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Inventor(s) OKAHARA; Masayuki et al.

MANAGEMENT DEVICE, MANAGEMENT METHOD, AND MANAGEMENT PROGRAM

Abstract

A management device includes a storage configured to store map information on each area in which a robot that travels autonomously outdoors and indoors travels, and processing circuitry configured to collect external information containing disaster information, receive a current position of the robot or a travel route for the robot from a control device that controls the robot, based on the external information, sense occurrence of a disaster and a disaster occurrence area in which the disaster occurs, based on the current position of the robot or the travel route for the robot, specify the robot that is positioned in the disaster occurrence area or the robot that is predicted to be positioned in the disaster occurrence area, and based on the external information and the map information, determine an evacuation route to an evacuation site that is set previously.

Inventors: **OKAHARA; Masayuki (Saitama-shi, JP), TAKI; Megumi (Tokyo, JP), TASHIRO; Takeharu (Yokohama-shi, JP)**

Applicant: **NTT Communications Corporation** (Tokyo, JP)

Family ID: **1000008618726**

Assignee: **NTT Communications Corporation (Tokyo, JP)**

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation application of International Application No. PCT/JP2023/037178, filed on Oct. 13, 2023 which claims the benefit of priority of the prior Japanese Patent Application No. 2022-165913, filed on Oct. 14, 2022, the entire contents of each 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 robots have been developed in order to deal with a labor shortage. Autonomous robots travel indoors and outdoors and thus perform tasks, such as goods delivery, guarding, guiding, cleaning, and transferring people.
[0004] There have been examinations on extension of an area in which the autonomous robots travel, not limited to the inside of a facility and an area around the facility, a plurality of facilities and areas around the facilities, and a plurality of areas and shuttles between the areas by remote operations and simultaneous control on a plurality of robots.
[0005] A task and a travel route are set in each robot, for example, by each robot operator and traveling by each robot is controlled by a control server of a robot business operator and accordingly each robot travels autonomously.
[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 a disaster occurs or in the case where occurrence of a disaster is predicted, each robot operator has to evacuate each robot traveling in a disaster occurrence area. In this case, for example, the robot operator has to collect disaster information, rewrite the travel route for the robot positioned in the disaster occurrence area to an evacuation route, and evacuate the robot.
[0009] With an increase in the area that the robot operator manages and in the number of robots in association with an increase in the number of robots and extension of the area, the robot operator has to evacuate each robot speedily when a disaster occurs or in the case where occurrence of a disaster is predicted. For this reason, the load of a process on the robot operator at the time of occurrence of a disaster or in the case where occurrence of a disaster is predicted increases extremely and difficulty in speedy evacuation of the robot is also assumed.
[0010] The present invention was made in view of the above-described circumstances and an object of the present invention is to provide a management device, a management method, and a management program that enable assistance in speedy evacuation of an autonomous robot at the time of occurrence of a disaster or in the case where occurrence of a disaster is predicted.
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 storage

