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| United States Patent Application Publication | 20250264880 |
| Kind Code | A1 |
| Publication Date | August 21, 2025 |
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## MANAGEMENT DEVICE, MANAGEMENT METHOD, AND MANAGEMENT PROGRAM

### Abstract


A management device includes a memory configured to store map information for each area where a robot, which autonomously travels outdoors and indoors, travels, and processing circuitry configured to collect external information, receive a current position of the robot or a travel route of the robot from a control device controlling the robot, detect an occurrence of an event and an event occurrence area where the event occurs, based on the external information, identify the robot located in the event occurrence area or the robot predicted to be located in the event occurrence area based on the current position of the robot or the travel route of the robot, determine information about a new travel route for each robot located in the event occurrence area or each robot predicted to be located in the event occurrence area based on the external information and the map information, and recommend information.



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**Appl. No.:** **19/176213**

**Filed:** **April 11, 2025**

### Foreign Application Priority Data

| | | |
|---|---|---|
| JP | 2022-165912 | Oct. 14, 2022 |

### Related U.S. Application Data

parent WO continuation PCT/JP2023/037177 20231013 PENDING child US 19176213

## Publication Classification

**Int. Cl.:** **G05D1/606** (20240101)

**U.S. Cl.:**

CPC **G05D1/606** (20240101);

## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation application of International Application No. PCT/JP2023/037177, filed on Oct. 13, 2023 which claims the benefit of priority of the prior Japanese Patent Application No. 2022-165912, filed on Oct. 14, 2022, the entire contents of which are incorporated herein by reference.

FIELD
[0002] The present invention relates to a management device, a management method, and a management program.
BACKGROUND
[0003] In recent years, autonomous mobile robots have been developed to address labor shortages. Autonomous mobile robots can travel indoors or outdoors to deliver goods, provide security, guide people, clean, transfer people, or the like.
[0004] The autonomous mobile robots are being considered for expanding their travel area to include not only the interior and surrounding areas of a single facility, but also the areas between and around multiple facilities and the traffic in and between multiple areas by remote control and simultaneous control of multiple robots.
[0005] Each robot travels autonomously, for example, with tasks and travel routes set by the respective robot operator, and its travel controlled by a robot provider's control server.
[0006] Patent Literature 1: Japanese Laid-open Patent Publication No. 2019-078618
[0007] Patent Literature 2: Japanese Laid-open Patent Publication No. 2019-079247
[0008] When an event (e.g., all events that interfere or may interfere with the autonomous traveling of robots, which include area restrictions and traffic restrictions due to an event, weather changes such as guerrilla downpours, and so on; hereinafter simply referred to as “event”) occurs or is predicted to occur in the area where robots are traveling, each robot operator needs to change the travel route of the corresponding robot traveling in the area where the event occurs, make a decision to cancel the travel, or change the timing of the travel (e.g., advancing or delaying the timing). In this case, for example, each robot operator needs to collect information about the event using external information or the like, and rewrite the travel route of the robot located in the event occurrence area to a new travel route (a travel route that avoids the occurring event, hereafter simply referred to as “new travel route”) to make the robot avoid the event. On the other hand, when each robot operator determines that the robot is not affected by the occurrence of an event, the robot needs to operate normally (normal travel) without changing its travel route.
[0009] As the areas expand and the number of robots increases, and thus the number of areas and robots managed by the robot operators increases, the robot operator needs to quickly change the travel route of each robot when an event occurs. This may result in a very high processing burden on the robot operator when an event occurs, making it difficult to quickly change the robot's travel route.
[0010] In view of the above, it is an object of the present invention to provide a management device, a management method, and a management program that can provide information that

enables understanding of the impact on a travel decision and a travel route of an autonomous mobile robot when an event occurs and is predicted to occur.

SUMMARY

[0011] It is an object of the present invention to at least partially solve the problems in the related technology.

[0012] According to an aspect of the embodiments, a management device includes: a memory configured to store map information for each area where a robot, which autonomously travels outdoors and indoors, travels; and processing circuitry configured to: collect external information; receive a current position of the robot or a travel route of the robot from a control device controlling the robot; detect an occurrence of an event and an event occurrence area where the event occurs, based on the external information; identify the robot located in the event occurrence area or the robot predicted to be located in the event occurrence area based on the current position of the robot or the travel route of the robot; determine information about a new travel route for each robot located in the event occurrence area or each robot predicted to be located in the event occurrence area based on the external information and the map information; and recommend information about the new travel route to a terminal device.

[0013] The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

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## Description

BRIEF DESCRIPTION OF DRAWINGS

[0014] FIG. **1** illustrates a schematic of a management system in an embodiment;

[0015] FIG. **2** is a block diagram illustrating an example of a configuration of the management system in the embodiment;

[0016] FIG. **3** is a block diagram illustrating an example of a configuration of a control server illustrated in FIG. **2**;

[0017] FIG. **4** is a block diagram illustrating an example of a configuration of a management server illustrated in FIG. **2**;

[0018] FIG. **5** is a diagram illustrating an example of a map diagram of an area;

[0019] FIG. **6** is a diagram illustrating an example of a screen of the management server illustrated in FIG. **2** at the time of travel restriction due to accident occurrence;

[0020] FIG. **7** is a diagram illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to accident occurrence;

[0021] FIGS. **8**A to **8**D are diagrams illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to accident occurrence;

[0022] FIG. **9** is a diagram illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to accident occurrence;

[0023] FIG. **10** is a diagram illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to a weather forecast;

[0024] FIG. **11** is a diagram illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to a weather forecast;

[0025] FIGS. **12**A to **12**D are diagrams illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to a weather forecast;

[0026] FIG. **13** is a diagram illustrating an example of the screen of the management server illustrated in FIG. **2** at the time of travel restriction due to a weather forecast;

[0027] FIG. **14** is a diagram illustrating an example of the screen of the management server illustrated in FIG. **2** when the travel restriction due to a weather forecast is lifted;

[0028] FIGS. **15**A to **15**D are diagrams illustrating an example of the screen of the management server illustrated in FIG. **2** when the travel restriction due to a weather forecast is lifted;

[0029] FIG. **16** is a sequence diagram illustrating a processing procedure of a management method according to an embodiment; and

[0030] FIG. **17** is a diagram illustrating a computer executing a computer program.

