DESCRIPTION

TITLE OF THE INVENTION:
ROUTE SETTING METHOD, MOVING BODY, MANAGEMENT SYSTEM, AND PROGRAM

Field

[0001] The present disclosure relates to a route setting method, a moving body, a management system, and a program.

Background

[0002] In order to cause a moving body to autonomously travel to a target position, the travel route for the moving body is set by performing various calculations, and the moving body autonomously travels on the basis of the travel route, whereby the moving body autonomously travels.

[0003] For example, Patent Literature 1 below describes that an obstacle-avoiding route is generated by approximating the occupied area of an autonomous moving body is by a single ellipse, and solving an optimization problem such that a constraint is satisfied for the future up to a certain time ahead, the constraint being that no obstacles are included in the ellipse.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2022-134905 A

Summary

Technical Problem

[0005] Here, when the occupied area of the moving body is set to be large, the degree of restriction on the settable route may be increased in the case where a route for avoiding obstacles is set. Therefore, it is required to appropriately set the route for the moving body.

[0006] In view of the above problems, an object of the present disclosure is to provide a route setting method, a moving body, a management system, and a program capable of appropriately setting a route for a moving body.

Solution to Problem

[0007] To solve the above problems and achieve the above object, a route setting method according to the present disclosure includes the steps of: acquiring information about a target position of a moving body; acquiring information about a position of an obstacle; and executing route calculation of the moving body. The step of executing the route calculation includes the steps of: setting, based on information regarding a shape of the moving body, a moving body area that overlaps an occupied area including an area occupied by the moving body and has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other; and setting, based on the information about the position of the obstacle, a route to the target position along which the obstacle does not overlap with the moving body area, as a route for the moving body.

[0008] To solve the above problems and achieve the above object, a moving body according to the present disclosure includes: a route acquiring unit that acquires a route to a target position on which an obstacle does not overlap with a moving body area, the route being set based on information about a position of the obstacle; and a traveling control unit that causes the moving body to travel along the route. The moving body area is an area that overlaps an occupied area including an area occupied by the moving body and that has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other, the area being set based on information regarding a shape of the moving body.

[0009] To solve the above problems and achieve the above object, a management system according to the present disclosure transmits the route set by the above-described route setting method to the moving body.

[0010] To solve the above problems and achieve the above object, a program according to the present disclosure causes a computer to execute the steps of: acquiring information about a target position of a moving body; acquiring information about a position of an obstacle; and executing route calculation of the moving body. The step of executing the route calculation includes the steps of: setting, based on information regarding a shape of the moving body, a moving body area that overlaps an occupied area including an area occupied by the moving body and has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other; and setting, based on the information about the position of the obstacle, a route to the target

position along which the obstacle does not overlap with the moving body area, as a route for the moving body.

Advantageous Effects of Invention

[0011] According to the present disclosure, it is possible to provide a moving body control device, a moving body control method, and a program capable of appropriately setting an occupied area of a moving body.

Brief Description of Drawings

[0012] FIG. 1 is a diagram for explaining an overview of a moving body control system according to the present disclosure.

FIG. 2 is a diagram illustrating a configuration example of the moving body control system according to the present disclosure.

FIG. 3 is a diagram schematically illustrating the configuration of a moving body according to the present disclosure.

FIG. 4 is a diagram illustrating a configuration example of a management system according to the present disclosure.

FIG. 5 is a diagram illustrating a configuration example of a control device of the moving body according to the present disclosure.

FIG. 6 is a detailed block diagram of a route acquiring unit.

FIG. 7 is a schematic diagram for explaining an example of an occupied area.

FIG. 8 is a schematic diagram for explaining an example of a moving body area.

FIG. 9 is a schematic diagram illustrating another example of the moving body area.

FIG. 10 is a schematic diagram illustrating another example of the moving body area.

FIG. 11 is a flowchart for explaining a route setting flow according to a first embodiment.

FIG. 12 is a schematic diagram for explaining setting of moving body areas.

FIG. 13 is a flowchart for explaining a moving body area setting flow in a second embodiment.

FIG. 14 is a flowchart for explaining a route setting flow according to another example of the second embodiment.

FIG. 15 is a flowchart for explaining a route setting flow according to another

example of the second embodiment.

FIG. 16 is a flowchart for explaining a route setting flow according to another example of the second embodiment.

FIG. 17 is a flowchart for explaining a moving body area setting flow in a third embodiment.

FIG. 18 is a hardware configuration diagram illustrating an example of a computer that implements functions of the control device according to the present disclosure.

Description of Embodiments

[0013] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. Note that the present disclosure is not limited by the embodiments described below.

[0014] (Configuration of Moving body Control System)

First, a moving body control system 1 according to the present disclosure will be described with reference to FIGS. 1 and 2. FIG. 1 is a diagram for explaining an overview of a moving body control system according to the present disclosure, and FIG. 2 is a diagram illustrating a configuration example of the moving body control system according to the present disclosure. As illustrated in FIG. 1, the moving body control system 1 according to the present disclosure includes a moving body 10 and a management system 200. The moving body control system 1 may include a plurality of moving bodies 10 such as moving bodies 10A, 100B, and 100C illustrated in FIG. 2.

[0015] The moving body 10 is a mobile platform capable of autonomously traveling. Note that the moving body 10 is not limited thereto, and may be a manned mobile platform in which a driver executes operations on the traveling direction or the like. Furthermore, in the present embodiment, the moving body 10 is a nonholonomic system that cannot travel laterally. Examples of the moving body 10 include an Automated Guided Forklift (AGF) that travels on a two-dimensional plane, an Automated Guided Vehicle (AGV), and the like. As described above, the moving body 10 is a mobile platform that can travel autonomously. The moving body 10 may be, for example, one that autonomously travels on the ground (e.g. Unmanned Ground Vehicle (UGV)), a moving body that autonomously flies in the air (e.g. Unmanned Aerial Vehicle (UAV)), or a moving body that autonomously travels in the water (Unmanned Underwater

Vehicle (UUV)). Therefore, the moving body 10 also includes a moving body capable of autonomously traveling in a three-dimensional space. Note that the types of the moving body 10 are not limited thereto, and may be any type.

[0016] In FIG. 1, an area where the moving body 10 can travel on a two-dimensional plane, namely, an area where the moving body 10 is scheduled to travel is denoted as an area AR. As illustrated in FIG. 1, a direction in the horizontal direction in the area AR is defined as an X direction, and the direction in the horizontal direction and orthogonal to the X direction is defined as a Y direction. Note that the area AR may be a three-dimensional space.

[0017] As illustrated in FIG. 1, the moving body 10 travels along a route R. Note that the route R is set by the moving body 10 or the management system 200 to go toward a target position P while avoiding an obstacle O present in the area AR.

[0018] Here, the obstacle O is an object to be avoided by the moving body 10. In the present embodiment, the obstacle O may be any object whose position may change, or any object which is present at a predetermined position at a certain timing due to traveling but is not necessarily present at the position at another timing. In other words, it can be said that the obstacle O is not a structure whose permanently-fixed position is known. Note that the obstacle O is not limited to being an inanimate object, and may be an organism such as a human or an animal. However, the present invention is not limited thereto, and the obstacle O may be a structure whose permanently-fixed position is known, such as a wall or a column of a facility.

[0019] The management system 200 is a system that manages the moving body 10, and sets the target position P of the moving body 10 moving body 10 in the present embodiment. The management system 200 is, for example, a Fleet Control System (FCS), but is not limited thereto, and may be any device that processes information regarding the travel of the moving body 10. The management system 200 may be implemented by, for example, a Personal Computer (PC), a Work Station (WS), a computer having a server function, or the like.

[0020] The network N connects the moving body 10 and the management system 200 in a wirelessly communicable manner with each other. The network N may be implemented by a wireless Local Area Network (LAN) defined in IEEE 802.11, Bluetooth (registered trademark), Wi-Fi (registered trademark), a 5th generation mobile

communication system (5G), or a 6th generation mobile communication system (6G).

[0021] The moving body control system 1 described above functions as one system by exchanging information between the moving body 10 and the management system 200. For example, group (swarm) control of a plurality of moving bodies 10 using broadcast control may be performed.

[0022] Note that the moving body control system 1 may further include a distribution management system that manages distribution in a facility W. The distribution management system is a Warehouse Control System (WCS) or a Warehouse Management System (WMS), but may be any system without being limited to the WCS or the WMS. For example, the distribution management system may be a backend system such as other production management systems. For example, the distribution management system may also manage mechanisms (e.g. an elevator, a door, or the like) other than the moving body 10 provided in the facility, and may also set information for controlling these mechanisms.

[0023] (About Moving body)

Next, the moving body according to the present disclosure will be described with reference to FIG. 3. FIG. 3 is a diagram schematically illustrating the configuration of the moving body according to the present disclosure. As illustrated in FIG. 3, the moving body 10 may be a forklift. Specifically, the moving body 10 is, for example, an Automated Guided Forklift (AGF). As illustrated in FIG. 3, the moving body 10 includes a vehicle body 20, a mast 22, a fork 24, sensors 26, a power unit 28, and a control device 100. The vehicle body 20 of the moving body 10 includes wheels 20A.

[0024] The mast 22 imposes a constraint on the traveling direction when the fork 24 is moved in the vertical direction. As illustrated in FIG. 3, the mast 22 is provided at one end in the front-rear direction of the vehicle body 20. The mast 22 extends in the vertical direction (here, direction Z) orthogonal to the front-rear direction.

[0025] The fork 24 is a member that is inserted into holes in a pallet, supports the load of the pallet, and lifts the pallet. As illustrated in FIG. 2, the fork 24 is attached to the mast 22 in such a manner as to be movable in the direction Z. The fork 24 may also be movable with respect to the mast 22 in the lateral direction of the vehicle body 20 (a direction intersecting the vertical direction and the front-rear direction). As illustrated

in FIG. 3, the fork 24 has a pair of claws 24A and 24B.

[0026] The claws 24A and 24B extend from the mast 22 toward the rear of the vehicle body 20. The claw 24A and the claw 24B are arranged apart from each other in parallel in the lateral direction of the mast 22. Hereinafter, in the front-rear direction, a direction toward the side on which the fork 24 is provided in the moving body 10 is referred to as the rear direction, and a direction on the side on which the fork 24 is not provided is referred to as the front direction.

[0027] The sensors 26 detect at least one of the position and orientation of an object present around the vehicle body 20. It can also be said that the sensors 26 detect the position of an object with respect to the moving body 10 and the orientation of the object with respect to the moving body 10. The sensors 26 are provided at the mast 22 and four corners of the vehicle body 20, namely, at left and right ends on the front side and left and right ends on the rear side of the vehicle body 20. However, the positions where the sensors 26 are provided are not limited thereto, and the sensors may be provided at any positions, and any number of the sensors may be provided. For example, a safety sensor provided in the moving body 10 may be used also as a sensor 26. With the safety sensor used also as a sensor 26, it is not necessary to newly provide a sensor.