configured to store map information on each area in which a robot that travels autonomously outdoors and indoors travels; and processing circuitry configured to: collect external information containing disaster information; receive a current position of the robot or a travel route for the robot from a control device that controls the robot; based on the external information, sense occurrence of a disaster and a disaster occurrence area in which the disaster occurs; based on the current position of the robot or the travel route for the robot, specify the robot that is positioned in the disaster occurrence area or the robot that is predicted to be positioned in the disaster occurrence area; based on the external information and the map information, determine an evacuation route to an evacuation site that is set previously with respect to each the robot positioned in the disaster occurrence area or each the robot predicated to be positioned in the disaster occurrence area; and recommend the evacuation 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.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0014] FIG. **1** is a diagram illustrating an overview 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 setting evacuation routes;
[0020] FIG. **7** is a diagram illustrating the example of setting evacuation routes;
[0021] FIG. **8** is a diagram illustrating an example of a screen of the management server illustrated in FIG. **2**;
[0022] FIGS. **9**A to **9**D are diagrams illustrating an example of the screen of the management server illustrated in FIG. **2**;
[0023] FIG. **10** is a diagram illustrating an example of a screen of the control server illustrated in FIG. **2**;
[0024] FIG. **11** is a sequence chart illustrating a process procedure of a management process according to the embodiment; and
[0025] FIG. **12** is a diagram illustrating a computer that executes a program.
DESCRIPTION OF EMBODIMENTS
[0026] An embodiment of a management device, a management method, and a management program according to the present application will be described in detail below according to the drawings. Note that the embodiment does not limit the management device, the management method, and the management program according to the present application.
Embodiment
[0027] In the following embodiment, the management device and a flow of a process of the management method according to the embodiment will be described in order and the effect brought by the embodiment will be described at the end.
[0028] FIG. **1** is a diagram illustrating an overview 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.
[0029] As illustrated in FIGS. **1** and **2**, the management system in the embodiment includes control servers **20**A and **20**B (control device) that control robots **10**A-**1**, **10**A-**2**, **10**B-**1**, and **10**B-**2** that travel indoors and outdoors autonomously and a management server **30** (management device) that provides information on control on the robots.
[0030] In the management system in the embodiment, the control servers **20**A and **20**B control the autonomous robots **10**A-**1**, **10**A-**2**, **10**B-**1**, and **10**B-**2** by radio communication, or the like.
[0031] Note that the configuration illustrated in FIGS. **1** and **2** is an example only and the specific configuration and the number of devices are not particularly limited. When referred to collectively, the robots **10**A-**1**, **10**A-**2**, **10**B-**1**, and **10**B-**2** are termed as robots **10**. When referred to collectively, the robots **10**A-**1** and **10**A-**2** are termed as robots **10**A. When referred to collectively, the robots **10**B-**1** and **10**B-**2** are termed as robots **10**B. When referred to collectively, the control servers **20**A and **20**B are termed as control servers **20**.
[0032] The control server **20**A controls autonomous travel by the robot **10**A according to a robot control system of a robot business operator A. The control server **20**B controls autonomous travel by the robot **10**B according to a robot control system of a robot business operator B. The control server **20**, for example, sets a task of and a travel route for each robot **10** to be controlled via an operation performed by a robot operator. Note that the robot operator (human) sets a task of and a travel route for each robot **10** to be controlled by operating a terminal device, or the like, as the aforementioned operation performed by the robot operator.
[0033] According to control performed by the control server **20**, the robot **10** travels areas E**1**-**1** to E**1**-**3** covering a plurality of facilities and areas around the facilities and shuttles among the areas E**1**-**1** to E**1**-**3** and executes tasks, such as goods delivery, guarding, guiding, cleaning, and transferring people.
[0034] The robot **10**, for example, includes a communication unit that communicates with the control server **20** and a travel function enabling autonomous travel. The robot **10** also includes various types of sensors that sense surrounding obstacles, a touch panel that receives an input of an operation performed by the user and outputs sound or image information, and an input-output unit, such as a microphone and a speaker. The robot **10**, for example, may include an imaging device and capture images of the surroundings of the robot **10**. The robot **10** transmits results of detection performed by the sensors, the images captured by the imaging device, and various types of information that are input by the user to the control server **20** via the communication unit.
[0035] The robot **10** travels according to the travel route that is set by the control server **20** and executes the task that is set by the control server **20**. Note that the current position of the robot **10** may be specifiable by the control server **20** using a positioning system, such as the GPS (Global Positioning System).
[0036] The management server **30** of a platformer provides the information on control on the robots to the terminal device. The management server **30** receives provision of the current position of or the travel route for the robot **10** from each control server **20**. A period of travel of the travel route is also given to the travel route. The management server **30** may receive, from each control server **20**, provision of the various types of information transmitted from the robot **10** to the control server **20**.
[0037] The management server **30** collects external information from external various types of servers that are connected via a communication network. Based on the collected information, the management server **30** provides the information on control on the robots to the terminal device.
[0038] For example, there are a disaster prediction server **40**, a sensor management server **50**, a flow-of-people prediction server **60**, and an external server **70** as external servers.
[0039] The disaster prediction server **40** is a sever that is set in the Japan Meteorological Agency, a local government, a private sector, or the like, predicts occurrence of an earthquake, a tsunami, a tornado or an eruption and announces a special warning, a warning, or an advisory and disaster

management information.
[0040] The sensor management server **50** manages operations of detection performed by various types of sensors that are set in a robot travel area and collets results of detection performed by the various types of sensors. There are a security camera, a human detection sensor, and a temperature sensor that are set in respective spots, etc., as the various types of sensors.
[0041] Based on mobile data, images obtained by the security camera, transportation use information, and the result of detection performed by the sensor (for example, the human detection sensor), the flow-of-people prediction server **60** predicts a flow of people in a prediction subject area in a prediction subject period.
[0042] The external server **70** is a server that announces a news article, a blog article, and SNS (Social Networking Service) article, etc.
[0043] The management server **30** collects external information from the external various types of servers and, when occurrence of a disaster is sensed, recommends an evacuation route to an evacuation site for the robot **10** that is positioned in a disaster occurrence area to a terminal device **90**. The evacuation site for the robot **10** is set previously. Note that the terminal device **90** that outputs the information transmitted from the management server **30** and that receives an operation on the management server **30** and the terminal device **90** capable of making an instruction to change the travel route for the robot **10** to the control server **20** are provided. A plurality of the terminal devices **90** may be provided per robot business operator.
[0044] The control server **20** sets an evacuation route for each robot, or the like, based on the information that is input from the terminal device **90** that the robot operator operates. For example, the robot operator rewrites the travel routes for the respective robots **10** to the evacuation routes that are recommended by the management server **30**, respectively, and evacuates the robots **10** to the evacuation site. As described above, the management server **30** assists the autonomous robots in speedy evacuation at the time of occurrence of a disaster or in the case where occurrence of a disaster is predicted. Note that the terminal device **90** that is operated by the robot operator may be provided as a terminal device that is independent with respect to each robot business operator.
Control Server
[0045] The control server **20** will be described. 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**, for example, includes a communication unit **21**, a storage unit **22**, and a controller **23**. Note that an input device, such as a mouse or a keyboard, and an output device, such as a display or a speaker, are connected to the control server **20**.
[0046] The communication unit **21** controls communication relating to various types of information. For example, the communication unit **21** controls communication performed with the robot **10** and communication performed with the management server **30**. The communication unit **21** may transmit an instruction to set a task and a travel route and travel control information to the robot **10** and control travel by the robot **10** and execution of the task. The communication unit **21** may receive information that is acquired by the robot **10**. The communication unit **21** may transmit the current position of the robot **10** or the travel route for the robot **10** to the management server **30**.
[0047] The storage unit **22** stores data necessary for various types of processing performed by the controller **23** and a program. For example, the storage unit **22** may be a semiconductor memory device, such as a RAM (Random Access Memory) or a flash memory, or a storage device, such as a hard disk or an optical disk. The storage unit **22** may have robot information **221**, map information **222**, a task storage unit **223**, travel route information **224**, and robot position information **225**.
[0048] The robot information **221** may be information containing identification information on, a type of, and a task executable by each robot that the control server **20** controls.
[0049] The map information **222** may be map information containing a map of each of the areas E**1-1** to E**1-3** and a map for shuttles among the areas E**1-1** to E**1-3**. The map information **222** may be acquired previously and may be updated as appropriate based on the various types of sensor