DESCRIPTION OF EMBODIMENTS

[0031] The following is a detailed description of embodiments of a management device, a management method, and a management program according to the present application with reference to the drawings. The management device, the management method, and the management program according to the present application are not limited by these embodiments.

Embodiments

[0032] In the following embodiments, a management device and a processing flow of a management method according to the embodiments will be described in order, and effects of the embodiments will be explained at the end.

[0033] FIG. **1** illustrates a schematic of a management system in the embodiment. FIG. **2** is a block diagram illustrating an example of a configuration of the management system in the embodiment.

[0034] As illustrated in FIGS. **1** and **2**, the management system in the embodiment includes control servers **20**A and **20**B (control devices) that control robots **10**A-**1**, **10**A-**2**, **10**B-**1**, and **10**B-**2**, which travel autonomously outdoors and indoors, and a management server **30** (management device) that provides information on robot control.

[0035] In the management system in the embodiment, a plurality of the control servers **20**A and **20**B use wireless communication or the like to control autonomous mobile robots **10**A-**1**, **10**A-**2**, **10**B-**1**, and **10**B-**2** by using wireless communication or the like.

[0036] The configuration illustrated in FIGS. **1** and **2** is only one example, and the specific configuration and the number of devices are not limited. When referring to the robots **10**A-**1**, **10**A-**2**, **10**B-**1**, and **10**B-**2** collectively, they are described as robots **10**. When referring to the robots **10**A-**1** and **10**A-**2** collectively, they are described as robots **10**A. When referring to the robots **10**B-**1** and **10**B-**2** collectively, they are described as robots **10**B. When referring to the control servers **20**A and **20**B collectively, they are described as control servers **20**.

[0037] The control server **20**A controls the autonomous traveling of the robots **10**A according to a robot control system of a robot provider A. The control server **20**B controls the autonomous traveling of the robots **10**B according to a robot control system of a robot provider B. The control server **20** sets a task and a travel route for each of the robots **10** to be controlled, for example, via robot operator's operation. As the aforementioned robot operator's operation, the robot operator (human) sets the task and the travel route for each of the robots **10** to be controlled by operating a terminal device or other device.

[0038] The robots **10** travel to and from a plurality of areas E**1**-**1** to E**1**-**3**, including areas between and around a plurality of facilities, and between the areas E**1**-**1** to E**1**-**3**, according to the control of the control servers **20**, and perform tasks such as goods delivery, security, guiding, cleaning, transferring people, and other tasks.

[0039] Each of the robots **10**, for example, has a communication unit that communicates with the corresponding control server **20** and a traveling function that enables autonomous traveling. The robot **10** also has various sensors that detect obstacles around it, and input/output units such as a touch panel, a microphone, and a speaker that receive operation input from a user and output audio or image information. The robot **10** may, for example, have an imaging device to capture images of the robot **10**'s surroundings. The robot **10** transmits the detection results by the sensors, images captured by the imaging device, and various information input by the user to the control server **20** via the communication unit.

[0040] The robot **10** travels according to the travel route set by the control server **20** and performs the task set by the control server **20**. The current position of the robot **10** may be identifiable by the control server **20** using a positioning system such as a global positioning system (GPS).

[0041] The management server **30** of a platformer provides information on robot control to a terminal device **90**. The management server **30** receives the current positions or travel routes of the robots **10** from the control servers **20**. Each of the travel routes is also assigned a travel period for this travel route. The management server **30** may also receive from the control servers **20** various information transmitted from the robots **10** to the control servers **20**.

[0042] The management server **30** then collects external information from various external servers to which the management server **30** connects via a communication network. The management server **30** provides information on robot control to the terminal device **90** based on the collected information.

[0043] External servers may include, for example, a disaster prediction server **40**, a sensor management server **50**, a human flow prediction server **60**, an external server **70**, and an off-limits area information server **80**.

[0044] The disaster prediction server **40** is a server installed at a meteorological agency, a local government, or a private company, which predicts the occurrence of earthquakes, tsunamis, tornadoes, and eruptions, and publishes special warnings, warnings, advisories, and disaster prevention information. The disaster prediction server **40** also predicts and publishes information on the probability of precipitation and the occurrence of guerrilla downpours in the areas based on meteorological information (e.g., precipitation probability, record-setting short-time heavy rainfall information, etc.) published by the meteorological agency and other organizations.

[0045] The sensor management server **50** manages the detection operations of the various sensors installed in the robot travel area and collects the detection results from the various sensors. The various sensors include security cameras, motion sensors, and temperature sensors installed in various locations.

[0046] The human flow prediction server **60** predicts the human flow in a prediction target area during a prediction target period based on mobile data, images from security cameras, transportation usage information, and detection results from sensors (e.g., human detection sensors).