[0028] The sensors 26 detect (receive) reflection light from a surrounding object to detect the position and orientation of the object. Furthermore, a sensor 26 is a sensor that emits light, and more specifically, pulse-emits laser light as light using a semiconductor laser. The sensor 26 detects the position and orientation of an object by detecting reflection light of the emitted laser light with a photodiode or the like. The sensor 26 emits laser light while performing scanning in one direction, and detects the position and orientation of the object from reflection light of the emitted laser light. The sensor 26 may be a 2D-Light Detection And Ranging (LiDAR).

[0029] A sensor 26 scans with a laser light in a horizontal direction, namely, in a direction orthogonal to the direction Z using a scanning device such as a polygon laser scanner having an optical system or a galvano scanner. However, the sensors 26 are not limited to the above, and may be a sensor that detects an object by any method, and may be, for example, a 3D-LiDAR that performs scanning in a plurality of directions or a camera.

[0030] The power unit 28 functions as power for causing the moving body 10 to travel. The specific configuration of the power unit 28 may be set in any manner depending on the operation mode of the moving body 10. As an example, in the case where the moving body 10 travels on the ground, the power unit 28 includes a plurality of wheels and a prime mover such as a diesel engine or an electric motor that drives some or all of the plurality of wheels. The specific configuration of the power unit 28 illustrated as an example here is merely an example, and is not limited thereto. It suffices that the power unit 28 functions as a power source that enables the moving body 10 to travel.

[0031] The control device 100 controls the travel of the moving body 10. The control device 100 will be described later.

[0032] (Management System)

FIG. 4 is a diagram illustrating a configuration example of the management system according to the present disclosure. As illustrated in FIG. 4, the management system 200 includes a communication unit 210, a storage unit 220, a control unit 230, an input unit 240, and a display unit 250.

[0033] The communication unit 210 is a communication module that communicates with an external device such as the moving body 10. The communication unit 210 may be implemented by an antenna or the like for transmitting and receiving radio waves of a wireless Local Area Network (LAN), 5G, 6G, or the like. The management system 200 performs communication by wireless communication; however, the communication scheme may be any scheme.

[0034] The storage unit 220 is a memory that stores various types of information such as calculation contents of the control unit 230 and programs, and includes at least one of, for example, a main storage device such as a Random Access Memory (RAM) and a Read Only Memory (ROM) and an external storage device such as a Hard Disk Drive (HDD). A program for the control unit 230 stored in the storage unit 220 may be stored in a recording medium readable by the management system 200.

[0035] The control unit 230 is an arithmetic device, and includes, for example, an arithmetic circuit such as a Central Processing Unit (CPU). As illustrated in FIG. 2, the control unit 230 includes an acquisition unit 231 and a notification unit 232. The control unit 230 reads and executes a program (software) from the storage unit 220 to implement these units and executes processing performed by the units. Note that the

control unit 230 may execute this processing by one CPU, or may include a plurality of CPUs and execute the processing by the plurality of CPUs. In addition, at least one of the acquisition unit 231 or the notification unit 232 may be implemented by a hardware circuit.

[0036] The acquisition unit 231 acquires the position information about the target position P of the moving body 10. For example, the acquisition unit 231 sets work content to be executed by the moving body 10, and sets the target position P depending on the work content. However, the method of setting the position information about the target position P by the acquisition unit 231 may be any method, and may be specified by the user, for example. For example, a distribution management system (not illustrated) may acquire order information indicating a target object to be carried, a conveyance source, and a conveyance destination, and set a target position P on the basis of the order information, and the acquisition unit 231 may acquire position information about the target position P from the distribution management system.

[0037] The notification unit 232 transmits the position information about the target position P of the moving body 10 to the moving body 10 via the communication unit 210. Note that, in the case where an acquisition request for the target position information is received from the moving body, the position information about the target position P may be transmitted to the moving body 10.

[0038] The input unit 240 receives various types of operation information from a user. For example, the input unit 240 may receive work content of the moving body 10, position information about the target position, and the like as various types of operation information. The input unit 240 may receive various types of operation information by, for example, various operation switches, dials, levers, handles, keyboards, joysticks, mouse, and the like. Furthermore, the input unit 240 may receive various types of operation information via a display screen by a touch panel.

[0039] The display unit 250 displays various types of information. The display unit 250 may display, for example, a Graphical User Interface (GUI) for receiving operation information regarding various types of processing from the user, results of various types of processing, and the like. The display unit 250 may be implemented by a liquid crystal display, an organic Electro Luminescence (EL) display, a micro Light Emitting Diode (LED) display, or the like. Furthermore, the display unit 250 may be a touch

panel of various types such as a capacitance type.

[0040] (Configuration of Control Device of Moving body)

FIG. 5 is a diagram illustrating a configuration example of the control device of the moving body according to the present disclosure. FIG. 6 is a detailed block diagram of a route acquiring unit. As illustrated in FIG. 5, the control device 100 of the moving body 10 according to the present disclosure includes a communication unit 110, a storage unit 120, a control unit 130, a self-localization unit 140, an obstacle detecting unit 150, and a drive signal transmitting unit 160. Hereinafter, these components will be described in order.

[0041] The communication unit 110 transmits and receives various types of information to and from an external device in a wired or wireless manner. In the wired case, for example, the communication unit 110 may be implemented by a Network Interface Card (NIC) including an interface such as a wired LAN terminal or a Universal Serial Bus (USB) terminal. In the wireless case, the communication unit 110 may be implemented by an antenna for a wireless LAN defined in IEEE 802.11, a Bluetooth (registered trademark) module, a Wi-Fi (registered trademark) module, an antenna for a 5th generation mobile communication system (5G), a 6th generation mobile communication system (6G), or the like.

[0042] The storage unit 120 is a storage device that stores various types of information. The storage unit 120 includes a main storage device and an auxiliary storage device. The main storage device may be implemented by, for example, a semiconductor memory element such as a RAM, a ROM, or a flash memory. In addition, the auxiliary storage device may be implemented by, for example, a hard disk, a Solid State Drive (SSD), an optical disc, or the like.

[0043] The control unit 130 is a controller that executes various types of arithmetic processing, processing for implementing functions, and the like. The control unit 130 is implemented by a Central Processing Unit (CPU), a Micro Processing Unit (MPU), or the like executing various programs stored in the storage unit 120 using the RAM as a work area. Furthermore, the control unit 130 may be implemented by, for example, an integrated circuit such as an Application Specific Integrated Circuit (ASIC) or a Field Programmable Gate Array (FPGA).

[0044] As illustrated in FIG. 5, the control unit 130 includes a target position

information acquiring unit 131, a self-localization information acquiring unit 132, an obstacle information acquiring unit 133, a route acquiring unit 134, and a traveling control unit 135 as functions implemented by execution of a program stored in the storage unit 120, a circuit configuration, and the like. As illustrated in FIG. 6, the route acquiring unit 134 includes an area setting unit 1341, a constraint condition setting unit 1342, and an optimization calculation executing unit 1343. Note that the control unit 130 may execute processing of these units by a single CPU, or may include a plurality of CPUs and execute the processing of these units by the plurality of CPUs. At least one of the target position information acquiring unit 131, the self-localization information acquiring unit 132, the obstacle information acquiring unit 133, the route acquiring unit 134, and the traveling control unit 135 may be implemented by a hardware circuit. The content of the processing of these units will be described later.

[0045] The self-localization unit 140 is a device that detects the position and orientation of the moving body 10, in other words, detecting the position and orientation of the moving body 10 itself. In the present embodiment, the position of the moving body 10 refers to coordinates at which the moving body 10 is located in the area AR. The orientation of the moving body 10 refers to a direction in which the moving body 10 faces, and in the present embodiment, refers to the direction (rotation angle) of the moving body 10 when viewed from a direction orthogonal to the direction X and the direction Y. Hereinafter, unless otherwise specified, "position" and "orientation" have similar meaning.

[0046] The self-localization unit 140 may detect the position and the orientation by any method, and examples of a specific implementation means of the self-localization unit 140 include a positioning device for detecting the position using a satellite positioning system such as Global Positioning System (GPS).

[0047] Furthermore, for example, the self-localization unit 140 may be an Inertial Measurement Unit (IMU) that includes an acceleration sensor and a gyro sensor and detects the position and orientation with respect to a predetermined starting point.

[0048] Furthermore, for example, the self-localization unit 140 may detect the position and orientation by laser light. In this case, for example, a reflector is provided in the area AR, and the self-localization unit 140 emits laser light toward the reflector and detects the laser light reflected from the reflector, whereby the position and orientation

can be detected.

[0049] The obstacle detecting unit 150 is a sensor that detects the position and orientation of the obstacle O. The obstacle detecting unit 150 may be any sensor as long as the sensor can detect the position and orientation of the obstacle O. For example, the obstacle detecting unit 150 may be a sensor 26 of the moving body. That is, the position and orientation of an obstacle may be detected on the basis of information acquired by Light Detection And Ranging (2D-LiDAR), 3D-LiDAR, a camera, or the like.

[0050] The drive signal transmitting unit 160 transmits a drive signal calculated by the traveling control unit 135 to the power unit 28. The drive signal transmitting unit 160 may be implemented by various cables for transmission of control signals. For example, the drive signal transmitting unit 160 may be implemented by various electric wires, and may be implemented by, for example, a control signal cable formed by bundling a plurality of electric wires in which the periphery of a conductor such as copper is covered with an insulator and covering the bundled electric wires with a sheath of Polyvinyl Chloride (PVC) having electrical insulating properties. That is, the drive signal transmitting unit 160 is connected to the power unit 28 by an electric wire.

[0051] (Route Setting Processing)

Next, setting processing of the route R for the moving body 10 by the control device 100 will be described. Hereinafter, a case where the moving body 10 detects the obstacle O while traveling along a preset route and sets the route R for avoiding the obstacle O will be described as an example.

[0052] (Acquisition of Target Position)

The target position information acquiring unit 131 acquires position information about the target position P which is the destination of the moving body 10. The target position information acquiring unit 131 acquires the position information about the target position P transmitted from the management system 200 via the communication unit 110. However, the target position information acquiring unit 131 is not limited to acquiring the position information about the target position P from the management system 200, and may set the target position P by itself.

[0053] (Self-localization)

The self-localization information acquiring unit 132 acquires information about the position and orientation of the moving body 10 itself. The self-localization information acquiring unit 132 controls the self-localization unit 140 described above to acquire position information (coordinate information) and orientation information (information indicating the direction) of the moving body 10 itself. Hereinafter, the position information and the orientation information are collectively referred to as position and orientation information as appropriate. The self-localization information acquiring unit 132 sequentially acquires the position and orientation information about the moving body 10 every predetermined time. However, the self-localization information acquiring unit 132 is not limited to detecting the position and orientation of the moving body 10 by itself, and for example, an external device such as the management system 200 may detect the position and orientation of the moving body 10, and the self-localization information acquiring unit 132 may acquire the detection result as the position and orientation information about the moving body 10.