information, the information transmitted from the robot **10**, etc. In the map information **222**, facilities in each of the area E**1-1** to E**1-3**, areas the robot **10** is able to travel in the facilities and around the facilities, and areas the robot **10** is able to travel among the areas E**1-1** to E**1-3** may be superimposed on a map. Note that the robot **10** may be able to travel indoors and outdoors.

[0050] The task storage unit **223** may be information on a history of tasks that are executed by each robot **10**. A task being executed by each robot **10** may be registered by a task setting unit **231** (described below) in the task storage unit **223**. There is goods delivery, guarding, guiding, cleaning, transferring people, or the like, as the task and the task storage unit **223** may store the identification information on the robot **10**, identification information on the task, a period of execution of the task, etc.

[0051] The travel route information **224** may be information indicating the route that the robot **10** travels. As for the travel route, for example, a plurality of representative routes may be set previously according to any one or both of the area, the task, and the type of the robot **10** and a correction or an addition may be made according to a travel status. Each travel route for each robot **10** that is set by a travel route setting unit **232** (described below) may be registered in the travel route information **224**.

[0052] The robot position information **225** may be information in which the identification information on the robot **10**, the position of the robot **10**, and the time of detection of the position are associate with one another.

[0053] The controller **23** includes an internal memory for storing a program defining various types of process procedures and necessary data and executes various processes according to the program and the data. The controller **23** may be an electronic circuit, such as a CPU (Central Processing Unit) or an MPU (Micro Processing unit), or an integrated circuit, such as an ASIC (Application Specific Integrated Circuit) or a FPGA (Field Programmable Gate Array).

[0054] The controller **23**, for example, includes the task setting unit **231**, the travel route setting unit **232**, a robot position acquisition unit **233**, a travel controller **234**, and a robot information transmission controller **235**.

[0055] For example, on receiving a request to provide a service from the user, the task setting unit **231** sets a task to be executed and selects the robot **10** that is to execute the task.

[0056] The travel route setting unit **232**, for example, sets a travel route corresponding to the task in the robot **10** that is selected by the task setting unit **231**. For example, the travel route setting unit **232** may select any one of the previously-set routes as the travel route according to an operation performed by the robot operator. The travel route setting unit **232** may set a route obtained by correcting the pre-set route according to an operation performed by the robot operator.

[0057] For example, using a positioning system, such as the GPS (Global Positioning System), the robot position acquisition unit **233** acquires the current position of each robot **10** to be controlled. The robot position acquisition unit **233** may store the position of the robot **10** and the time of detection of the position in the storage unit **22** in association with the identification information on the robot **10**.

[0058] The travel controller **234**, for example, controls the travel by the robot **10** to be controlled, thereby causing the robot **10** to be controlled to travel according to the travel route that is set by the travel route setting unit **232**.

[0059] The robot information transmission controller **235**, for example, transmits the information on each robot **10** to be controlled to the management server **30** via the communication unit **21**. The robot information transmission controller **235** may transmit the current position of each robot **10** or the travel route for each robot **10** to the management server **30** together with the identification information on each robot **10** to be controlled. The robot information transmission controller **235** may transmit both the current position of each robot **10** to be controlled and the travel route for each robot **10** to the management server **30**. The robot information transmission controller **235** may transmit the task of the robot **10** to be controlled and the information received from the robot **10** to the management server **30**.

Management Server

[0060] The management server **30** illustrated in FIG. **2** will be described next. 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 storage unit **32**, and a controller **33**. Note that an input device, such as a mouse or a keyboard, and an output device, such as a display or a speaker, are connected to the management server **30**.

[0061] The communication unit **31** controls communication relating to various types of information. For example, the communication unit **31** controls communication performed with each external server and communication performed with the management server **30**. The communication unit **31** receives the current position of the robot **10** to be controlled or the travel route for the robot **10** from the control server **20**. The communication unit **31** receives the information acquired by the robot **10** to be controlled from the control server **20**. The communication unit **31** receives external information containing disaster information from the external server.