[0047] The external server **70** is a server that publishes news articles, blog articles, social networking service (SNS) articles, or the like.

[0048] The off-limits area information server **80** is a server that predicts and publishes the occurrence of an area that is off-limits to robots based on event information, accident occurrence information, construction information, traffic restriction information, or the like in the relevant area published by administrative offices, facility managers, event operators, or the like. The off-limits area information server **80** may use other information, not limited to the aforementioned information, to predict off-limits areas.

[0049] The management server **30** collects external information from various external servers, and when it detects the occurrence of an event, it recommends a new travel route for the robot **10** located in the event occurrence area to the terminal device **90**. Instead of a new travel route, the management server **30** may recommend an off-limits area or the like to the terminal device **90**. Note that the provided terminal device **90** outputs information transmitted from the management server **30** and receives operations on the management server **30**, and can implement an instruction to the control server **20** to change the travel route of the robot **10**. A plurality of the terminal devices **90** may be installed for respective robot providers.

[0050] The control server **20** sets a new travel route or the like for each robot based on information input from the terminal device **90** operated by the robot operator. For example, the robot operator changes the travel routes of the robots **10** by rewriting the travel routes to new travel routes recommended by the management server **30**. In this way, the management server **30** supports quick change of travel routes of an autonomous mobile robot when an event occurs. The terminal device

**90** operated by the robot operator may be provided as an independent terminal device for each robot provider. Control server

[0051] The control server **20** is described below. FIG. **3** is a block diagram illustrating an example of a configuration of the control server **20** illustrated in FIG. **2**. As illustrated in FIG. **3**, the control server **20** may include a communication unit **21**, a memory unit **22**, and a control unit **23**. The control server **20** may be connected to input devices such as a mouse and a keyboard, and output devices such as a display and a speaker.

[0052] The communication unit **21** may control communication regarding various types of information. For example, the communication unit **21** may control communication with each of the robots **10** and communication with the management server **30**. The communication unit **21** may transmit task and travel route setting instructions and travel control information to the robot **10** to control the travel and task execution of the robot **10**. The communication unit **21** may also receive information acquired by the robot **10**. The communication unit **21** may transmit the current position of the robot **10** or the travel route of the robot **10** to the management server **30**.

[0053] The memory unit **22** may store data and a computer program necessary for various processing by the control unit **23**. For example, the memory unit **22** may be a semiconductor memory element such as a random access memory (RAM) and a flash memory, or a storage device such as a hard disk and an optical disk. The memory unit **22** may include robot information **221**, map information **222**, a task memory unit **223**, travel route information **224**, and robot position information **225**.

[0054] The robot information **221** may be information that includes the identification information, type, and executable tasks of each robot controlled by the control server **20**.

[0055] The map information **222** may be map information for each area where the robot autonomously travels outdoors and indoors, which is stored by the memory unit **22**. For example, the map information **222** is map information that includes a map of the areas E**1-1** to E**1-3** and a map of traffic between the areas E**1-1** to E**1-3**. The map information **222** may be acquired in advance and updated as needed based on various sensor information, information transmitted from the robot **10**, or the like. For the map information **222**, the facilities in the areas E**1-1** to E**1-3**, robot **10** travelable areas in and around the facilities, and robot **10** travelable areas between the areas E**1-1** to E**1-3** may be superimposed on the map. The robot **10** may be capable of traveling outdoors and indoors.

[0056] The task memory unit **223** may store historical information on tasks executed by each robot **10**. A task that is being executed by each robot **10** may also be registered in the task memory unit **223** by a task setting unit **231** (to be described below). Tasks include goods delivery, security, guiding, cleaning, transferring people, and other tasks. The task memory unit **223** may store identification information of the robot **10**, task identification information, a task execution period, or the like.

[0057] The travel route information **224** may be information indicating a travel route of the robot **10**. A plurality of representative routes may be preset for travel routes, for example, depending on the area, task, and/or type of robot **10**, and may be modified or added as appropriate depending on the traveling conditions. A travel route for each robot **10** set by a travel route setting unit **232** (to be described below) may also be registered in the travel route information **224**.

[0058] The robot position information **225** may be information associated with the identification information of the robot **10**, and the position and the position detection time of the robot **10**.

[0059] The control unit **23** includes an internal memory for storing a computer program that specify various processing procedures or the like, and requested data, and may perform various processing with the computer program and the data. Here, the control unit **23** may be an electronic circuit such as a central processing unit (CPU) and a micro processing unit (MPU), or an integrated circuit such as an application specific integrated circuit (ASIC) and a field programmable gate array (FPGA).