[0054] (Acquisition of Position of Obstacle)

The obstacle information acquiring unit 133 acquires information about the position of the obstacle O. The obstacle information acquiring unit 133 controls the obstacle detecting unit 150 to acquire the position information about the obstacle O. The obstacle information acquiring unit 133 sequentially acquires the position information about the obstacle O every predetermined time. However, the obstacle information acquiring unit 133 is not limited to detecting the position of the obstacle O by itself, and for example, an external device such as the management system 200 may detect the position of the obstacle O, and the obstacle information acquiring unit 133 may acquire the detection result as the position and orientation information about the obstacle O. Note that the obstacle information acquiring unit 133 may acquire the orientation of the obstacle O in addition to the position of the obstacle O.

[0055] (Setting Route)

The route acquiring unit 134 acquires the route R for the moving body 10. In the present embodiment, the route acquiring unit 134 sets a moving body area B0 in which interference by the obstacle O is prohibited on the basis of information regarding the shape of the moving body 10, and sets the route R for the moving body 10 on the basis of the moving body area B0. Hereinafter, a specific description will be given.

[0056] (Setting Occupied Area)

FIG. 7 is a schematic diagram for explaining an example of the occupied area. The area setting unit 1341 of the route acquiring unit 134 sets an occupied area A0 including a vehicle body area A1 occupied by the moving body 10 on the basis of the information regarding the shape of the moving body 10. The occupied area A0 is an area used for setting the moving body area B0. More specifically, the area setting unit 1341 specifies the vehicle body area A1 occupied by the moving body 10 on the basis of the information regarding the shape of the moving body 10, and sets an area including the entire area of the vehicle body area A1 as the occupied area A0. The information regarding the shape of the moving body 10 is information that allows the area occupied by the moving body 10 to be specified, and may be, for example, coordinate information about each point on the outer contour of the moving body 10 in the coordinate system of the moving body 10, or information about the width and length (lengths in the X direction and the Y direction) of the moving body 10. The area setting unit 1341 may acquire the information regarding the shape of the moving body 10 by any method. For example, in the present embodiment, the information regarding the shape of the moving body 10 is stored in the storage unit 120 as design information, and the area setting unit 1341 reads the information regarding the shape of the moving body 10 from the storage unit 120.

[0057] More specifically, in the present embodiment, the area setting unit 1341 sets a front area A2 and a rear area A3 in addition to the vehicle body area A1, and sets an area including the vehicle body area A1, the front area A2, and the rear area A3 (the area coinciding with the entire area of these areas) as the occupied area A0. The front area A2 and the rear area A3 are safety areas set in consideration of the braking distance until the moving body 10 stops. The front area A2 is an area located on the front side of the moving body 10 with respect to the vehicle body area A1 and adjacent to the vehicle body area A1. The rear area A3 is an area located on the rear side of the moving body 10 with respect to the vehicle body area A1 and adjacent to the vehicle body area A1. The area setting unit 1341 acquires a planned speed that is the speed of the moving body 10 when the moving body 10 travels on a route R to be set from now, and sets the size of the occupied area A0 (in this example, areas of the front area A2 and the rear area A3) on the basis of the planned speed. The planned speed is set in

advance for each section through which the moving body 10 is planned to travel, for example. The area setting unit 1341 sets the size of the occupied area A0 (the front area A2 and the rear area A3 in this example) such that the occupied area A0 (the front area A2 and the rear area A3 in this example) becomes wider as the planned speed is higher. The area setting unit 1341 sets the front area A2 having a size set on the front side of the vehicle body area A1, sets the rear area A3 having a size set on the rear side of the vehicle body area A1, and sets an area including the vehicle body area A1, the front area A2, and the rear area A3 as the occupied area A0.

[0058] Note that, since the occupied area A0 is an area around the moving body 10 including the vehicle body area A1, the position of the occupied area A0 in the coordinate system of the area AR travels as the moving body 10 travels. Hereinafter, the position of the occupied area A0 may refer to the position of the occupied area A0 in the coordinate system of the moving body 10 unless otherwise specified.

[0059] Furthermore, in the case where the moving body 10 is carrying a load, the area setting unit 1341 may set the occupied area A0 in consideration of the size of the load as well. In the case where the moving body 10 is carrying a load, the area setting unit 1341 may widen the occupied area A0 as compared with a state where the load is not carried. For example, in the case where the area setting unit 1341 determines that the moving body 10 is in a state of carrying a load, the rear area A3 may be expanded by a predetermined size as compared to the state where the load is not carried. Note that the method of determining that the moving body 10 is in the state of carrying a load may be any method, and for example, in the case where the moving body 10 is traveling on a route from a position where the moving body loads the load to a position where the moving body unloads the load, it may be determined that the moving body 10 is in the state of carrying a load. In addition, the size (predetermined size) for expanding the rear area A3 may be set in any manner, and, for example, the rear area A3 may be expanded by a preset size.

[0060] In addition, the area setting unit 1341 may set the occupied area A0 on the basis of the detection result of the size of the load carried by the moving body 10. The method of detecting the size of the load may be any method. For example, the sensors 26 mounted on the moving body 10 may detect the protruding lengths of the load carried by the moving body 10 from the edges of the moving body 10 in the left-right

direction. Furthermore, for example, the moving body 10 may insert the claws 24A and 24B into holes in a pallet on which the load is loaded at the time of loading a load, and may calculate the protruding lengths of the load by moving the claws 24A and 24B to the left and right in the state where the claws 24A and 24B are inserted into the holes in the pallet. That is, in this case, the protruding lengths of the load are calculated on the basis of the travel amount of the claws 24A and 24B in the left-right direction from the state where the claws 24A and 24B abut against the inner walls on one side (for example, on the left side) of the holes to the state where the claws 24A and 24B abut against the inner walls on the other side (for example, on the right side) of the holes. The area setting unit 1341 may widen the rear area A3 in the left-right direction by the protruding lengths of the load (or longer than the protruding lengths).

[0061] Note that, for example, there are cases where the load carried by the moving body 10 is displaced, and the load protrudes from the vehicle body area A1 while also protruding from the rear area A3. In this case, the area setting unit 1341 may widen the vehicle body area A1 in the left-right direction by the protruding lengths of the load (or longer than the protruding lengths).

[0062] (Setting Moving body Area)

The area setting unit 1341 for the moving body area sets the moving body area B0 on the basis of the occupied area A0. The moving body area B0 refers to an area which the obstacle O should not enter when the moving body 10 is traveling on the route R. That is, the route acquiring unit 134 sets the route R such that the obstacle O does not overlap the moving body area B0. Note that the position of the moving body area B0 in the coordinate system of the area AR also travels as the moving body 10 travels. Hereinafter, the position of the moving body area B0 may refer to the position of the moving body area B0 in the coordinate system of the moving body 10 unless otherwise specified.

[0063] FIG. 8 is a schematic diagram for explaining an example of the moving body area. The area setting unit 1341 sets the moving body area B0 such that the moving body area B0 overlaps the occupied area A0 and that the moving body area B0 has a shape in which a plurality of unit areas B are partially overlapped with each other. The shape in which the unit areas B partially overlap each other refers to a shape in which a partial area of the entire area of a unit area B overlaps a partial area of another unit area

B. A unit area B is a circular or elliptical area when viewed from the Z direction. Therefore, the moving body area B0 has a shape in which a plurality of circles or ellipses is continuous while partially overlapping.

[0064] In the present embodiment, the area setting unit 1341 sets the position and size of the moving body area B0, namely, the position and size of each unit area B such that the moving body area B0 overlaps the entire occupied area A0. In the example of the present embodiment, the area setting unit 1341 sets the moving body area B0 such that a unit area B1 (first unit area) overlapping the vehicle body area A1, a unit area B2 (second unit area) overlapping the front area A2, and a unit area B3 (third unit area) overlapping the rear area A3 are included and that at least two of the unit areas B1, B2, and B3 overlap each other. More specifically, in the example of FIG. 8, the area setting unit 1341 sets the moving body area B0 such that the unit areas B3, B1, and B2 are arranged in this order toward the front side of the moving body 10. In the example of FIG. 8, the unit area B1 overlaps the entire area of the vehicle body area A1, the unit area B2 overlaps the entire area of front area A2, the unit area B3 overlaps the entire area of the rear area A3, the area on the front side of the unit area B1 overlaps the area on the rear side of the unit area B2, and the area on the rear side of the unit area B1 overlaps the area on the front side of the unit area B3.

[0065] However, the moving body area B0 is not limited to overlapping the entire occupied area A0, and may overlap a partial area of the occupied area A0. For example, the area setting unit 1341 may set the moving body area B0 in such a manner as to overlap the peripheral edge of the occupied area A0. In this case, the moving body area B0 does not necessarily overlap an area radially inside the peripheral edge of the occupied area A0.

[0066] (Another Example of Moving body Area)

FIGS. 9 and 10 are schematic diagrams illustrating other examples of the moving body area. In the present embodiment, the area setting unit 1341 sets the moving body area B0 such that the unit area B2 overlapping the front area A2, the unit area B1 overlapping the vehicle body area A1, and the unit area B3 overlapping the rear area A3 are arranged in this order in the rearward direction; however, the shape of the moving body area B0 is not limited thereto. For example, the number of unit areas B is not limited to three, and may be two or four or more. In the example of FIG. 9, the

example is illustrated in which the area setting unit 1341 sets the moving body area B0 such that two unit areas B, namely, a unit area B1 overlapping the entire area of the front area A2 and an area on the front side of the vehicle body area A1, and a unit area B2 overlapping an area on the rear side of the vehicle body area A1 and the entire area of the rear area A3 are arranged in this order in the rearward direction.

[0067] Furthermore, for example, the unit areas B are not limited to being arranged in the front-rear direction of the moving body 10, and may be arranged in the left-right direction of the moving body 10. In the example of FIG. 9, the area setting unit 1341 sets the moving body area B0 such that two unit areas B, namely, a unit area B1 overlapping areas on the left side of the front area A2, the vehicle body area A1, and the rear area A3 and a unit area B2 overlapping areas on the right side of the front area A2, the vehicle body area A1, and the rear area A3 are arranged in this order in the rightward direction. In addition, the area setting unit 1341 may set the moving body area B0 in such a manner as to include unit areas B arranged in the front-rear direction and unit areas B arranged in the left-right direction.

[0068] Calculation of Route

On the basis of the position information about the target position P, the position information about the obstacle O, and the position and size information about the moving body area B0, the route acquiring unit 134 calculates, as the route R for the moving body 10, a route on which the moving body 10 travels toward the target position P without the obstacle O overlapping the moving body area B0. The route acquiring unit 134 may calculate the route R by any method based on these pieces of information. However, in the present embodiment, a constraint condition and an evaluation function are set, whereby the route R is calculated using an optimization calculation method.

[0069] (Setting Constraint Condition)

The constraint condition setting unit 1342 of the route acquiring unit 134 sets, as a constraint condition, that the obstacle O does not overlap the moving body area B0 when the moving body 10 travels along the route R. In the present embodiment, the constraint condition setting unit 1342 sets, as the constraint condition, that the moving body 10 does not interfere with the obstacle O in each look-ahead step on the basis of the position of the moving body 10, the moving body area B0, and the position of the

obstacle O. That is, the constraint condition is that the moving body area B0 does not interfere with the obstacle O in each look-ahead step.

