A) is about to pass through the security gate (3), the human (H1) is also about to pass through the security gate (3). The management step includes causing, when there is no passage conflict between the first robot (5A) and the second robot (5B) and there is no passage conflict between the first robot (5A) and the human (H1), the security gate (3) to permit the first robot (5A) to pass through.

[0175] This configuration enables traffic congestion at the installation place of the security gate (3) to be mitigated.

[0176] A program of an eleventh aspect is a program for causing one or more processors of a computer system to execute the entry/exit management method of the tenth aspect.

[0177] This configuration enables traffic congestion at the installation place of the security gate (3) to be mitigated.

[0178] Various configurations (including variations) of the entry/exit management system (1) according to the embodiments are not limited to the aspects described above but may be implementable by an entry/exit management method, a (computer) program, or a non-transitory recording medium storing the program.

Reference Signs List

[0179]	1	Entry/Exit Management System
	2	Sensor
	3	Security Gate
	5	Autonomous Robot
	5A	First Robot
	5B	Second Robot
	70	Sensing Area
	80	Predetermined Place
	111	Management Unit

112 Human Sensing Unit

H1 Human

CLAIMS

[Claim 1] An entry/exit management system comprising:

 a management unit configured to control a security gate through which a plurality of autonomous robots and a human are to pass, the plurality of autonomous robots including a first robot and a second robot; and

 a human sensing unit configured to determine, based on an output of a sensor configured to sense the human staying in a sensing area at an installation place of the security gate, presence or absence of the human in the sensing area,

 the management unit being configured to, when the entry/exit management system receives a passage request requesting passage through the security gate from the first robot, determine whether or not there is a passage conflict between the first robot and the second robot and determine, based on a determination result by the human sensing unit, whether or not there is a passage conflict between the first robot and the human,

 a state where there is the passage conflict between the first robot and the second robot being a state where around the same time that the first robot is about to pass through the security gate, the second robot is also about to pass through the security gate,

 a state where there is the passage conflict between the first robot and the human being a state where around the same time that the first robot is about to pass through the security gate, the human is also about to pass through the security gate,

 the management unit being configured to, when there is no passage conflict between the first robot and the second robot and there is no passage conflict between the first robot and the human, cause the security gate to permit the first robot to pass through.

[Claim 2] The entry/exit management system of claim 1, wherein

 the management unit is configured to, when the human sensing unit determines the

presence of the human in the sensing area at reception of the passage request from the first robot by the entry/exit management system, determine that there is the passage conflict between the first robot and the human.

[Claim 3] The entry/exit management system of claim 1 or 2, wherein

the management unit is configured to, when the entry/exit management system receives a passage request from the second robot around the same time that the entry/exit management system receives the passage request from the first robot, determine that there is the passage conflict between the first robot and the second robot.

[Claim 4] The entry/exit management system of any one of claims 1 to 3, wherein

the management unit is configured to determine, based on at least one of a congestion degree of the human in the sensing area, a task carried out by the first robot, or a destination of the first robot, whether or not to permit the first robot to pass through the security gate when there is the passage conflict between the first robot and the human or the second robot.

[Claim 5] The entry/exit management system of claim 4, wherein

the management unit is configured to
obtain, based on a past congestion degree of the human in the sensing area, a predicted value of a current congestion degree of the human in the sensing area and
determine, based on the predicted value, whether or not to permit the first robot to pass through the security gate when there is the passage conflict between the first robot and the human or the second robot.

[Claim 6] The entry/exit management system of claim 4 or 5, wherein

the management unit is configured to, when the number of humans staying in the sensing

area is larger than or equal to a predetermined value, prohibit the first robot from passing through the security gate.

[Claim 7] The entry/exit management system of any one of claims 4 to 6, wherein
the human in a predetermined place is able to travel to the installation place of the security gate,
the management unit is configured to predict, based on the number of humans staying in the predetermined place, the congestion degree of the human in the sensing area, and
the management unit is configured to determine, based on the congestion degree of the human in the sensing area thus predicted, whether or not to permit the first robot to pass through the security gate when there is the passage conflict between the first robot and the human or the second robot.

[Claim 8] The entry/exit management system of any one of claims 4 to 7, wherein
the management unit is configured to determine a degree of priority of the first robot on a basis of at least one of the congestion degree of the human in the sensing area, the task carried out by the first robot, or the destination of the first robot, and
the management unit is configured to, when there is the passage conflict between the first robot and the human or the second robot, determine, based on the degree of priority, whether priority is given to passage of the first robot over passage of the human, or priority is given to the passage of the human over the passage of the first robot, or the human and the first robot are allowed to pass through on a first come, first served basis.

[Claim 9] The entry/exit management system of any one of claims 1 to 8, wherein
the management unit is configured to, when causing the security gate to permit the first robot to pass through, notify the human that the human is prohibited from passing through the

security gate.

[Claim 10] An entry/exit management method comprising:

a management step of controlling a security gate through which a plurality of autonomous robots and a human are to pass, the plurality of autonomous robots including a first robot and a second robot; and

a human sensing step of determining, based on an output of a sensor configured to sense the human staying in a sensing area at an installation place of the security gate, presence or absence of the human in the sensing area,

the management step including: determining, when receiving a passage request requesting passage through the security gate from the first robot, whether or not there is a passage conflict between the first robot and the second robot; and determining, based on a determination result in the human sensing step, whether or not there is a passage conflict between the first robot and the human,

a state where there is the passage conflict between the first robot and the second robot being a state where around the same time that the first robot is about to pass through the security gate, the second robot is also about to pass through the security gate,

a state where there is the passage conflict between the first robot and the human being a state where around the same time that the first robot is about to pass through the security gate, the one of the humans is also about to pass through the security gate,

the management step including causing, when there is no passage conflict between the first robot and the second robot and there is no passage conflict between the first robot and the human, the security gate to permit the first robot to pass through.

[Claim 11] A program for causing one or more processors of a computer system to execute the entry/exit management method of claim 10.