[0060] The control unit **23** may include the task setting unit **231**, the travel route setting unit **232**, a robot position acquisition unit **233**, a travel control unit **234**, and a robot information transmission control unit **235**.
[0061] For example, when the task setting unit **231** receives a request for service provision from a user, it may set a task to be executed and select a robot **10** to execute this task.
[0062] The travel route setting unit **232** may set a travel route for the robot **10** selected by the task setting unit **231** according to the task. The travel route setting unit **232** may select one of preset routes as the travel route in response to the robot operator's operation. Alternatively, the travel route setting unit **232** may set a route that is a modified version of a preset route in response to the robot operator's operation.
[0063] The robot position acquisition unit **233** may acquire the current position of each robot **10** to be controlled using a positioning system such as a GPS. The robot position acquisition unit **233** may associate the identification information of the robot **10** with the position and position detection time of the robot **10** and store them in the memory unit **22**.
[0064] The travel control unit **234** may control the traveling of the robot **10** to be controlled, thereby causing the robot **10** to travel according to the travel route set by the travel route setting unit **232**.
[0065] The robot information transmission control unit **235** may transmit information about each robot **10** to be controlled to the management server **30** via the communication unit **21**. The robot information transmission control unit **235** may transmit, along with the identification information of each robot **10** to be controlled, the current position of the robot **10** or the travel route of the robot **10** to the management server **30**. The robot information transmission control unit **235** may transmit both the current position of each robot **10** to be controlled and the travel route of each robot **10** to the management server **30**. The robot information transmission control unit **235** may transmit the task of the robot **10** to be controlled and information received from the robot **10** to the management server **30**.
Management Server
[0066] Next, the management server **30** illustrated in FIG. **2** will be described. FIG. **4** is a block diagram illustrating an example of a configuration of the management server **30** illustrated in FIG. **2**. As illustrated in FIG. **4**, the management server **30** includes a communication unit **31**, a memory unit **32**, and a control unit **33**. The management server **30** is connected to input devices such as a mouse and a keyboard, and output devices such as a display and a speaker.
[0067] The communication unit **31** controls communication regarding various types of information. For example, the communication unit **31** controls communication with each external server and communication with the management server **30**. The communication unit **31** receives from the control server **20** the current position of the robot **10** to be controlled or the travel route of the robot **10**. The communication unit **31** also receives information acquired by the robot **10** to be controlled from the control server **20**. The communication unit **31** also receives external information, which is information for predicting and estimating the occurrence of an event, from an external server.
[0068] The memory unit **32** stores data and a computer program necessary for various processing by the control unit **33**. For example, the memory unit **32** is a semiconductor memory element such as a RAM and a flash memory, or a storage device such as a hard disk and an optical disk. The memory unit **32** includes robot information **321**, map information **322**, a task memory unit **323**, travel route information **324**, robot position information **325**, disaster information **326**, a sensor information group **327**, human flow prediction information **328**, an external information group **329**, and an off-limits area information group **330**.
[0069] The robot information **321** is information registered by associating the identification information of the control server **20** with the identification information of each robot controlled by the control server **20**. When the type and executable task of the robot **10** are provided by the control server **20**, the robot information **321** is registered with the type and executable task of the robot **10**

in association with the identification information of the robot **10**.

[0070] The map information **322** is map information that includes a map of the areas E**1-1** to E**1-3** and a map of traffic between the areas E**1-1** to E**1-3**. For the map information **322**, the facilities in the areas E**1-1** to E**1-3**, robot **10** travelable areas in and around the facilities, and robot **10** travelable areas between the areas E**1-1** to E**1-3** are superimposed on the map. The map information **322** is provided, for example, by the control server **20**.

[0071] When information on the task of the robot **10** is provided by the control server **20**, the task memory unit **323** stores the task, the task execution period, and the like in association with the identification information of the robot **10**.

[0072] The travel route information **324** is information provided by the control server **20** that indicates the travel route of the robot **10**. The travel route information **324** corresponds to the identification information of the robot **10** and the travel route of the robot **10**. The travel route is also assigned a travel period for this travel route.

[0073] The robot position information **325** is information provided by the control server **20** that indicates the current position of the robot **10**. The robot position information **325** is associated with the identification information of the robot **10**, the position of the robot **10**, and the position detection time.

[0074] The disaster information **326** is, for example, special warnings, warnings, advisories, and disaster prevention information for disasters, including the type of disaster that is predicted to occur, the degree of disaster, the time of occurrence, and the duration of the disaster. Furthermore, the disaster Information **326** includes information on precipitation probability and the occurrence of guerrilla downpours in the relevant area. The disaster information **326** is contained, for example, in information received from the disaster prediction server **40**.

[0075] The sensor information group **327** is an information group received from the sensor management server **50** that indicates the detection results of various sensors installed in the robot travel areas. The sensor information group **327** is, for example, an image captured by a security camera, a sensing result by a human sensor, a detected temperature by a temperature sensor, and the like.

[0076] The human flow prediction information **328** is information indicating the human flow in the prediction target area during the prediction target period, as predicted by the human flow prediction server **60**. When the management server **30** receives information about an event (e.g., the holding of an event), the human flow prediction information **328** acquires the human flow prediction information in the event occurrence area during the event occurrence period by means of a prediction request by the management server **30** to the human flow prediction server **60**.

[0077] The external information group **329** is information about various articles and smart cities published and released by the external server **70**. These pieces of information may allow for the sequential recognition of the occurrence status of events, which is held by administrative offices or local governments.

[0078] The off-limits area information group **330** is information predicted and published by the off-limits area information server **80**, and is included in event information, accident occurrence information, construction information, traffic restriction information, or the like in the relevant area published by administrative offices, facility managers, event operators, or the like.

[0079] The control unit **33** includes an internal memory for storing a computer program that specify various processing procedures or the like, and requested data, and performs various processing with the computer program and the data. Here, the control unit **33** is an electronic circuit such as a CPU and MPU, or an integrated circuit such as an ASIC and FPGA.

[0080] The control unit **33** includes a robot position acquisition unit **331** (acquisition unit), a travel route acquisition unit **332** (acquisition unit), an information collection unit **333** (collection unit), an event occurrence detection unit **334** (detection unit), a target robot identification unit **335** (identification unit), a new travel route determination unit **336** (determination unit), and a new travel route recommendation unit **337** (recommendation unit).