[0070] (Execution of Optimization Calculation)

The optimization calculation executing unit 1343 of the route acquiring unit 134 executes optimization calculation on the basis of the constraint condition set by the constraint condition setting unit 1342 and an evaluation function in which the smaller the deviation between the position of the moving body 10 and the target position P for each look-ahead step is, the higher the evaluation is. That is, the route acquiring unit 134 predicts (pre-reads) the route satisfying the constraint condition using the concept of model predictive control, and evaluates the deviation between the moving body 10 and the target position regarding the position of each predictive step of the moving body 10 using the evaluation function in which the shorter the distance in the relationship between the moving body 10 and the target position P is in each look-ahead step, the higher the evaluation is, thereby specifying the route R. As a result, the route acquiring unit 134 can specify the optimum route R, namely, the optimum position and orientation of the moving body 10 for each look-ahead step.

[0071] (Specific Example of Optimization Calculation)

Hereinafter, a specific example of the optimization calculation will be described.

[0072] The optimization calculation executing unit 1343 executes the optimization calculation and calculates a driving condition of the moving body 10 that can implement the optimized route R for the moving body 10. The driving condition refers to an input value for operating the power unit 28 of the moving body 10. In the present embodiment, the constraint condition setting unit 1342 sets the constraint condition that the moving body area B0 does not interfere with the obstacle O for each look-ahead step in order to execute the optimization calculation. The look-ahead step means a discretized time step after the current time (the timing at which the position of the obstacle O and the position and orientation of the moving body 10 have been detected most recently). Then, the optimization calculation executing unit 1343 performs the optimization calculation on the basis of the evaluation function in which the smaller the deviation between the position of the moving body 10 and the target position P for each look-ahead step is, the higher the evaluation is, and the constraint condition, and calculates the driving condition of the moving body 10 that can implement the route R

for the moving body 10 optimized by the optimization calculation. Note that, hereinafter, the travel of the moving body 10 on the two-dimensional coordinate plane in the X direction and the Y direction will be described as an example; however, the present invention is also applicable to a motion model on three-dimensional coordinates.

[0073] Here, the optimized route R calculated by the optimization calculation executing unit 1343 can be said to be a set of positions and orientations of the moving body 10 for respective look-ahead steps (for each discrete time from the present time onward), and can be said to be a future route. Denoting the position (coordinates) of the moving body 10 in the X direction and the Y direction as $[x, y]^T$, the orientation of the moving body 10 as θ, and the look-ahead step (discrete time) as k, the position and orientation of the moving body 10 in the look-ahead step k, namely, the route R in the look-ahead step k is expressed by the following Equation (1). Note that T represents transposition. Note that, as described above, the description of the present embodiment exemplifies the motion on two-dimensional plane coordinates. For example, in the case of a motion model on three-dimensional coordinates, the following equations and the like are adapted to three-dimensional coordinates.

[0074]

$$p(k) = [x(k)\ y(k)\ \theta(k)]^{\mathrm{T}} \quad \cdots (1)$$

[0075] In this case, the motion model of the moving body 10 is expressed by the following Equation (2).

[0076]

$$p(k+1) = f(p(k), u(k), \Delta t) \quad \cdots (2)$$

[0077] Δt in Equation (2) denotes the time width related to transition from (k) to (k + 1). Δt may be the same as the update interval of the route R (the time width from the update of the route R to the next update of the route R), but may be shorter than the update interval or longer than the update interval, for example. By making Δt shorter than the update interval, a detailed route R can be generated, and by making Δt longer than the update interval, a calculation load can be reduced. In addition, u(k) is an input by the system and indicates the driving condition of the moving body 10. In the example of the present embodiment, u(k) is expressed by the following Equation (3) using the speed v(k) of the moving body 10 and the steering angle Φ(k) of the moving body 10.

[0078]

$$u(k) = [v(k)\ \phi(k)]^{\mathrm{T}} \qquad \cdots (3)$$

[0079] In the case where a motion on two-dimensional plane coordinates is assumed, f, which is a state equation of the system, is expressed as the following Equation (4) as an example. Note that L denotes to a wheel base, and represents, for example, a distance between the front wheels and the rear wheels.

[0080]

$$f(p(k), u(k), \Delta t) = \begin{bmatrix} x(k) + \Delta t \cdot v(k) \cdot \cos\theta(k) \\ y(k) + \Delta t \cdot v(k) \cdot \sin\theta(k) \\ \theta(k) + \Delta t \cdot \dfrac{v(k)}{L} \cdot \tan\phi(k) \end{bmatrix} \qquad \cdots (4)$$

[0081] In the present embodiment, the optimization calculation executing unit 1343 provisionally sets the position and orientation of the moving body 10 for each look-ahead step when setting the constraint condition. Then, the optimization calculation executing unit 1343 calculates the position (coordinates) of the obstacle O in the coordinate system of the moving body 10 for each look-ahead step. That is, the optimization calculation executing unit 1343 converts the position (coordinates) of the obstacle O in the coordinate system in the direction X and the direction Y acquired by the obstacle information acquiring unit 133 into a position (coordinates) with the position of the moving body 10 in the look-ahead step set as the coordinate origin. For example, the optimization calculation executing unit 1343 calculates the position of the obstacle O in the coordinate system of the moving body 10 using the following Equation (5).

[0082]

$$\begin{bmatrix} x_{ob}(k) \\ y_{ob}(k) \end{bmatrix} = \begin{bmatrix} \cos(\theta(k)) & \sin(\theta(k)) \\ -\sin(\theta(k)) & \cos(\theta(k)) \end{bmatrix} \begin{bmatrix} x'_{ob} - x(k) \\ y'_{ob} - y(k) \end{bmatrix} \qquad \cdots (5)$$

[0083] Note that $[x'_{ob}, y'_{ob}]$ represents the position of the obstacle O in the coordinate system in the direction X and the direction Y acquired by the obstacle information acquiring unit 133 and that $[x_{ob}(k), y_{ob}(k)]^{T}$ represents the position of the obstacle O in the coordinate system of the moving body 10 in the look-ahead step k.

[0084] Then, the optimization calculation executing unit 1343 sets, as the constraint condition, that the position of the obstacle O is outside the moving body area B0 in each look-ahead step.

[0085] Note that the constraint condition can be solved at each look-ahead step in this manner because the position and orientation of the moving body 10 in a look-ahead step are predictively calculated and set on the basis of the motion model.

[0086] (Optimization Calculation)

The optimization calculation executing unit 1343 executes the optimization calculation on the basis of the constraint condition set in the above manner and the evaluation function in which the smaller the deviation between the position of the moving body 10 and the target position P for each look-ahead step is, the higher the evaluation is. That is, the optimization calculation executing unit 1343 predicts (pre-reads) the traveling route satisfying the constraint condition using the concept of model predictive control, and evaluates the deviation between the moving body 10 and the target position regarding the position of each predictive step of the moving body 10 using the evaluation function in which the shorter the distance in the relationship between the moving body 10 and the target position P is in each look-ahead step, the higher the evaluation is, thereby specifying the route R. As a result, the optimization calculation executing unit 1343 can specify the optimum route R, namely, the optimum position and orientation of the moving body 10 for each look-ahead step. In other words, the optimization calculation executing unit 1343 specifies the optimum position and orientation (namely, the optimum route R) of the moving body 10 for each look-ahead step such that the constraint condition that the position of the moving body 10 for each look-ahead step does not interfere with the obstacle O is satisfied and that the deviation between the position of the moving body 10 and the target position P for each look-ahead step is minimized.

[0087] In the present embodiment, it is based on the premise that an objective function V(u, p, k) for optimizing the route R is expressed by the following Equation (6).

[0088]

$$V(u,p,k) = \min_{u} \sum_{k} J(u,p,k) \qquad \cdots (6)$$

[0089] Here, J(u, p, k) is an evaluation function representing the purpose of the optimization, and is set to such a function that includes approach and arrival to the target position in the case of route planning. In the example of the present embodiment, the optimization calculation executing unit 1343 sets the evaluation

function J(u, p, k) as the following Equation (7).

[0090]

$$J(u,p,k) = A_1(x(k) - x_T)^2 + A_2(y(k) - y_T)^2 + A_3(\theta(k) - \theta_T)^2 \quad \cdots (7)$$

[0091] Here, $p_r = [x(k), y(k), \theta(k)]^T$, namely, x_r, y_r, and θ_r in Equation (7) represent targeted position and orientation. A_1, A_2, and A_3 are weighting coefficients and may be set in any manner. On the basis of this evaluation function, optimization is performed such that the deviation between the position and orientation (p(k)) and the targeted position and orientation (p_r) in each look-ahead step k of the moving body 10 becomes small. That is, such an optimization result that the moving body 10 approaches the targeted position and orientation in the shortest distance is obtained.

[0092] By executing the optimization calculation as described above, the optimization calculation executing unit 1343 obtains the value of u(k), which is the driving condition (input of the system) for each look-ahead step, as an output (optimal solution) of the optimization calculation. It can be said that the driving condition for each look-ahead step obtained by the optimization calculation executing unit 1343 is a driving condition for implementing the optimized route R. The optimization calculation executing unit 1343 may calculate the optimized route R on the basis of the driving condition for each look-ahead step obtained by the optimization calculation. For example, the optimization calculation executing unit 1343 may calculate the optimized route R by substituting u(k) obtained by the optimization calculation into Equation (2).

[0093] Note that the method of imposing the constraint condition on the optimization calculation is not limited to the method described above, and for example, the constraint condition may be incorporated in the objective function V(u, p, k) and the evaluation function J(u, p, k). In the above description, the case where there is a single obstacle O has been described as an example; however, there may be a plurality of obstacles O. As the method for solving the optimization problem, for example, a nonlinear optimization method such as a sequential quadratic programming method may be used. The optimization method used here is capable of solving an optimization problem in which a constraint condition is imposed. Note that, for example, in the case where Equation (2) and the constraint condition are nonlinear functions, it is preferable to use nonlinear optimization, and there is a possibility that linear optimization methods are not suitable.

[0094] (Causing Moving body to Travel)

The traveling control unit 135 controls the moving body 10 on the basis of the driving conditions acquired by the route acquiring unit 134. The traveling control unit 135 drives the power unit 38 under the driving conditions acquired by the route acquiring unit 134. As a result, the traveling control unit 135 causes the moving body 10 to travel along the optimized route R. In the present embodiment, the traveling control unit 135 generates a control signal to be given to the power unit 28 on the basis of the driving conditions calculated by the route acquiring unit 134. That is, the traveling control unit 135 generates a control signal for implementing the driving conditions on the basis of the driving conditions calculated by the route acquiring unit 134. In the example of the present embodiment, a control signal for implementing the driving conditions is generated by using the speed v(k) of the moving body 10 and the steering angle $\Phi(k)$ of the moving body 10.

[0095] Note that, in the above description, the route acquiring unit 134 calculates the driving condition for each look-ahead step for implementing the optimized route R by performing the optimization calculation as the output; however, the present invention is not limited thereto. For example, the route acquiring unit 134 may calculate the optimized route R by performing optimization calculation. In this case, the route acquiring unit 134 may calculate the driving conditions for each look-ahead step on the basis of the optimized route R. Alternatively, the route acquiring unit 134 of the control device 100 may calculate the route R, and another device or program may acquire information about the route R from the control device 100 and calculate the driving conditions. That is, the control device 100 can be rephrased as a route generation device that sets the route R.