[0062] The storage unit **32** stores data necessary for various types of processing performed by the controller **33** and a program. For example, the storage unit **32** may be a semiconductor memory device, such as a RAM or a flash memory, or a storage device, such as a hard disk or an optical disk. The storage unit **32** has robot information **321**, map information **322**, a task storage unit **323**, travel route information **324**, robot position information **325**, disaster information **326**, a sensor information group **327**, a flow-of-people prediction information **328**, and an external information group **329**.

[0063] The robot information **321** is information in which identification information on the control server **20** and the identification information on each robot that the control server **20** controls are registered in association with each other. When the type of the robot **10** and an executable task are provided from the control server **20**, the type of the robot **10** and the executable task are registered in the robot information **321** in association with the identification information on each robot.

[0064] The map information **322** is map information containing the map of each of the areas E**1-1** to E**1-3** and the map for shuttles among the areas E**1-1** to E**1-3**. In the map information **322**, the facilities in each of the area E**1-1** to E**1-3**, the areas the robot **10** is able to travel in the facilities and around the facilities, and the areas the robot **10** is able to travel among the areas E**1-1** to E**1-3** are be superimposed on the map. The map information **322**, for example, is provided from the control server **20**.

[0065] When information on the task of the robot **10** is provided from the control server **20**, the task storage unit **323** stores the task, a period of execution of the task, etc., in association with the identification information on the robot **10**.

[0066] The travel route information **324** is information that indicates the travel route for the robot **10** that is provided from the control server **20**. The identification information on the robot **10** and the travel route for the robot **10** are associated with the travel route information **324**. The period of travel of the travel route is given to the travel route.

[0067] The robot position information **325** is information that indicates the current position of the robot **10** that is provided from the control server **20**. The identification information on the robot **10**, the position of the robot **10**, and the time of detection of the position are associated with the robot position information **325**.

[0068] The disaster information **326** is, for example, a special warning, a warning, or an advisory on a disaster and disaster management information and contains a type of a disaster of which occurrence is predicted, a degree of the disaster, a time of occurrence, and a period of occurrence. The disaster information **326**, for example, is contained in information that is received from the disaster prediction server **40**.

[0069] The sensor information group **327** is a group of sets of information indicating the results of detection performed by the various types of sensors that are set in the area the robots travel that are received from the sensor management server **50**. The sensor information group **327** is, for example, images that are captured by the security cameras, the results of sensing by the human detection sensors, the temperatures detected by the temperature sensors, etc.

[0070] The flow-of-people prediction information **328** is information indicating a flow of people in the prediction subject period in the prediction subject area, which is the flow predicted by the flow-of-people prediction server **60**. For example, when the management server **30** receives a special warning, a warning, or an advisory on a disaster and disaster management information, flow-of-people prediction information on a period of occurrence of the disaster in a disaster occurrence area is acquired according to a prediction request made by the management server **30** to the flow-of-people prediction server **60**.

[0071] The external information group **329** is various types of articles that are announced by the external server **70** and SmartCity data. With the information, it is sometimes possible to recognize the status of the disaster consecutively.

[0072] The controller **33** includes an internal memory for storing a program that defines various types of process procedures and necessary data and execute various processes according to the program and the data. The controller **33** is an electronic circuit, such as a CPU or an MPU, or an integrated circuit, such as an ASIC or a FPGA.

[0073] The controller **33** includes a robot position acquisition unit **331** (acquisition unit), a travel route acquisition unit **332** (acquisition unit), an information collecting unit **333** (collecting unit), a disaster occurrence sensing unit **334** (sensing unit), a subject robot specifying unit **335** (specifying unit), an evacuation route determination unit **336** (determination unit), and an evacuation route recommending unit **337** (recommending unit).

[0074] The robot position acquisition unit **331** receives the identification information on the robot **10** and the current position of the robot **10** from the control server **20**, thereby acquiring the current position of the robot **10**. The robot position acquisition unit **331** registers the acquired current position of the robot **10** in the robot position information **325**.

[0075] The travel route acquisition unit **332** receives the identification information on the robot and the travel route for the robot **10**, thereby acquiring the travel route for the robot **10**. The travel route acquisition unit **332** registers the acquired travel route for the robot **10** in the travel route information **324**.

[0076] The information collecting unit **333** collects external information containing the disaster information. The information collecting unit **333** collects, as the external information, the special warning, warning, or advisory on the disaster and the disaster management information that are received from the disaster prediction server **40**, the results of detection performed by the various types of sensors that are set in the area the robot travels that are received from the sensor management server **50**, the flow-of-people prediction information on the disaster occurrence area that is predicted by the flow-of-people prediction server **60**, and the various types of articles that are announced by the external server **70**.

[0077] The information collecting unit **333** requests the flow-of-people prediction server **60** to predict a flow of people in the disaster occurrence area, thereby acquiring the flow-of-people prediction information on the disaster occurrence area. The information collecting unit **333** may collect the images captured by the robot **10** and the result of detection performed by the sensor of the robot **10** in order to determine whether it is possible to travel the surroundings of the robot **10**.