[0081] The robot position acquisition unit **331** may receive the identification information of the robot **10** and the current position of the robot **10** from the control server **20**, which is the control device controlling the robot **10**. The robot position acquisition unit **331** registers the acquired current position of the robot **10** in the robot position information **325**.

[0082] The travel route acquisition unit **332** may receive the identification information of the robot **10** and the travel route of the robot **10** from the control server **20**, which is the control device controlling the robot **10**. The travel route acquisition unit **332** registers the acquired travel route of the robot **10** in the travel route information **324**.

[0083] The information collection unit **333** collects various types of external information. The information collection unit **333** collects, as external information, special warnings, warnings, advisories, and disaster prevention information for disasters, and information about weather received from the disaster prediction server **40**; detection results of various sensors installed in the robot travel areas received from the sensor management server **50**; human flow prediction information in an event occurrence area predicted by the human flow prediction server **60**; various articles published by the external server **70**; event information, accident occurrence information, construction information, traffic restriction information, or the like in the relevant area published by event operators or the like, which is published by the off-limits area information server **80**.

[0084] The information collection unit **333** may collect an image taken by the robot **10** and a detection result detected by a sensor of the robot **10** to determine whether the area around the robot **10** is travelable or not.

[0085] The event occurrence detection unit **334** determines, based on external information, whether an event has occurred or is predicted to occur. Based on the external information, the event occurrence detection unit **334** detects the occurrence of an event, the event occurrence area where the event occurs, and the event occurrence period during which the event is predicted to occur. The event occurrence detection unit **334** may identify the occurrence of an event and the event occurrence area based on: special warnings, warnings, advisories, and disaster prevention information for disasters, and information about weather received from the disaster prediction server **40**; detection results of various sensors installed in the robot travel areas received from the sensor management server **50**; human flow prediction information in an event occurrence area predicted by the human flow prediction server **60**; various articles published by the external server **70**; event information, accident occurrence information, construction information, traffic restriction information, or the like in the relevant area published by event operators or the like, which is published by the off-limits area information server **80**.

[0086] The target robot identification unit **335** identifies the robot **10** located in an event occurrence area as the robot subject to travel route change, based on the current position of the robot **10** or the travel route of the robot **10**. The target robot identification unit **335** identifies the robot **10** currently located in the event occurrence area detected by the event occurrence detection unit **334** or the robot **10** predicted to be located in the event occurrence area, based on the current position of the robot **10** provided by the control server **20**. The target robot identification unit **335** identifies the robot **10** that is currently traveling or is predicted to travel in the event occurrence area detected by the event occurrence detection unit **334**, based on the travel route of the robot **10** provided by the control server **20**.

[0087] Furthermore, when the robot **10** does not retain information about the travel route, the target robot identification unit **335** identifies the robot located in the event occurrence area based on the current position of the robot. When the robot **10** retains information about the travel route, the target robot identification unit **335** identifies the robot **10** that retains the travel route included in the event occurrence area.

[0088] The new travel route determination unit **336** determines information about a new travel route for each robot **10** located in an event occurrence area or predicted to be located in an event occurrence area, based on the external information collected by the information collection unit **333** and the map information **322**. Specifically, the external information includes a result of event occurrence prediction based on one or more of information about a disaster in each area, information acquired by the robot **10**, information about human flow, information about weather, and information about traffic. The new travel route determination unit **336** determines information about a new travel route that avoids the event indicated by the result of the event occurrence prediction.

[0089] The new travel route determination unit **336** then determines new travel routes that differ among robots located or predicted to be located in the event occurrence area. The new travel route determination unit **336** may determine what new travel route to travel based on the task of the robot **10** and the type of robot **10**. The new travel route determination unit **336** may, for example, determine a new travel route by assigning a shaded travel location to a robot **10** that has been set the task of delivering refrigerated or frozen goods.

[0090] Furthermore, the new travel route determination unit **336** determines a new travel route for the robot **10** by selecting or modifying one of the preset travel routes and setting the travel direction according to a preset determination rule.

[0091] Alternatively, the new travel route determination unit **336** may determine the new travel route using a determination model **3361** that determines a new travel route. The determination model **3361** is, for example, a model that has been trained to output a new travel route for each robot **10**, using, as training data, various types of information such as map information of each area, positions of the robots **10**, the number of robots **10**, types of robots **10**, predicted human flow information or human flow historical information, types and scales of events to occur, and event occurrence periods, and the like, and the new travel route for each condition.

[0092] The new travel route recommendation unit **337** recommends information on the new travel route determined by the new travel route determination unit **336** to the terminal device **90**. For example, the new travel route recommendation unit **337** may transmit the robot **10** subject to travel route change and the new travel route for the robot **10** so that they are displayed on a system screen displayed on a terminal device or other device operated by a robot operator. Alternatively, the new travel route recommendation unit **337** may transmit, to the terminal device **90**, visualization information including text recommending a change in travel route due to the occurrence of an event or other items and the new travel route for each robot **10** that are superimposed on the map of the event occurrence area. Furthermore, based on the recommended information, the robot operator may operate a terminal device or other device to change the travel route of the robot **10**.

Example of Set Route

[0093] An example of a travel route of the robot **10** transmitted from the control server **20** will be described. In FIG. **5** and beyond, for example, the area E**1-1** is explained among a plurality of areas. FIG. **5** is a diagram illustrating an example of a map diagram of the area E**1-1**.