[0096] Note that, in the present embodiment, the moving body 10 includes the control device 100, and the control device 100 included in the moving body 10 performs processing related to the setting of the route R, such as the setting of the moving body area B0 and the setting of the route R. However, the processing related to the setting of the route R such as the setting of the moving body area B0 and the setting of the route R is not limited to being performed by the moving body 10, and may be performed by an external device such as the management system 12. In this case, the moving body 10 may acquire the set route R and the driving condition for traveling

along the route R from the external device, and control the moving body 10 (power unit 38) using the acquired route R and driving condition. In other words, the control device 30 may be included in the moving body 10 or may be included in a device (for example, the management system 12) other than the moving body 10. Furthermore, at least one function of the target position information acquiring unit 131, the self-localization information acquiring unit 132, the obstacle information acquiring unit 133, and the route acquiring unit 134 may be included in the moving body 10, or may be included in another device (for example, the management system 12).

[0097] Furthermore, in the above description, it has been described that the moving body 10 detects the obstacle O during the travel on the preset route and sets the route R to avoid the obstacle O. However, the route R is not limited to one that is set with detection of the obstacle O as a trigger. For example, the control device 100 and the management system 12 may set a route on which the moving body 10 is scheduled to travel in the future as the route R. In this case, the control device 100 and the management system 12 may acquire the position information about the origin of traveling (the start point of the route R) of the moving body 10, the position of the target position P, and the position information about the obstacle O (for example, a wall, a column, or the like) whose position is known, and set the route R from the origin of traveling to the target position P without the obstacle O overlapping the moving body area B0 by a method similar to the method described above.

[0098] (Processing Flow)

Next, a setting flow of the route R in the first embodiment will be described. FIG. 11 is a flowchart for explaining a route setting flow according to a first embodiment. As illustrated in FIG. 11, in the present embodiment, the control device 100 of the moving body 10 acquires various types of position information (step S10). Specifically, the control device 100 acquires the position information about the target position P by the target position information acquiring unit 131, and acquires the position information about the obstacle O by the obstacle information acquiring unit 133. The control device 100 sets, by the area setting unit 1341, the moving body area B0 having a shape overlapping the occupied area A0 including the area occupied by the moving body 10 and having a shape in which a plurality of unit areas B partially overlaps with each other (step S12). Then, the control device 100 sets, by the

constraint condition setting unit 1342, the constraint condition that the obstacle O does not overlap the moving body area B0 (step S14), and executes, by the optimization calculation executing unit 1343, the optimization calculation on the basis of the constraint condition and the evaluation function to set the route R (step S16).

[0099] (Effects)

As described above, the control device 100 according to the present embodiment sets the moving body area B0 which overlaps the occupied area A0 including the area occupied by the moving body 10 and has a shape in which the plurality of unit areas B partially overlaps with each other. Then, the control device 100 sets a route to the target position P on which the obstacle O does not overlap with the moving body area B0 as the route R for the moving body 10. Since the moving body area B0 is an area where the moving body 10 may enter, the route R is set such that the obstacle O does not overlap the moving body area B0, whereby the moving body 10 can be caused to travel while suppressing interference with the obstacle O.

[0100] In addition, when the moving body area B0 is set to be too small, the route can be flexibly set; however, there is a risk that interference with the obstacle O cannot be avoided. On the other hand, when the moving body area B0 is set to be too large, the degree of restriction on the settable route may be increased in the case where a route for avoiding the obstacle O is set. For example, in the case where the moving body area B0 is set with a single ellipse or circle, when the moving body area B0 is set to a size that allows interference with the obstacle O to be avoided, the moving body area B0 becomes excessively larger than the original occupied area A0 of the moving body 10, and there is a possibility that the degree of restriction on the settable route increases. In this case, for example, the operable range may become narrower such as that the passage width is increased. On the other hand, in the present embodiment, the moving body area B0 is set such that the plurality of unit areas B of circles or ellipses partially overlaps each other. As a result, even if the moving body area B0 is set to such a size that the interference with the obstacle O can be avoided, it is possible to suppress the area size of the moving body area B0 from becoming excessively large, and it is possible to flexibly set the route R. As described above, according to the present embodiment, the route for the moving body 10 can be appropriately set.

[0101] (Second Embodiment)

Next, a second embodiment will be described. The second embodiment is different from the first embodiment in that a moving body area B0 is set using optimization calculation. In the second embodiment, the description of parts having the same configuration as that of the first embodiment will be omitted.

[0102] FIG. 12 is a schematic diagram for explaining setting of moving body areas. In the second embodiment, a moving body area B0 is set by setting the position and size of unit areas B using optimization calculation. Hereinafter, a specific description will be given.

[0103] (Setting Occupied Area)

In the second embodiment, the area setting unit 1341 sets an occupied area A0. Since the method of setting the occupied area A0 in the second embodiment is similar to that in the first embodiment, detailed description thereof will be omitted. In this example, the area setting unit 1341 sets an area including a vehicle body area A1, a front area A2, and a rear area A3 as the occupied area A0.

[0104] (Setting Number of Unit Areas)

In the second embodiment, the area setting unit 1341 sets the number of unit areas B included in the moving body area B0. The method of setting the number of unit areas B may be any method; however, for example, in the present embodiment, the area setting unit 1341 sets a predetermined number set in advance as the number of unit areas B. The number of unit areas B may be any number, but is preferably within a range of about two to five, for example. Furthermore, for example, the area setting unit 1341 may set the number of unit areas B on the basis of the information regarding the shape of the moving body 10. For example, the area setting unit 1341 may set three unit areas B in the case where the moving body 10 has one fork 24, and may set four unit areas B in the case where the moving body 10 has two forks 24 aligned in the left-right direction. Hereinafter, the case where three unit areas B are provided will be described as an example.

[0105] (Setting Unit Occupied Area)

The area setting unit 1341 divides the occupied area A0 into a plurality of unit occupied areas A on the basis of the number of unit areas B. In the present embodiment, the area setting unit 1341 divides the occupied area A0 into unit occupied areas A as many as the unit areas B. In this example, since the number of unit areas B

is three, the area setting unit 1341 divides the occupied area A0 into three unit occupied areas A.

[0106] The position and size of each unit occupied area A may be set in any manner. In the example of FIG. 12, the area setting unit 1341 divides an occupied area A0 into a unit occupied area A overlapping a vehicle body area A1, a unit occupied area A overlapping a front area A2, and a unit occupied area A overlapping a rear area A3. Note that, for example, in the case where the moving body 10 has two forks 24 aligned in the left-right direction and four unit areas B are set, the area setting unit 1341 may divide the occupied area A0 into a unit occupied area A that is a left area of the vehicle body area A1, a unit occupied area A that is a right area of the vehicle body area A1, a unit occupied area A that is a front area A2, and a unit occupied area A that is a rear area A3.

[0107] (Setting Constraint Condition)

The area setting unit 1341 sets, as a constraint condition, that a unit area B overlaps with positions on the peripheral edge of the unit occupied area A for each of the unit occupied areas A. That is, the area setting unit 1341 allocates one unit area B to each of the unit occupied areas A. Then, for each of the unit occupied areas A, the area setting unit 1341 sets, as a constraint condition, that the unit area B allocated to the unit occupied area A overlaps with positions P on the peripheral edge of the unit occupied area A. That is, in the example of FIG. 12, the area setting unit 1341 allocates a unit area B1 to the unit occupied area A corresponding to the vehicle body area A1, allocates a unit area B2 to the unit occupied area A corresponding to the front area A2, and allocates a unit area B3 to the unit occupied area A corresponding to the rear area A3. Then, the area setting unit 1341 sets, as constraint conditions, that the unit area B1 overlaps positions P1 on the peripheral edge of the unit occupied area A corresponding to the vehicle body area A1, that the unit area B2 overlaps positions P2 on the peripheral edge of the unit occupied area A corresponding to the front area A2, and that the unit area B3 overlaps positions P2 on the peripheral edge of the unit occupied area A corresponding to the rear area A3.

[0108] Here, the area setting unit 1341 may set the position P on the peripheral edge of the unit occupied area A by any method based on the position and size of the unit occupied area A. For example, the area setting unit 1341 may calculate coordinates of

each position on the peripheral edge of a unit occupied area A from the position and size of the unit occupied area A, and select some of the positions on the peripheral edge of the unit occupied area A as the position P on the peripheral edge of the unit occupied area A. In this case, for example, the area setting unit 1341 may select corner positions on the peripheral edge of the unit occupied area A as the positions P on the peripheral edge of the unit occupied area A. In the example of FIG. 12, since each of the unit occupied areas A has a rectangular shape, the area setting unit 1341 selects vertex portions of the rectangle of a unit occupied area A as the positions P on the peripheral edge of the unit occupied area A.

[0109] Furthermore, in the above description, a position P on the peripheral edge of the unit occupied area A is set as coordinates (point) having no range; however, the present invention is not limited thereto, and an area having a predetermined size centered on central coordinates (center point) may be set as the position P. In this case, for example, the area setting unit 1341 may set a point on the peripheral edge of the unit occupied area A as central coordinates (center point), and may set a circle having a predetermined radius centered at the central coordinates as the position P. The predetermined radius here may be set as appropriate in consideration of a detection error, a dimensional error of the moving body 10, and the like.

[0110] In addition, the area setting unit 1341 may include, in the constraint conditions, a condition other than that the unit areas B overlap with the positions P on the peripheral edges of the unit occupied areas A. For example, the area setting unit 1341 may set, as a constraint condition, that the sizes of the unit areas B (the lengths in the front-rear direction and the left-right direction) are within a range of a predetermined upper limit value and a predetermined lower limit value. Furthermore, for example, the area setting unit 1341 may set, as a constraint condition, that the ratios of the major axis to the minor axis of the unit areas B fall within a range of a predetermined upper limit value and a predetermined lower limit value.

[0111] (Optimization Calculation)

The area setting unit 1341 calculates the position and size of each of the unit areas B by setting the area size of the unit areas B as an evaluation function and executing optimization calculation that minimizes the evaluation function while satisfying the constraint condition set as described above.

[0112] The area setting unit 1341 executes optimization calculation for each of the unit areas B and calculates the position and size of each of the unit areas B. That is, for a targeted unit area B, the area setting unit 1341 calculates the position and size of the unit area B, in which the size of the unit area B is minimized, as the optimized position and size (solution) of the unit area B while satisfying the constraint condition that all the positions P on the peripheral edge of the allocated unit occupied area A are within the unit area B. The area setting unit 1341 performs similar calculation for each of the unit areas B to calculate the position and size of the unit area B. For example, in the example of FIG. 12, the area setting unit 1341 calculates the position and size of the unit area B1 in which the size of the unit area B1 is minimized as the optimized position and size (solution) of the unit area B1 while satisfying the constraint condition that all the positions P1 on the peripheral edge of the vehicle body area A1 are inside the unit area B1. Similarly, the area setting unit 1341 calculates the position and size of the unit area B2 in which the size of the unit area B2 is minimized as the optimized position and size (solution) of the unit area B2 while satisfying the constraint condition that all the positions P2 on the peripheral edge of the front area A2 are inside the unit area B2. Similarly, the area setting unit 1341 calculates the position and size of the unit area B3 in which the size of the unit area B3 is minimized as the optimized position and size (solution) of the unit area B3 while satisfying the constraint condition that all the positions P3 on the peripheral edge of the rear area A3 are inside the unit area B3.