[0078] Based on the external information, the disaster occurrence sensing unit **334** determines whether occurrence of a disaster is predicted. Based on the external information, the disaster occurrence sensing unit **334** senses occurrence of a disaster, a disaster occurrence area where the disaster occurs, and a disaster occurrence period on which occurrence of a disaster is predicted. Based on the special warning, warning, or advisory on the disaster and the disaster management information that are received from the disaster prediction server **40**, the disaster occurrence sensing unit **334** senses that a disaster occurs in any one of the areas to be managed. Alternatively, the disaster occurrence sensing unit **334** may identify occurrence of a disaster and a disaster occurrence area from the various types of articles that are announced by the external server **70**.

[0079] Based on the current position of the robot **10** and the travel route for the robot **10**, the subject robot specifying unit **335** specifies the robot **10** positioned in the disaster occurrence area as a robot to be evacuated. Based on the current position of the robot **10** that is provided from the control server **20**, the subject robot specifying unit **335** specifies the robot **10** that is positioned currently in the disaster occurrence area that is sensed by the disaster occurrence sensing unit **334**. Based on the travel route for the robot **10** that is provided from the control server **20**, the subject robot specifying unit **335** specifies the robot **10** currently traveling in the disaster occurrence area that is sensed by the disaster occurrence sensing unit **334**.

[0080] Based on the external information that is collected by the information collecting unit **333** and the map information **322**, the evacuation route determination unit **336** determines an evacuation route to the pre-set evacuation site with respect to each robot **10** positioned in the disaster occurrence area. The evacuation site is set previously and is registered in the map information **322**. In addition to the position of the evacuation site, the number of robots that can be evacuated, the size, etc., are registered as the evacuation site in the map information **322**.

[0081] When a plurality of evacuation sites is set in the disaster occurrence area, the evacuation route determination unit **336** determines evacuation routes for evacuating each robot positioned in the disaster occurrence area to the evacuation sites dispersedly.

[0082] The evacuation route determination unit **336** determines an evacuation route for each robot, avoiding a flow of people indicated by the result of predicting a flow of people. The evacuation route determination unit **336** determines evacuation routes that are different between robots positioned in the disaster occurrence area.

[0083] The evacuation route determination unit **336** may determine to which evacuation site the robot **10** is to be evacuated according to the task of the robot **10** and the type of the robot **10**. The evacuation route determination unit **336**, for example, may allot a shady evacuation site to the robot **10** in which a task of delivering refrigerated goods or frozen goods is set and determine an evacuation route.

[0084] For example, the evacuation route determination unit **336** selects or corrects any one of the travel routes that are set previously according to a determination rule that is set previously and sets a travel direction, thereby determining an evacuation route for the robot **10**.

[0085] Alternatively, using a determination model **3361** for determining an evacuation route, the evacuation route determination unit **336** may determine an evacuation route. The determination model **3361** is a model that is trained to output an evacuation route for each robot **10** using, for example, as training data, various types of information, such as the map information on each area, the evacuation site, the positions of the robots **10**, the number of the robots **10**, the types of the robots **10**, predicted flow-of-people information or history information on the flow of people, the type and the scale of the disaster, and the period of occurrence of the disaster, and evacuation routes corresponding to respective conditions.

[0086] The evacuation route recommending unit **337** recommends the evacuation route that is determined by the evacuation route determination unit **336** to the terminal device **90**. For example, the evacuation route recommending unit **337** makes a transmission such that the robot **10** to be evacuated and the evacuation route for the robot **10** are displayed on a system screen that is displayed on a terminal device that the robot operator operates, or the like. Alternatively, the evacuation route recommending unit **337** may transmit visualized information obtained by superimposing text recommending evacuation associated with occurrence of the disaster and the evacuation route of each robot **10** on the map of the disaster occurrence area to the terminal device **90**. Furthermore, based on the recommended information, the robot operator operates the terminal device, and the like, and changes the travel route for the robot **10**.

Example of Setting Routes

[0087] An example of the travel route for the robot **10** that is transmitted from the control server **20** will be described. With FIG. **5** and the following drawings, for example, the area E**1-1** of the areas is exemplified and described. FIG. **5** is a diagram illustrating an example of a map diagram of the area E**1-1**.

[0088] As illustrated in a map M**1**s in FIG. **5**, a plurality of facilities is provided in the area E**1-1**. The robot **10** is able to travel the inside of these facilities, the outdoors including areas other than buildings around the facilities, and the outdoors including areas other than objects. As illustrated in Map M**1**s, two evacuation sites T**1** and T**2** may be set as sites of evacuation of the robot **10** in the area E**1-1**. It is possible to evacuate two robots **10** to each of the evacuation sites T**1** and T**2**.

[0089] For example, travel routes for the two robots **10**A-**1** and **10**B-**2** and the current positions of the robots are provided from the control server **20** to the management server **30**. For example, the travel route for the robot **10**A-**1** is a travel route R**1**s and the travel route for the robot **10**B-**2** is a travel route R**2**s.

Example of Setting Evacuation Routes

[0090] Subsequently, setting an evacuation route for the robot **10** in the case where it is sensed that the area E**1-1** is a disaster occurrence area will be described. FIG. **6** and FIG. **7** are diagrams illustrating an example of setting evacuation routes.