[0094] As illustrated in a map M**1**s in FIG. **5**, a plurality of facilities are provided in the area E**1-1**. The robots **10** can travel inside these facilities and outdoors including non-building areas around the facilities. In the area E**1-1**, two evacuation sites T**1** and T**2** may be set as evacuation sites for the robots **10**, as illustrated in the map M**1**s. In addition to avoiding events by changing the travel routes, the robots **10** can also retreat to the evacuation sites T**1** and T**2**. In both T**1** and T**2**, two robots **10** can be evacuated.

[0095] For example, the management server **30** receives, from the control server **20**, the travel routes and/or current positions of the two robots **10**A-**1** and **10**B-**2**. For example, the travel route of robot **10**A-**1** is a travel route R**1***s* and the travel route of the robot **10**B-**2** is a travel route R**2***s*.

Example of Screen Display

[0096] From here, an example of a screen display of the management server **30** when an event occurs in the area E**1-1** will be described. FIGS. **6** through **15** illustrate examples of screens of the management server **30** illustrated in FIG. **2**. In the following sections, FIGS. **6** through **9** illustrate the case of “travel restriction due to accident occurrence”, FIGS. **10** through **13** illustrate the case of “travel restriction due to weather forecast”, and FIGS. **14** and **15** illustrate “lifting of travel restriction due to weather forecast”.

Travel Restriction Due to Accident Occurrence

[0097] When the management server **30** detects, based on external information, that a travel restriction due to accident occurrence has occurred in the area E**1-1**, the management server **30** may indicate on the map M**1**s of the area E**1-1** that the travel restriction due to accident occurrence has been published, as illustrated in FIG. **6** (for example, refer to a window W**1** in FIG. **6**). The location where the travel restriction occurs in this case is assumed to be a travel restriction area A**1** in the area E**1-1** illustrated in FIG. **7**.

[0098] The management server **30** then indicates in a control instruction list L**1-2** illustrated in FIGS. **8**A to **8**D the robot **10** located in the area E**1-1** during the period when the travel restriction is in effect as the robot **10** subject to travel route change. For example, as illustrated in columns C**1-1** and C**1-2** of the control instruction list L**1-2**, the robots **10**A-**1** and **10**B-**2** are indicated as the robots **10** located in the area E**1-1**.

[0099] When a button B**1-2** to “Notify robot operator” is selected by an administrator of the management server **30**, the management server **30** determines a new travel route R**1** for the robot **10**A-**1**. On the other hand, since the travel route of the robot **10**B-**2** does not involve the travel restriction area A**1**, the travel route R**2***s* is determined as the set travel route. The management server **30** then recommends the new travel route R**1** for the robot **10**A-**1** and alert information about the information on the travel restriction area A**1** for the robot **10**B-**2** to the terminal device **90** (refer to control instruction lists L**1-3** and L**1-4**). Based on the recommended information, the robot operator may then operate the terminal device or other device to change the travel route of the robot **10**.

[0100] Then, when the management server **30** detects, based on the external information, that the accident has been processed and the travel restriction due to accident occurrence has been lifted, the management server **30** may indicate on the map M**1**s of the area E**1-1** that the travel restriction due to accident occurrence has been lifted, as illustrated in FIG. **9** (for example, refer to a window W**2** in FIG. **9**).

Travel Restriction Due to Weather Forecast

[0101] Next, when the management server **30** detects, based on external information, that a travel restriction due to weather forecast has occurred in the area E**1-1**, the management server **30** may indicate on the map M**1**s of the area E**1-1** that the travel restriction due to weather forecast has been published, as illustrated in FIG. **10** (for example, refer to a window W**3** in FIG. **10**). In this case, it is assumed that the travel restriction occurs due to the occurrence of a guerrilla downpour as a weather phenomenon, and that the location where the travel restriction occurs is a travel restriction area A**2** in the area E**1-1** illustrated in FIG. **11**.

[0102] The management server **30** then indicates in a control instruction list L**2-2** illustrated in FIGS. **12**A to **12**D the robot **10** located in the area E**1-1** during the period when the travel restriction is in effect as the robot **10** subject to travel route change. For example, as illustrated in columns C**2-1** and C**2-2** of the control instruction list L**2-2**, the robots **10**A-**1** and **10**B-**2** are indicated as the robots **10** located in the area E**1-1**.

[0103] When a button B**2-2** to “Notify robot operator” is selected by the administrator of the management server **30**, the management server **30** determines that, for the robots **10**A-**1** and **10**B-**2**, the travel is cancelled due to the occurrence of a guerrilla downpour. Then, for the robots **10**A-**1** and **10**B-**2**, the management server **30** recommends new travel routes R**3** and R**4** to the evacuation site TI to the terminal device **90** (refer to control instruction lists L**2-3** and L**2-4**). Instead of a new travel route to the evacuation site T**1**, the management server **30** may recommend to the terminal device **90** a new travel route to the evacuation site T**2** or a new travel route outside the travel restriction area. Based on the recommended information, the robot operator may then operate the terminal device or other device to change the travel routes of the robots **10**.

[0104] Then, when the management server **30** detects, based on external information, that the guerrilla downpour has ended and the travel restriction have been lifted, the management server **30** may indicate on the map M**1**s of the area E**1-1** that the travel restriction due to weather forecast has been lifted, as illustrated in FIG. **13** (for example, refer to a window W**4** in FIG. **13**).

Lifting of Travel Restriction Due to Weather Forecast

[0105] Next, when the management server **30** detects, based on external information, that the travel restriction has been lifted due to a decrease in precipitation probability in the area E**1-1**, as illustrated in FIG. **14**, the management server **30** may indicate on the map M**1**s of the area E**1-1** that the lifting of the travel restriction due to weather forecast (forecast of decreased precipitation probability) has been published (for example, refer to a window W**5** in FIG. **14**). The location where the travel restriction occurs in this case is assumed to be the same as the travel restriction area A**2** in the area E**1-1** illustrated in FIG. **11**.