[0113] The area setting unit 1341 sets the moving body area B0 on the basis of the position and size of each unit area B set in this manner. Since the setting processing of the route R using the moving body area B0 is similar to that of the first embodiment, description thereof will be omitted.

[0114] (Processing Flow)

Next, a moving body area setting flow in the second embodiment will be described. FIG. 13 is a flowchart for explaining a moving body area setting flow in the second embodiment. As illustrated in FIG. 13, the area setting unit 1341 sets the number of unit areas B (step S20), and sets unit occupied areas A on the basis of the number of unit areas B (step S22). For each of the unit occupied areas A, the area setting unit 1341 sets, as a constraint condition, that the unit area B overlaps with positions P on the peripheral edge of the unit occupied area A (step S24), and executes

optimization calculation on the basis of the constraint condition and the evaluation function to set the position and size of each unit area B (step S26). The area setting unit 1341 calculates the position and size of the unit area B in which the size of the unit area B is minimized while satisfying the constraint condition that all the positions P on the peripheral edge of the unit occupied area A are inside the unit areas B. The area setting unit 1341 sets the moving body area B0 on the basis of the position and size of each unit area B set in this manner.

[0115] (Effects)

As in the second embodiment, by setting the position and size of the unit areas B by the optimization calculation, it is possible to set the moving body area B0 whose area size does not become excessively large while appropriately suppressing interference between the obstacle O and the moving body 10. Therefore, according to the present embodiment, the route R can be appropriately set. Furthermore, in the second embodiment, the number of unit areas B is set, and the same number of unit occupied areas A as the number of unit areas B are set to perform optimization calculation. Therefore, it is possible to appropriately set a moving body area B0 whose area size is not excessively large while suppressing an increase in the computational load.

[0116] (Other examples)

Next, other examples of the second embodiment will be described.

[0117] (Another Example 1)

FIG. 14 is a flowchart for explaining a route setting flow according to another example of the second embodiment. The present example is different from the second embodiment in that the number of unit areas B is increased and the moving body area B0 is reset in a case where a route R cannot be set by using the set moving body area B0.

[0118] Specifically, as illustrated in FIG. 14, the area setting unit 1341 of the present example sets a moving body area B0 by a similar method to that of the second embodiment on the basis of the number of unit areas B set by a similar method to that of the second embodiment (step S30). Then, in the present example, the route acquiring unit 134 attempts to set the route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 in a similar method to those of the first embodiment and the second embodiment (step S32).

[0119] If the route R cannot be set (step S34; No), namely, for example, if no optimized route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 can be set, the area setting unit 1341 increases the number of unit areas B (step S36), returns to step S30, resets the moving body area B0 by a similar method on the basis of the reset (increased) number of unit areas B, and continues the subsequent processing. Note that the number of unit areas B to be increased is, for example, one, but is not limited thereto, and may be any number. If the route R has been set (step S34; Yes), namely, for example, if the optimized route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 has been set, the present processing is ended. Note that, for example, also in the case where the route R cannot be set when the number of unit areas B is increased to a predetermined maximum number, it may be determined that the route R cannot be set, and this processing may be ended. In this case, for example, the setting of the route R may be repeated by changing the calculation condition of the route R in such a manner as to pass through a section having been set not to be passed through at the time of initial setting of the route R.

[0120] When the number of unit areas B is increased, the moving body area B0 can be set to be narrower, whereby the possibility that the route R can be set is increased. Therefore, as in the present example, in the case where the route R cannot be set, the route R can be appropriately set by increasing the number of unit areas B and retrying to set the route R.

[0121] In addition, in the above example, in the case where the route R cannot be set, the route R is reset by increasing the number of unit areas B; however, it is also possible to perform the reverse processing. That is, for example, in the case where the route R can be set using the moving body area B0 calculated on the basis of the set number of unit areas B, the number of unit areas B may be reduced to recalculate the moving body area B0, and the setting of the route R may be attempted using the recalculated moving body area B0. In this case, when the route R can be set by reducing the number of unit areas B, the route R may be adopted as an actual route for the moving body 10. As a result, it is possible to set the route R in which the number of unit areas B is as small as possible. Note that this processing can also be used, for example, to set an avoiding route when the moving body 10 detects the obstacle O, but is particularly effective

when a route along which the moving body 10 is scheduled to travel in the future is set in advance.

[0122] (Another Example 2)

FIG. 15 is a flowchart for explaining a route setting flow according to another example of the second embodiment. The present example is different from the second embodiment in that the planned speed of the moving body 10 is decreased and the moving body area B0 is reset in the case where the route R cannot be set by using the set moving body area B0.

[0123] Specifically, as illustrated in FIG. 15, the area setting unit 1341 of the present example sets the occupied area A0 and the moving body area B0 on the basis of the set planned speed (the traveling speed planned to be adopted by the moving body 10 when traveling on the route R) by a similar method to those in the first embodiment and the second embodiment (step S40). That is, for example, the area setting unit 1341 sets the size of the front area A2 and the size of the rear area A3 on the basis of the planned speed, and sets the occupied area A0 including the vehicle body area A1, the front area A2, and the rear area A3 on the basis of the sizes. The area setting unit 1341 of the present example sets the moving body area B0 in a similar method to that in the second embodiment on the basis of the set occupied area A0.

[0124] Then, the route acquiring unit 134 attempts to set the route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 in a similar method to those of the first embodiment and the second embodiment (step S42).

[0125] If the route R cannot be set (step S44; No), namely, for example, if no optimized route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 can be set, the area setting unit 1341 decreases the planned speed (step S46), returns to step S40, resets the occupied area A0 and the moving body area B0 by a similar method on the basis of the reset (decreased) planned speed, and continues the subsequent processing. Note that the planned speed may be decreased by any degree. If the route R has been set (step S44; Yes), namely, for example, if the optimized route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 has been set, the present processing is ended. Note that, for example, also in the case where the route R cannot be set when the

planned speed is decreased to a predetermined lower limit value, it may be determined that the route R cannot be set, and this processing may be ended. In this case, for example, the setting of the route R may be repeated by changing the calculation condition of the route R in such a manner as to pass through a section having been set not to be passed through at the time of initial setting of the route R.

[0126] When the planned speed is decreased, the occupied area A0 (in this example, the front area A2 and the rear area A3) can be set to be narrower, and accordingly, the moving body area B0 can also be set to be narrower, and thus the possibility that the route R can be set is increased. Therefore, as in the present example, in the case where the route R cannot be set, the route R can be appropriately set by decreasing the planned speed and retrying to set the route R.

[0127] Furthermore, in the above example, when the route R cannot be set, the route R is reset by decreasing the planned speed; however, it is also possible to perform the reverse processing. That is, for example, in the case where the route R can be set using the moving body area B0 calculated on the basis of the set planned speed, the planned speed may be increased to recalculate the moving body area B0, and the setting of the route R may be attempted using the recalculated moving body area B0. In this case, when the route R can be set by increasing the planned speed, the route R may be adopted as the actual route for the moving body 10, and the planned speed may be set as the upper limit speed of the moving body 10. As a result, the route R can be set while the upper limit speed of the moving body 10 is increased. Note that this processing can also be used, for example, to set an avoiding route when the moving body 10 detects the obstacle O, but is particularly effective when a route along which the moving body 10 is scheduled to travel in the future is set in advance.

[0128] (Another Example 3)

As in the present example, it is also possible to combine the other example 1 and the other example 2 described above. FIG. 16 is a flowchart for explaining a route setting flow according to another example of the second embodiment.

[0129] As illustrated in FIG. 16, the area setting unit 1341 of the present example sets the moving body area B0 on the basis of the set planned speed and the number of unit areas B by a similar method to that of the second embodiment (step S50). That is, the area setting unit 1341 sets the occupied area A0 on the basis of the set planned speed,

and sets the moving body area B0 on the basis of the number of unit areas B. The route acquiring unit 134 attempts to set the route R toward the target position P along which the obstacle O does not overlap with the moving body area B0 in a similar method to those of the first embodiment and the second embodiment (step S52).

[0130] If the route R cannot be set (step S54; No), and if the currently set planned speed is higher than or equal to a predetermined threshold (step S56; Yes), the area setting unit 1341 decreases the planned speed (step S58), returns to step S50, resets the occupied area A0 and the moving body area B0 by a similar method on the basis of the reset (decreased) planned speed, and continues the subsequent processing. On the other hand, if the route R cannot be set (step S54; No), and if the currently set planned speed is less than the predetermined threshold (step S56; No), the area setting unit 1341 increases the number of unit areas B (step S59), returns to step S50, resets the moving body area B0 by a similar method on the basis of the reset (increased) number of unit areas B, and continues the subsequent processing. Note that if the route R has been set (step S54; Yes), this processing ends.

[0131] As described above, in the present example, the process of decreasing the planned speed and resetting the route R is repeated until the planned speed becomes lower than the threshold, and when the route R cannot be set, the process is switched to the process of increasing the number of unit areas B and resetting the route R. By decreasing the planned speed first, the route R can be appropriately set while suppressing an increase in the computational load of setting the moving body area B0.

[0132] However, the present invention is not limited thereto, and the process of setting the route R by increasing the number of unit areas B may be repeated until the number of unit areas B reaches a predetermined threshold, and when the route R cannot be set even in this manner, the process may be switched to the process of decreasing the planned speed and resetting the route R. As a result, since the route R can be set without decreasing the planned speed as much as possible, it is possible to suppress an increase in the traveling time.

[0133] (Third Embodiment)

Next, a third embodiment will be described. The third embodiment is different from the second embodiment in that the number of unit areas B is also set using optimization calculation. In the third embodiment, the description of parts having the

same configuration as that of the second embodiment will be omitted.

[0134] (Setting Occupied Area)

In the third embodiment, the area setting unit 1341 sets an occupied area A0. Since the method of setting the occupied area A0 in the third embodiment is similar to those in the first embodiment and the second embodiment, detailed description thereof will be omitted. In this example, the area setting unit 1341 sets an area including a vehicle body area A1, a front area A2, and a rear area A3 as the occupied area A0.

[0135] (Setting Constraint Condition)

The area setting unit 1341 sets, as a constraint condition, that a position P on the peripheral edge of the occupied area A0 overlaps with at least one of the unit areas B. That is, the area setting unit 1341 sets, as the constraint condition, that all of the positions P on the peripheral edge of the occupied area A0 overlap at least one of unit areas B. In other words, in the present embodiment, it is set as the constraint condition that all of the positions P on the peripheral edge of the occupied area A0 are within one of the unit areas B.