[0091] As illustrated in the map M**1** (FIG. **6**), when the two robots **10**A-**1** and **10**B-**2** travel in the area E**1-1**, the evacuation route determination unit **336** determines evacuation routes R**1** and R**2** for evacuating the robots **10**A-**1** and **1**-B-**2** to the closest evacuation site T**1**.

[0092] The evacuation route determination unit **336** determines evacuation routes R**1** and R**2** so as not to overlap a flow of people Fp that is predicted on the period of occurrence of the disaster. The flow of people Fp is a predicted route in which people moves for evacuation.

[0093] For example, for the robot **10**A-**1**, the evacuation route determination unit **336** determines the evacuation route R**1** containing not a route R**1-2** partly overlapping the flow of people Fp but a route R**1-1** avoiding the flow of people Fp in an area D**1**. Accordingly, the management system is able to evacuate the robot **10** to the evacuation site without blocking the route in which people evacuates. In other words, the management system is able to prevent the robot **10** from being an obstacle on the route of evacuation of people (for example, the flow of people Fp) when a disaster occurs. For the robot **10**B-**2**, the evacuation route determination unit **336** determines the shortest route to the evacuation site T**1** as an evacuation route R**2**.

[0094] As illustrated in a map M**2** (FIG. **7**), when four robots **10**A-**1** and **10**B-**2** to **10**B-**4** travel in the area E**1-1**, the evacuation route determination unit **336** determines evacuation routes for evacuating the robots **10**A-**1** and **10**B-**2** to **10**B-**4** to the evacuation sites T**1** and T**2** dispersedly.

[0095] For example, for the robots **10**A-**1** and **10**B-**2**, the evacuation route determination unit **336** determines the evacuation routes R**1** and R**2** for evacuation to the evacuation site T**1**. For the robots **10**B-**3** and **10**B-**4**, the evacuation route determination unit **336** determines evacuation routes R**3** and R**4** for evacuation to the evacuation site T**2**. The management system determines evacuation routes such that the robots **10** are able to evacuate to each evacuation site dispersedly, thereby preventing congestions in the evacuation sites. In other words, by arranging evacuation spots for the robots **10** appropriately, the management system is able to evacuate the robots **10** while preventing the robots **10** from being stagnant.

[0096] Furthermore, for the robots **10**B-**3** and **10**B-**4** of which positions are close, the evacuation route determination unit **336** also disperses evacuation routes between the robots **10**B-**3** and **10**B-**4**. Specifically, the evacuation route determination unit **336** determines the evacuation routes R**3** and R**4** different between the robots **10**B-**3** and **10**B-**4**, thereby avoiding a crash between the robots **10**B-**3** and **10**B-**4** and smoothly evacuating each of the robots **10**B-**3** and **10**B-**4**.

Example of Screen Display

[0097] For example, an example of a screen display of the management server in the case where a tsunami waning is announced in the area E**1-1** will be described. FIG. **8** and FIGS. **9**A to **9**D are diagrams illustrating an example of the screen of the management server **30** illustrated in FIG. **2**.

[0098] On sensing that a tsunami warning is announced in the area E**1-1** based on the information received from the disaster prediction server **40**, the management server **30** superimposes a window W**1** indicating that an evacuation advisory on the tsunami warning is issued onto the map M**1**s (FIG. **8**) of the area E**1-1**.

[0099] The management server **30** specifies the robot **10** positioned in the area E**1-1** as the robot **10** to be evacuated in a period on which a tsunami is predicted. For example, the management server **30** specifies that the robots **10**A-**1** and **10**B-**2** as the robots **10** positioned in the area E**1-1** and displays the robots in columns C**1-1** and C**1-2** in a control instruction list L**1-2** (FIGS. **9**A to **9**D).

[0100] When a button B**1-2** for "notifying the robot operator of the evacuation route" is selected by the operator of the management server **30**, the management server **30** determines the evacuation routes R**1** and R**2** for the robots **10**A-**1** and **10**B-**2**. The management server **30** transmits the evacuation route R**1** for the robot **10**A-**1** to the terminal device **90**. The management server **30** transmits the evacuation route R**2** 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 change the travel route for the robot **10** by operating the terminal device, and the like.

[0101] FIG. **10** is a diagram illustrating an example of a screen of the control server **20**A illustrated in FIG. **2**. On the terminal device of the operator of the robot **10**A-**1**, it is displayed that a tsunami waning is announced in the area E**1-1** on the control instruction list of an evacuation route recommendation screen (FIG. **10**). In the column C**2** of the control instruction list, identification information "**10**A-**1**" on the robot **10** that is specified as a subject to be evacuated and text information on the evacuation site "T**1**" and the evacuation route "R**1**" for the robot **10**A-**1** are displayed. Furthermore, the evacuation route R**1** for the robot **10**A-**1** is displayed in a superimposed manner on a map M**3** of the area E**1-1**.

[0102] By checking the evacuation route recommendation screen (FIG. **10**), the robot operator is able to recognize the information on the robot **10** to be evacuated, the evacuation site, and the evacuation route.