[0106] The management server **30** then indicates in a control instruction list L**3-2** in FIGS. **15**A to **15**D the robot **10** located in the area E**1-1** at the timing when the travel restriction is lifted as the robot **10** subject to travel route change. For example, as illustrated in columns C**3-1** and C**3-2** of the control instruction list L**3-2**, the robots **10**A-**1** and **10**B-**2** are indicated as the robots **10** located in the area E**1-1**.

[0107] When a button B**3-2** to “Notify robot operator” is selected by the administrator of the management server **30**, the management server **30** determines that, for the robots **10**A-**1** and **10**B-**2**, the travel restriction due to weather forecast (forecast of decreased precipitation probability) is lifted. The management server **30** then recommends to the terminal device **90** that, for the robots **10**A-**1** and **10**B-**2**, the travel restriction has been lifted and operation is now possible (refer to control instruction lists L**3-3** and L**3-4**). At this time, for the robots **10**A-**1** and **10**B-**2**, the management server **30** may recommend, to the terminal device **90**, new travel routes or existing travel routes (R**1***s* and R**2***s*) preset for the robots **10**A-**1** and **10**B-**2**. Based on the recommended information, the robot operator may then operate the terminal device or other device to change the travel routes of the robots **10**.

Management Processing

[0108] Next, management processing according to the embodiment will be explained. FIG. **16** is a sequence diagram illustrating a processing procedure of the management processing according to the embodiment.

[0109] As illustrated in FIG. **16**, the control servers **20**A and **20**B set tasks and travel routes to the robots **10**A and **10**B and control autonomous traveling of the robots **10**A and **10**B by communicating with the robots **10**A and **10**B (steps S**1** and S**3**).

[0110] By receiving the current positions or travel routes of the robots **10** from the respective control servers **20** (steps S**2** and S**4**), the management server **30** acquires the current positions or travel routes of the robots **10** (step S**5**).

[0111] The management server **30** collects external information from an external server or other sources (step S**6**). The management server **30** then determines, based on the external information, whether an event is predicted to occur (step S**7**). The management server **30** returns to the beginning if an event is not predicted to occur (No at step S**7**).

[0112] If an event is predicted to occur (Yes at step S**7**), the management server **30** detects the event occurrence area where the event will occur and the event occurrence period during which the event is predicted to occur (step S**8**).

[0113] The management server **30** identifies the robot **10** that is located or predicted to be located in the event occurrence area based on the current position of the robot **10** or the travel route of the robot **10** (step S**9**).

[0114] Subsequently, the management server **30** determines a new travel route for each robot **10** located in the event occurrence area based on the external information collected by the information

collection unit **333** and the map information **322** (step S**10**).
[0115] Then, the management server **30** recommends the information about each robot that is located or predicted to be located in the event occurrence area and the new travel route of each robot, as determined by the new travel route determination unit **336**, to the terminal device **90**, for example (steps S**11** and S**12**). When the new travel route of each robot **10** located in the event occurrence area is set via the terminal device **90** operated by the robot operator (steps S**13**, S**14**, S**15**, and S**16**), the control servers **20**A and **20**B change the travel routes of the respective robots **10** located in the event occurrence area according to the set new travel routes (steps S**17** and S**18**).
Effects of Embodiments
[0116] Thus, the terminal device **90** is provided by the management server **30** with information about event occurrence and information about the robot **10** located in an event occurrence area. This eliminates the need for the robot operator of the control server **20** to collect information about event occurrence, detect the occurrence of an event, and identify the robot **10** located in the event occurrence area.
[0117] Furthermore, the terminal device **90** receives a recommendation from the management server **30** for a new travel route for the robot **10** located in the event occurrence area. Therefore, when the robot operator of the control server **20** rewrites the travel route of the robot **10** to a new travel route, it is sufficient to set the new travel route based on the travel route recommended by the management server **30**, instead of creating a new travel route from scratch.
[0118] Therefore, according to the embodiments, the processing burden of the robot operator until the travel route of the robot is changed is reduced, and the change of the travel route of the robot **10** when an event occurs can be executed quickly.
[0119] If a new travel route is set by each robot provider, there may be cases of collisions while traveling on new travel routes because the positions of robots controlled by other operators cannot be determined. In contrast, in the embodiments, the management server **30** collects information collectively, identifies each robot **10** located in the event occurrence area, regardless of which provider's robot **10**, and recommends a new travel route suitable for each robot **10** to the terminal device **90**.
[0120] Therefore, according to the embodiments, new travel route determination across areas and robot providers is possible even when many robots are introduced in a plurality of areas by a plurality of robot providers. Therefore, according to the embodiments, when an event occurs, quick and smooth change of a travel route for each robot **10** located in the event occurrence area can be supported.
System Configuration, etc.
[0121] In addition, each component of the devices illustrated in the drawings is a functional concept and does not necessarily have to be physically configured as illustrated in the drawings. In other words, the specific form of distribution and integration of the devices is not limited to that illustrated in the drawings, but can be configured by functionally or physically distributing and integrating all or some of them in optional units according to various loads and usage conditions. Furthermore, each processing function performed by the devices can be implemented, in whole or in part, by a CPU or graphics processing unit (GPU) and a program that is analyzed and executed by the CPU or GPU, or can be implemented as hardware using wired logic.
[0122] Of the various processing described in the present embodiment, all or part of the processing described as being performed automatically can be performed manually, or all or part of the processing described as being performed manually can be performed automatically by related methods. Other information including the processing procedures, control procedures, specific names, and various data and parameters illustrated in the above text and drawings may be changed as desired, unless otherwise noted.
Computer Program
[0123] It is also possible to create a computer program that describes the processing executed by