[0136] Here, the area setting unit 1341 may set the positions P on the peripheral edge of the occupied area A0 by any method based on the position and size of the occupied area A0. For example, the area setting unit 1341 may calculate coordinates of each position on the peripheral edge of the occupied area A0 from the position and size of the occupied area A0, and select some of the positions on the peripheral edge of the occupied area A0 as the positions P on the peripheral edge of the occupied area A0. In this case, for example, the area setting unit 1341 may select corner positions on the peripheral edge of the occupied area A0 as the positions P on the peripheral edge of the occupied area A0. In the example of FIG. 12, in the area setting unit 1341, the positions of the four corners of the vehicle body area A1, the positions of the four corners of the front area A2, and the positions of the four corners of the rear area A3 are selected as the positions P on the peripheral edge of the occupied area A0.

[0137] Furthermore, in the above description, a position P on the peripheral edge of the occupied area A0 is set as coordinates (point) having no range; however, the present invention is not limited thereto, and an area having a predetermined size centered on central coordinates (center point) may be set as the position P. In this case, for example, the area setting unit 1341 may set a point on the peripheral edge of the unit

occupied area A as central coordinates (center point), and may set a circle having a predetermined radius centered at the central coordinates as the position P. The predetermined radius here may be set as appropriate in consideration of a detection error, a dimensional error of the moving body 10, and the like.

[0138] In addition, the area setting unit 1341 may include, in the constraint conditions, a condition other than that a position P on the peripheral edge of the occupied area A0 overlap with at least one of the unit areas B. For example, the area setting unit 1341 may set, as a constraint condition, that the sizes of the unit areas B (the lengths in the front-rear direction and the left-right direction) are within a range of a predetermined upper limit value and a predetermined lower limit value. Furthermore, for example, the area setting unit 1341 may set, as a constraint condition, that the ratios of the major axis to the minor axis of the unit areas B fall within a range of a predetermined upper limit value and a predetermined lower limit value.

[0139] (Optimization Calculation)

The area setting unit 1341 sets a difference between the moving body area B0 and the occupied area A0 (the value obtained by subtracting the area size of the occupied area A0 from the area size of the moving body area B0) as the evaluation function. The area size of the moving body area B0 refers to the area size of the area surrounded by the peripheral edge of the moving body area B0, and can also be rephrased as the area size obtained by subtracting the area size of the area where the unit areas B overlap each other from the total value of area sizes of the unit areas B.

[0140] The area setting unit 1341 executes optimization calculation that minimizes the evaluation function set as described above while satisfying the constraint conditions set as described above to calculate the number, position, and size of the unit areas B. That is, the area setting unit 1341 calculates, as the optimized number, position, and size (solution) of the unit areas B, the number, position, and size of the unit areas B that satisfy the constraint conditions that all the positions P on the peripheral edge of the occupied area A0 overlap at least one of the unit areas B and that the difference between the moving body area B0 and the occupied area A0 is minimized.

[0141] The area setting unit 1341 sets the moving body area B0 on the basis of the number, position, and size of the unit areas B set in this manner. Since the setting processing of the route R using the moving body area B0 is similar to that of the first

embodiment, description thereof will be omitted.

[0142] (Processing Flow)

Next, a moving body area setting flow in the third embodiment will be described. FIG. 17 is a flowchart for explaining the moving body area setting flow in the third embodiment. As illustrated in FIG. 17, the area setting unit 1341 sets that a position P on the peripheral edge of the occupied area A0 overlaps with at least one of the unit areas B as the constraint condition (step S60), executes optimization calculation on the basis of the constraint condition and the evaluation function, and sets the number, position, and size of the unit areas B (step S62). The area setting unit 1341 sets the moving body area B0 on the basis of the number, position, and size of the unit areas B set in this manner.

[0143] (Effects)

As in the third embodiment, by setting the number, position, and size of the unit areas B by the optimization calculation, it is possible to set the moving body area B0 whose area size does not become excessively large while appropriately suppressing interference between the obstacle O and the moving body 10. Therefore, according to the present embodiment, the route R can be appropriately set. Furthermore, in the third embodiment, the number of unit areas B is also calculated by the optimization calculation, and thus the number of unit areas B can also be optimized to appropriately set the route R.

[0144] (Hardware Configuration)

The control device 100 according to the above-described embodiment is implemented by, for example, a computer 1000 having a configuration as illustrated in FIG. 18. FIG. 18 is a hardware configuration diagram illustrating an example of a computer that implements functions of the control device according to the present disclosure. The computer 1000 is connected to an output device 1010 and an input device 1020, and has a form in which an arithmetic device 1030, a primary storage device 1040, a secondary storage device 1050, an output interface (IF) 1060, an input IF 1070, and a network IF 1080 are connected by a bus 1090. Note that in the case where the control device 100 is mounted on the moving body 10, the output device 1010 and the input device 1020 may not be provided.

[0145] The arithmetic device 1030 operates on the basis of a program stored in the

primary storage device 1040 or the secondary storage device 1050, a program read from the input device 1020, or the like, and executes various types of processing. The primary storage device 1040 is a memory device such as a RAM that temporarily stores data used for various calculations performed by the arithmetic device 1030. The secondary storage device 1050 is a storage device that stores data used by the arithmetic device 1030 for various arithmetic operations and various databases, and is implemented by a ROM, an HDD, a flash memory, or the like.

[0146] The output IF 1060 is an interface for transmitting information to be output to the output device 1010 that outputs various types of information, such as a monitor and a printer, and is implemented by, for example, a connector conforming to standards such as the Universal Serial Bus (USB), the Digital Visual Interface (DVI), or the High Definition Multimedia Interface (HDMI) (registered trademark). Furthermore, the input IF 1070 is an interface for receiving information from various input devices 1020 such as a mouse, a keyboard, and a scanner, and is implemented by, for example, a USB or the like.

[0147] Note that the input device 1020 may be, for example, a device that reads information from an optical recording medium such as a Compact Disc (CD), a Digital Versatile Disc (DVD), or a Phase change rewritable Disk (PD), a magneto-optical recording medium such as a Magneto-Optical disk (MO), a tape medium, a magnetic recording medium, a semiconductor memory, or the like. Furthermore, the input device 1020 may be an external storage medium such as a USB memory.

[0148] The network IF 1080 receives data from another device via the network N and transmits the data to the arithmetic device 1030, and transmits data generated by the arithmetic device 1030 to another device via the network N.

[0149] The arithmetic device 1030 controls the output device 1010 and the input device 1020 via the output IF 1060 and the input IF 1070. For example, the arithmetic device 1030 loads a program from the input device 1020 or the secondary storage device 1050 onto the primary storage device 1040, and executes the loaded program.

[0150] For example, in the case where the computer 1000 functions as the control device 100, the arithmetic device 1030 of the computer 1000 implements the function of the control unit 130 of the control device 100 by executing a program loaded on the primary storage device 1040.

[0151] (Configuration and Effects)

A route setting method according to a first aspect includes the steps of: acquiring information about a target position of a moving body 10; acquiring information about a position of an obstacle O; and executing route calculation of the moving body 10, in which the step of executing the route calculation includes the steps of: setting, based on information regarding the shape of the moving body 10, a moving body area that overlaps an occupied area including an area occupied by the moving body 10 and has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other; and setting, based on the information about the position of the obstacle O, a route to the target position along which the obstacle O does not overlap with the moving body area, as a route for the moving body 10.

[0152] According to this configuration, it is possible to set the moving body area that overlaps the occupied area including the area occupied by the moving body 10 and has a shape in which the plurality of unit areas are partially superimposed on each other. Then, a route to the target position on which an obstacle does not overlap with the moving body area is set as the route R for the moving body 10. Since the moving body area is an area where the moving body 10 may enter, the route R is set such that the obstacle O does not overlap the moving body area, whereby the moving body 10 can be caused to travel while suppressing interference with the obstacle O. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0153] A route setting method according to a second aspect is the route setting method according to the first aspect, in which the step of executing the route calculation includes the steps of: setting, based on the position of the moving body 10a, the moving body area, and the position of the obstacle O, a constraint condition that the position of the obstacle O is outside the moving body area; and calculating the route for the moving body 10 by performing optimization calculation based on an evaluation function in which evaluation increases as a difference between the position of the moving body 10 and the target position decreases, and based on the constraint condition.

[0154] According to this configuration, the route R can be flexibly set based on the moving body area in which the area size of the moving body area B0 is suppressed from becoming excessive. Therefore, it is possible to provide the route setting method

capable of appropriately setting the route for the moving body 10.

[0155] A route setting method according to a third aspect is the route setting method according to the first aspect or the second aspect, in which, the step of setting the moving body area includes setting the moving body area such that a first unit area that is the unit area overlapping the area occupied by the moving body 10, a second unit area that is the unit area overlapping a front area on a traveling direction side of the moving body 10, and a third unit area that is the unit area overlapping a rear area on a side opposite to the traveling direction of the moving body 10 are included and that at least two of the first unit area, the second unit area, and the third unit area overlap each other.

[0156] According to this configuration, even if the moving body area B0 is set to such a size that the interference with the obstacle O can be avoided, it is possible to suppress the area size of the moving body area B0 from becoming excessively large, and it is possible to flexibly set the route R. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0157] A route setting method according to a fourth aspect is any one of the route setting methods according to the first aspect to the third aspect, in which the step of setting the moving body area includes the steps of: setting a number of the unit areas included in the moving body area; partitioning the occupied area into unit occupied areas as many as the unit areas; and setting the moving body area for each of the unit occupied areas by setting a constraint condition that a unit area among the unit areas overlaps with a position on a peripheral edge of the unit occupied area, setting an area size of the unit areas as an evaluation function, executing optimization calculation that minimizes the evaluation function while the constraint condition is satisfied, and setting a position and a size of each of the unit areas.

[0158] According to this configuration, by setting the position and size of the unit areas by the optimization calculation, it is possible to set the moving body area B0 whose area size does not become excessively large while appropriately suppressing interference between the obstacle O and the moving body 10. Therefore, according to the present embodiment, the route R can be appropriately set. The number of unit areas B is set, and the same number of unit occupied areas A as the number of unit areas B are set to perform optimization calculation. Therefore, it is possible to appropriately set the moving body area B0 whose area size is not excessively large while suppressing an

increase in the computational load. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0159] A route setting method according to a fifth aspect is any one of the route setting methods according to the first aspect to the fourth aspect, in which the step of setting the moving body area includes, in a case where it is not possible to set a route to the target position on which the obstacle does not overlap the moving body area, increasing the number of the unit areas is increased to reset the moving body area, and the step of executing the route calculation includes setting the route for the moving body based on the reset moving body area.

[0160] According to this configuration, in the case where the route R cannot be set, the route R can be reset by increasing the number of unit areas B. As a result, it is possible to set the route R in which the number of unit areas B is as small as possible. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0161] A route setting method according to a sixth aspect is any one of the route setting methods according to the first aspect to the fifth aspect, in which, the step of setting the moving body area includes: setting the occupied area based on a planned speed of the moving body 10 such that the occupied area becomes wider as the planned speed becomes faster; and in the case where it is not possible to set a route to the target position on which the obstacle O does not overlap the moving body area, resetting the occupied area by decreasing the planned speed, and resetting the moving body area is reset based on the reset occupied area, and in the step of executing the route calculation, the route for the moving body 10 is set on the basis of the reset moving body area.