[0103] After correcting the recommended evacuation route R**1** for the robot **10**A-**1**, the robot operator may input a control process to evacuate the robot **10**A-**1** in the corrected evacuation route.

Management Process

[0104] A management process according to the embodiment will be described next. FIG. **11** is a sequence chart illustrating a process procedure of the management process according to the embodiment.

[0105] As illustrated in FIG. **11**, the control servers **20**A and **20**B communicate with the robots **10**A and **10**B and thereby sets tasks and travel routes in the robots **10**A and **10**B and controls autonomous travel by the robots **10**A and **10**B (step S**1** and S**3**).

[0106] The management server **30** receives the current positions of or the travel routes for the respective robots **10** from the respective control servers **20** (step S**2** and S**4**), thereby acquiring the current positions of and the travel routes for the respective robots **10** (step S**5**).

[0107] The management server **30** collects external information containing disaster information from the external server, or the like (step S**6**). Based on the external information, the management server **30** determines whether occurrence of a disaster is predicted (step S**7**).

[0108] When occurrence of a disaster is not predicted (Step S**7**: No), the management server **30** goes back to the beginning.

[0109] When occurrence of a disaster is predicted (step S**7**: Yes), the management server **30** senses a disaster occurrence area where a disaster occurs and a disaster occurrence period on which occurrence of the disaster is predicted (step S**8**).

[0110] Based on the current positions of the robots **10** and the travel routes for the robots **10**, the management server **30** specifies the robot **10** that is positioned in the disaster occurrence area or the robot **10** that is predicted to be positioned in the disaster occurrence area (step S**9**).

[0111] Subsequently, based on the external information collected by the information collecting unit **333** and the map information **322**, the management server **30** determines an evacuation route to a pre-set evacuation site with respect to each robot **10** positioned in the disaster occurrence area (step S**10**). The management server **30** then recommends the information on the robot **10** positioned in the disaster occurrence area or the robot **10** predicted to be positioned in the disaster occurrence area and the evacuation route for each robot that are determined by the evacuation route determination unit **336** to, for example, the terminal device **90** (steps S**11** and S**12**).

[0112] When the evacuation route for the robot **10** positioned in the disaster occurrence area is set via the terminal device **90** that is operated by the robot operator (steps S**13**, S**14**, S**15** and S**16**), the control servers **20**A and **20**B cause the robot **10** positioned in the disaster occurrence area to travel to the evacuation site according to the set evacuation route (steps S**17** and S**18**).

Effect of Embodiment

[0113] As described above, the disaster information and the information on the robot **10** positioned in the disaster occurrence area or the robot **10** that is predicted to be positioned in the disaster occurrence area are provided from the management server **30** to the terminal device **90**. For this reason, the robot operator of the control server **20** does not have to collect disaster information, sense occurrence of a disaster, or specify the robot **10** positioned in the disaster occurrence area.

[0114] Furthermore, the evacuation route for the robot **10** positioned in the disaster occurrence area is recommended by the management server **30** to the terminal device **90**. For this reason, when rewriting the travel route for the robot **10** to an evacuation route, the robot operator of the control server **20** does not create an evacuation route from scratch and only has to set an evacuation route based on the evacuation route that is recommended by the management server **30**.

[0115] Thus, according to the embodiment, the load of the process on the robot operator until evacuation of the robots is reduced and it is possible to speedily execute evacuation of the robots **10** at the time of occurrence of a disaster or in the case where occurrence of a disaster is predicted.

[0116] When an evacuation route is set with respect to each robot business operator, because it is not possible to know the position of a robot controlled by another business operator, the case of a crash during evacuation is also assumed. On the other hand, in the embodiment, the management server **30** collectively collects information, specifies, not limited to the robot **10** of any business operator, each robot **10** positioned in the disaster occurrence area, and recommends an evacuation route suitable to each robot **10** to the terminal device **90**.

[0117] For this reason, according to the embodiment, even when a large number of robots are introduced by a plurality of robot business operators to a plurality of areas, determination of evacuation routes across the areas and the robot business operators is enabled. Thus, according to the embodiment, it is possible to assist in speedy and smooth evacuation of the robot **10** positioned in the disaster occurrence area when a disaster occurs.

System Configuration, Etc.

[0118] Each component of each device illustrated in the drawings is a functional idea and need not necessarily be configured physically as illustrated in the drawings. In other words, specific modes of distribution and integration of devices are not limited to those illustrated in the drawings and all or part of the devices can be configured by functional or physical distribution or integration in any unit according to various types of loads and usage. Furthermore, all or given part of each processing function implemented by each device can be realized by a CPU or a GPU (Graphics Processing Unit) and a program that is analyzed and executed by the CPU or the GPU or can be realized as hardware according to wired logic.

[0119] Among the processes described in the above-described embodiment, all or part of the process that is described as one performed automatically can be performed manually or all or part of the process that is described as one performed manually can be performed automatically by a known method. In addition to this, the process procedure, the control procedure, the specific names, and the information including various types of data and parameters that are presented in the description above and the drawings are changeable freely unless otherwise noted.