the management server **30** described in the above embodiment in a language that can be executed by a computer. For example, a computer program can be created that describes the processing executed by the management server **30** in the embodiment in a language that can be executed by a computer. In this case, the same effects as in the above embodiment can be obtained by a computer executing the computer program. Furthermore, the same processing as the above embodiment may be realized by recording such a computer program on a computer-readable recording medium, and having a computer read and execute the computer program recorded on the recording medium.
[0124] FIG. **17** is a diagram illustrating a computer executing a computer program. As illustrated in FIG. **17**, a computer **1000** includes, for example, a memory **1010**, a CPU **1020**, a hard disk drive interface **1030**, a disk drive interface **1040**, a serial port interface **1050**, a video adapter **1060**, and a network interface **1070**, and these parts are connected by a bus **1080**.
[0125] The memory **1010** includes a read only memory (ROM) **1011** and a RAM **1012**, as illustrated in FIG. **17**. The ROM **1011** stores boot programs such as a basic input output system (BIOS) for example. The hard disk drive interface **1030** is connected to a hard disk drive **1090**, as illustrated in FIG. **17**. The disk drive interface **1040** is connected to a disk drive **1100**. A removable storage medium, such as a magnetic or optical disk, for example, is inserted into the disk drive **1100**. The serial port interface **1050** is connected to, for example, a mouse **1110** and a keyboard **1120**. The video adapter **1060** is connected to a display **1130**, for example.
[0126] Here, as illustrated in FIG. **17**, the hard disk drive **1090** stores, for example, an operating system (OS) **1091**, an application program **1092**, a program module **1093**, and program data **1094**. That is, the above computer program is stored in the hard disk drive **1090**, for example, as a program module describing instructions to be executed by the computer **1000**.
[0127] The various data described in the above embodiment is stored as program data, for example, in the memory **1010** or the hard disk drive **1090**. The CPU **1020** reads the program module **1093** and the program data **1094** stored in the memory **1010** and the hard disk drive **1090** to the RAM **1012** as needed and executes various processing procedures.
[0128] The program module **1093** and the program data **1094** pertaining to the computer program are not limited to being stored in the hard disk drive **1090**, but, for example, may be stored in a removable storage medium, and read out by the CPU **1020** via a disk drive or the like. Alternatively, the program module **1093** and the program data **1094** pertaining to the computer program are stored in another computer connected via a network (local area network (LAN), wide area network (WAN), etc.) and may be read out by the CPU **1020** via the network interface **1070**.
[0129] The above embodiment and modifications thereof are included within the scope of the claimed invention and its equivalents as well as within the technology disclosed by the present application.
[0130] According to the present invention, it is possible to support the rapid change of travel routes of an autonomous mobile robot when an event occurs.
[0131] Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

## Claims

**1**. A management device comprising: a memory configured to store map information for each area where a robot, which autonomously travels outdoors and indoors, travels; and processing circuitry configured to: collect external information; receive a current position of the robot or a travel route of the robot from a control device controlling the robot; detect an occurrence of an event and an event occurrence area where the event occurs, based on the external information; identify the robot located in the event occurrence area or the robot predicted to be located in the event occurrence area based on the current position of the robot or the travel route of the robot; determine information about a new travel route for each robot located in the event occurrence area or each robot predicted to be located in the event occurrence area based on the external information and the map information; and recommend information about the new travel route to a terminal device.

**2**. The management device according to claim 1, wherein when the robot does not retain information about the travel route, the processing circuitry is further configured to identify the robot located in the event occurrence area based on the current position, and when the robot retains information about the travel route, identify the robot that retains the travel route included in the event occurrence area.

**3**. The management device according to claim 1, wherein the external information includes a result of event occurrence prediction based on one or more of information about a disaster in each area, information acquired by the robot, information about human flow, information about weather, and information about traffic, and the processing circuitry is further configured to determine information about the new travel route that avoids the event indicated by the result of the event occurrence prediction.

**4**. The management device according to claim 1, wherein the processing circuitry is further configured to determine information about new travel routes that differ among robots located in the event occurrence area.

**5**. A management method executed by a management device, the management method comprising: collecting external information; receiving a current position of a robot or a travel route of the robot from a control device controlling the robot; detecting an occurrence of an event and an event occurrence area where the event occurs based on the external information; identifying the robot located in the event occurrence area or the robot predicted to be located in the event occurrence area based on the current position of the robot or the travel route of the robot; determining information about a new travel route for each robot located in the event occurrence area or each robot predicted to be located in the event occurrence area based on the external information and the map information; and recommending information about the new travel route to a terminal device.

**6**. A non-transitory computer-readable recording medium storing therein a management program that causes a computer to execute a process comprising: collecting external information; receiving a current position of a robot or a travel route of the robot from a control device controlling the robot; detecting an occurrence of an event and an event occurrence area where the event occurs based on the external information; identifying the robot located in the event occurrence area or the robot predicted to be located in the event occurrence area based on the current position of the robot or the travel route of the robot; determining information about a new travel route for each robot located in the event occurrence area or each robot predicted to be located in the event occurrence area based on the external information and the map information; and recommending information about the new travel route to a terminal device.