[0162] According to this configuration, when the planned speed is decreased, the occupied area can be set to be narrower, and accordingly, the moving body area can also be set to be narrower, and thus the possibility that the route R can be set is increased. Therefore, in the case where the route R cannot be set, the route R can be appropriately set by decreasing the planned speed and retrying to set the route R. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0163] A route setting method according to a seventh aspect is any one of the route setting methods according to the first to sixth aspects, in which the step of setting the

moving body area includes further setting upper and lower limit values of a major axis radius and upper and lower limit values of a minor axis radius of the unit areas, as the constraint condition.

[0164] According to this configuration, by setting the upper and lower limit values and the upper and lower limit values of the minor axis radius in the unit areas as the constraint conditions, it is possible to prevent the moving body area from becoming excessively large. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0165] A route setting method according to an eighth aspect is any one of the route setting methods according to the first aspect to the seventh aspect, in which the step of setting the moving body area includes the steps of: setting a constraint condition that a position on a peripheral edge of the occupied area overlaps with at least one of the unit areas and setting a difference between the moving body area and the occupied area as an evaluation function; and setting the moving body area by executing optimization calculation that minimizes the evaluation function while the constraint condition is satisfied and by setting the number of the unit areas and a size and a position of each of the unit areas.

[0166] According to this configuration, by setting the number, position, and size of the unit areas by the optimization calculation, it is possible to set the moving body area whose area size does not become excessively large while appropriately suppressing interference between the obstacle O and the moving body 10. Therefore, the route R can be appropriately set. Since the number of unit areas is also calculated by the optimization calculation, the number of unit areas can also be optimized to appropriately set the route R. Therefore, it is possible to provide the route setting method capable of appropriately setting the route for the moving body 10.

[0167] A moving body 10 according to a first aspect causes the moving body 10 to travel in accordance with the route set by the route setting method.

[0168] According to this configuration, it is possible to set a moving body area that overlaps with an occupied area including the area occupied by the moving body 10 and has a shape in which the plurality of unit areas are partially superimposed on each other, to set a route to the target position on which the obstacle does not overlap with the moving body area as the route R for the moving body 10, and to cause the moving body

10 to travel in accordance with the route R. Therefore, it is possible to provide the moving body 10 capable of appropriately setting the route for the moving body 10.

[0169] A moving body 10 according to a second aspect is the moving body 10 according to the first aspect, including: a route acquiring unit 134 that acquires a route to a target position on which an obstacle O does not overlap with a moving body area, the route set based on information about a position of the obstacle O; and a traveling control unit 135 that causes the moving body 10 to travel in accordance with the route, in which the moving body area is an area that overlaps an occupied area including an area occupied by the moving body 10 and that has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other, the area being set based on information regarding the shape of the moving body 10.

[0170] According to this configuration, it is possible to set the moving body area that overlaps the occupied area including the area occupied by the moving body 10 and has a shape in which the plurality of unit areas are partially superimposed on each other. Then, a route to the target position on which an obstacle does not overlap with the moving body area is set as the route R for the moving body 10. Since the moving body area is an area where the moving body 10 may enter, the route R is set such that the obstacle O does not overlap the moving body area, whereby the moving body 10 can be caused to travel while suppressing interference with the obstacle O. Therefore, it is possible to provide the moving body 10 capable of appropriately setting the route for the moving body 10.

[0171] A management system 200 according to a first aspect transmits the route set by the route setting method to the moving body 10.

[0172] According to this configuration, it is possible to set a moving body area that overlaps with an occupied area including the area occupied by the moving body 10 and has a shape in which the plurality of unit areas are partially superimposed on each other, to set a route to the target position on which the obstacle does not overlap with the moving body area as the route R for the moving body 10, and to cause the moving body 10 to travel along the route R by transmitting the route R to the moving body 10. Therefore, it is possible to provide the management system 200 capable of appropriately setting the route for the moving body 10.

[0173] A program according to a first aspect is a program for causing a computer to

execute the steps of: acquiring information about a target position of a moving body 10; acquiring information about a position of an obstacle O; and executing route calculation of the moving body 10, in which the step of executing route calculation includes the steps of: setting, based on information regarding the shape of the moving body 10, a moving body area that overlaps an occupied area including an area occupied by the moving body 10 and has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other; and setting, based on the information about the position of the obstacle O, a route to the target position along which the obstacle O does not overlap with the moving body area, as a route for the moving body 10.

[0174] According to this configuration, it is possible to set the moving body area that overlaps the occupied area including the area occupied by the moving body 10 and has a shape in which the plurality of unit areas are partially superimposed each other. Then, a route to the target position on which an obstacle does not overlap with the moving body area is set as the route R for the moving body 10. Since the moving body area is an area where the moving body 10 may enter, the route R is set such that the obstacle O does not overlap the moving body area, whereby the moving body 10 can be caused to travel while suppressing interference with the obstacle O. Therefore, it is possible to provide a program capable of appropriately setting the route for the moving body 10.

[0175] Although the embodiments of the present disclosure have been described above, embodiments are not limited by the content of the embodiments. In addition, the above-described components include those that can be easily conceived by those skilled in the art, those that are substantially the same, and those in a so-called equivalent range. Furthermore, the above-described components can be combined as appropriate. Furthermore, various omissions, substitutions, or modifications of the components can be made without departing from the gist of the above-described embodiments.

Reference Signs List

[0176] 1 MOVING BODY CONTROL SYSTEM
10 MOVING BODY
20 VEHICLE BODY
22 MAST
24 FORK
26 SENSOR

28 POWER UNIT
100 CONTROL DEVICE
110 COMMUNICATION UNIT
120 STORAGE UNIT
130 CONTROL UNIT
131 TARGET POSITION INFORMATION ACQUIRING UNIT
132 SELF-LOCALIZATION INFORMATION ACQUIRING UNIT
133 OBSTACLE INFORMATION ACQUIRING UNIT
134 ROUTE ACQUIRING UNIT
1341 AREA SETTING UNIT
1342 CONSTRAINT CONDITION SETTING UNIT
1343 OPTIMIZATION CALCULATION EXECUTING UNIT
135 TRAVELING CONTROL UNIT
140 SELF-LOCALIZATION UNIT
150 OBSTACLE DETECTING UNIT
160 DRIVE SIGNAL TRANSMITTING UNIT
200 MANAGEMENT SYSTEM
210 COMMUNICATION UNIT
220 STORAGE UNIT
230 CONTROL UNIT
231 ACQUISITION UNIT
232 NOTIFICATION UNIT
240 INPUT UNIT
250 DISPLAY UNIT
N NETWORK

CLAIMS

[Claim 1]

A route setting method, comprising the steps of:

acquiring information about a target position of a moving body;

acquiring information about a position of an obstacle; and

executing route calculation of the moving body, wherein

the step of executing the route calculation includes the steps of:

setting, based on information regarding a shape of the moving body, a moving body area that overlaps an occupied area including an area occupied by the moving body and has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other; and

setting, based on the information about the position of the obstacle, a route to the target position along which the obstacle does not overlap with the moving body area, as a route for the moving body.

[Claim 2]

The route setting method according to claim 1, wherein the step of executing the route calculation includes the steps of:

setting, based on the position of the moving body, the moving body area, and the position of the obstacle, a constraint condition that the position of the obstacle is outside the moving body area; and

calculating the route for the moving body by performing optimization calculation based on an evaluation function in which evaluation increases as a difference between the position of the moving body and the target position decreases, and based on the constraint condition.

[Claim 3]

The route setting method according to claim 1 or 2, wherein the step of setting the moving body area includes setting the moving body area such that a first unit area that is the unit area overlapping the area occupied by the moving body, a second unit area that is the unit area overlapping a front area on a traveling direction side of the

moving body, and a third unit area that is the unit area overlapping a rear area on a side opposite to the traveling direction of the moving body are included and that at least two of the first unit area, the second unit area, and the third unit area overlap each other.

[Claim 4]

The route setting method according to claim 1 or 2, wherein the step of setting the moving body area includes the steps of:

setting a number of the unit areas included in the moving body area;

partitioning the occupied area into unit occupied areas as many as the unit areas; and

setting the moving body area for each of the unit occupied areas by setting a constraint condition that a unit area among the unit areas overlaps with a position on a peripheral edge of the unit occupied area, setting an area size of the unit area as an evaluation function, executing optimization calculation that minimizes the evaluation function while the constraint condition is satisfied, and setting a position and a size of each of the unit areas.

[Claim 5]

The route setting method according to claim 4, wherein

the step of setting the moving body area includes, in a case where it is not possible to set a route to the target position on which the obstacle does not overlap the moving body area, increasing the number of the unit areas to reset the moving body area, and

the step of executing the route calculation includes setting the route for the moving body based on the reset moving body area.

[Claim 6]

The route setting method according to claim 4, wherein

the step of setting the moving body area includes:

setting the occupied area based on a planned speed of the moving body such that the occupied area becomes wider as the planned speed becomes faster; and

in the case where it is not possible to set a route to the target position on

which the obstacle does not overlap the moving body area, resetting the occupied area by decreasing the planned speed, and resetting the moving body area based on the reset occupied area, and

the step of executing the route calculation includes setting the route for the moving body based on the reset moving body area.

[Claim 7]

The route setting method according to claim 4, wherein the step of setting the moving body area includes further setting upper and lower limit values of a major axis radius and upper and lower limit values of a minor axis radius of the unit areas, as the constraint condition.

[Claim 8]

The route setting method according to claim 1 or 2, wherein

the step of setting the moving body area includes the steps of:

setting a constraint condition that a position on a peripheral edge of the occupied area overlaps with at least one of the unit areas and setting a difference between the moving body areas and the occupied area as an evaluation function; and

setting the moving body area by executing optimization calculation that minimizes the evaluation function while the constraint condition is satisfied and by setting a number of the unit areas and a size and a position of each of the unit areas.

[Claim 9]

A moving body, wherein the moving body is caused to travel in accordance with the route set by the route setting method according to claim 1 or 2.

[Claim 10]

A moving body comprising:

a route acquiring unit that acquires a route to a target position on which an obstacle does not overlap with a moving body area, the route being set based on information about a position of the obstacle; and

a traveling control unit that causes the moving body to travel in accordance with

the route, wherein

the moving body area is an area that overlaps an occupied area including an area occupied by the moving body and that has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other, the area being set based on information regarding a shape of the moving body.

[Claim 11]

A management system that transmits the route set by the route setting method according to claim 1 or 2 to the moving body.

[Claim 12]

A program for causing a computer to execute the steps of:

acquiring information about a target position of a moving body;

acquiring information about a position of an obstacle; and

executing route calculation of the moving body, wherein

the step of executing the route calculation includes the steps of:

setting, based on information regarding a shape of the moving body, a moving body area that overlaps an occupied area including an area occupied by the moving body and has a shape in which a plurality of circular or elliptical unit areas are partially superimposed on each other; and

setting, based on the information about the position of the obstacle, a route to the target position along which the obstacle does not overlap with the moving body area, as a route for the moving body.