Program

[0120] It is possible to create a program in which the process that the management server **30** described in the above-described embodiment executes is written in a computer-executable language. For example, it is also possible to create a program in which the processes that the control server **20** and the management server **30** in the embodiment execute in a computer-executable language. In In this case, execution of the program by a computer makes it possible to obtain the same effect as that of the above-described embodiment. Furthermore, the program may be recorded in a computer-readable recording medium and a computer may be caused to read and execute the program that is recorded in the recording medium, thereby realizing the same processes as those of the above-described embodiment.

[0121] FIG. **12** is a diagram illustrating a computer that executes a program. As exemplified in FIG. **12**, 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 each of these units is connected via a bus **1080**.

[0122] As exemplified in FIG. **12**, the memory **1010** includes a ROM (Read Only Memory) **1011** and a RAM **1012**. The ROM **1011**, for example, stores a boot program, such as a BIOS (Basic Input Output System). As exemplified in FIG. **12**, the hard disk drive interface **1030** is connected to a hard disk drive **1090**. The disk drive interface **1040** is connected to a disk drive **1100**. For example, a detachable recording medium, such as a magnetic disk or an optical disk, 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, for example, a display **1130**.

[0123] As exemplified in FIG. **12**, the hard disk drive **1090** stores, for example, an OS (Operating System) **1091**, an application program **1092**, a program module **1093**, and program data **1094**. In other words, the above-described program is stored in, for example, the hard disk drive **1090** as a program module in which instructions to be executed by the computer **1000** are written.

[0124] The various types of data described in the above-described embodiment are stored in, for example, the memory **1010** and the hard disk drive **1090** as program data. The CPU **1020** reads the program module **1093** and the program data **1094** that are stored in the memory **1010** and the hard disk drive **1090** to the RAM **1012** as requested and executes various types of process procedure.

[0125] Note that the program module **1093** and the program data **1094** according to the program are not limited to being stored in the hard disk drive **1090**, and the program module **1093** and the program data **1094** may be stored in, for example, a detachable storage medium and may be read by the CPU **1020** via the disk drive, or the like. Alternatively, the program module **1093** and the program data **1094** according to the program may be stored in another computer that is connected via a network (such as a LAN (Local Area Network) or a WAN (Wide Area Network)) and may be read by the CPU **1020** via the network interface **1070**.

[0126] The above-described embodiment and modifications of the embodiment are covered by the invention described in CLAIMS and equivalents of the invention as being covered by the technique disclosed by the present application.

[0127] According to the present invention, it is possible to assist in speedy evacuation of an autonomous robot at the time of occurrence of a disaster or in the case where occurrence of a disaster is predicted.

[0128] 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 storage configured to store map information on each area in which a robot that travels autonomously outdoors and indoors travels; and processing circuitry configured to: collect external information containing disaster information; receive a current position of the robot or a travel route for the robot from a control device that controls the robot; based on the external information, sense occurrence of a disaster and a disaster occurrence area in which the disaster occurs; based on the current position of the robot or the travel route for the robot, specify the robot that is positioned in the disaster occurrence area or the robot that is predicted to be positioned in the disaster occurrence area; based on the external information and the map information, determine an evacuation route to an evacuation site that is set previously with respect to each the robot positioned in the disaster occurrence area or each the robot predicated to be positioned in the disaster occurrence area; and recommend the evacuation route to a terminal device.
2. The management device according to claim 1, wherein, when a plurality of the evacuation sites is set in the disaster occurrence area, the processing circuitry is further configured to determine evacuation routes for evacuating each robot positioned in the disaster occurrence area to the evacuation sites dispersedly.
3. The management device according to claim 1, wherein the external information contains a result of predicting a flow of people in the disaster occurrence area, and the processing circuitry is further configured to determine evacuation routes avoiding the flow of people presented by the result of predicting the flow of people.
4. The management device according to claim 1, wherein the processing circuitry is further configured to determine evacuation routes that are different between robots positioned in the disaster occurrence area.
5. A management method executed by a management device, the management method comprising: collecting external information containing disaster information; receiving a current position of the robot or a travel route for the robot from a control device that controls a robot that travels autonomously outdoors and indoors; based on the external information, sensing occurrence of a disaster and a disaster occurrence area in which the disaster occurs; based on the current position of the robot or the travel route for the robot, specifying the robot that is positioned in the disaster occurrence area or the robot that is predicted to be positioned in the disaster occurrence area; based on the external information and map information on each area in which the robot travels, determining an evacuation route to an evacuation site that is set previously with respect to each the robot positioned in the disaster occurrence area or each the robot predicated to be positioned in the disaster occurrence area; and recommending the evacuation 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 containing disaster information; receiving a current position of the robot or a travel route for the robot from a control device that controls a robot that travels autonomously outdoors and indoors; based on the external information, sensing occurrence of a disaster and a disaster occurrence area in which the disaster occurs; based on the current position of the robot or the travel route for the robot, specifying the robot that is positioned in the disaster occurrence area or the robot that is predicted to be positioned in the disaster occurrence area; based on the external information and map information on each area in which the robot travels, determining an evacuation route to an evacuation site that is set previously with respect to each the robot positioned in the disaster occurrence area or each the robot predicated to be positioned in the disaster occurrence area; and recommending the evacuation route to a terminal device.