DESCRIPTION

Title of Invention

CONTROL METHOD, PROGRAM, AND MOVING BODY

Technical Field

[0001]

The present disclosure relates to a control method, a program, and a moving body.

Background Art

[0002]

A moving body including a sensor that detects surroundings and configured to automatically move is known. For example, PTL 1 describes that an obstacle is detected, a position and an orientation of a front surface of the obstacle are identified based on a detection result for the obstacle, and an avoidance path for avoiding the obstacle is generated based on an identification result.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2022-141380

Summary of Invention

Technical Problem

[0004]

Here, there is room for improvement in controlling the moving body so as to

avoid the obstacle.

[0005]

The present disclosure is to solve the above-described problem, and an object thereof is to provide a control method, a program, and a moving body capable of appropriately avoiding an obstacle.

Solution to Problem

[0006]

The present disclosure relates to a control method of a moving body that automatically moves, the control method including: a step of moving the moving body along a reference path; a step of causing a sensor provided on the moving body to detect an obstacle located on a side toward a first direction that is a traveling direction of the moving body when the moving body is moving along the reference path; a step of stopping the moving body in a case where the obstacle is present on the side toward the first direction; a step of setting a reverse path that returns to a second direction opposite to the first direction based on the reference path; and a step of moving the stopped moving body along the reverse path.

[0007]

The present disclosure relates to a program for causing a computer to execute a control method of a moving body that automatically moves, the program causing the computer to execute: a step of moving the moving body along a reference path; a step of causing a sensor provided on the moving body to detect an obstacle located on a side toward a first direction that is a traveling direction of the moving body when the moving body is moving along the reference path; a step of stopping the moving body in a case where the obstacle is present on the side toward the first direction; a step of setting a reverse path that returns to a second direction opposite to the first direction based on the

reference path; and a step of moving the stopped moving body along the reverse path.

[0008]

The present disclosure relates to a moving body that automatically moves, including: a movement control unit that moves the moving body along a reference path; a detection control unit that causes a sensor provided on the moving body to detect an obstacle located on a side toward a first direction that is a traveling direction of the moving body when the moving body is moving along the reference path; and a reverse path acquisition unit that acquires a reverse path that returns to a second direction opposite to the first direction, the reverse path being set based on the reference path, in which the movement control unit stops the moving body in a case where the obstacle is present on the side toward the first direction, and moves the stopped moving body along the reverse path.

Advantageous Effects of Invention

[0009]

According to the present disclosure, the obstacle can be appropriately avoided.

Brief Description of Drawings

[0010]

FIG. 1 is a schematic diagram of a movement control system according to the present embodiment.

FIG. 2 is a schematic diagram of a configuration of a moving body.

FIG. 3 is a schematic block diagram of a management device.

FIG. 4 is a schematic block diagram of an information processing device.

FIG. 5 is a schematic block diagram of a control device of the moving body.

FIG. 6 is a schematic diagram showing an example of detection of an obstacle.

FIG. 7 is a schematic diagram showing an example of stopping of the moving

body.

FIG. 8 is a schematic diagram showing an example of a reverse path.

FIG. 9 is a schematic diagram showing an example of an avoidance path.

FIG. 10 is a flowchart showing a control flow of the moving body.

FIG. 11 is a schematic diagram showing an example of a method of setting subgoals.

FIG. 12 is a schematic diagram showing an example of the method of setting the subgoals.

FIG. 13 is a schematic diagram showing an example of the method of setting the subgoals.

FIG. 14 is a schematic diagram showing an example of setting of a basis path.

FIG. 15 is a schematic diagram showing an example of setting of the avoidance path.

FIG. 16 is a schematic diagram showing setting of a non-interference region.

FIG. 17 is a schematic diagram showing the setting of the non-interference region.

FIG. 18 is a schematic diagram showing another example of the setting of the non-interference region.

FIG. 19 is a schematic diagram showing an example of a method of extracting a point cloud for analysis.

FIG. 20 is a schematic diagram showing an example of a reverse position.

FIG. 21 is a schematic diagram showing an example of the reverse position.

FIG. 22 is a schematic diagram showing an avoidance path of another moving body.

Description of Embodiments

[0011]

Hereinafter, preferred embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. The present disclosure is not limited to the following embodiments, and includes, in a case where there are a plurality of embodiments, a configuration in which the embodiments are combined.

[0012]

(First Embodiment)

(Movement Control System)

FIG. 1 is a schematic diagram of a movement control system according to the present embodiment. As shown in FIG. 1, a movement control system 1 according to the present embodiment includes a moving body 10, a management device 12, and an information processing device 14. The movement control system 1 is a system that controls movement of the moving body 10 belonging to a facility W. The facility W is, for example, a facility managed for logistics, such as a warehouse, but may be any facility as long as the moving body 10 is operated. In the movement control system 1, the moving body 10 picks up and transports an object disposed within a region AR of the facility W. The region AR is a region in which the object is placed or the moving body 10 moves, and is, for example, a floor surface of the facility W. In the present embodiment, the object transported by the moving body 10 is a transport object with cargo loaded on a pallet. However, the object is not limited to the object with cargo loaded on the pallet, and may be in any form, for example, an object with only the cargo without the pallet. In addition, the moving body 10 is not limited to the moving body that transports the object, and may be a device that moves in the facility W for any purpose.

[0013]

Hereinafter, one direction along the region AR will be referred to as an X direction, and a direction along the region AR, which intersects the direction X, will be referred to as a Y direction. In the present embodiment, the Y direction is a direction orthogonal to the X direction. The X direction and the Y direction may be directions along a horizontal plane. In addition, a direction orthogonal to the X direction and the Y direction, more specifically, a direction toward an upper side in a vertical direction, will be referred to as a Z direction. Further, in the present embodiment, unless otherwise noted, the term "position" refers to a position (coordinates) in a coordinate system (coordinate system of the region AR) on a two-dimensional plane in the region AR. In addition, unless otherwise noted, the term "orientation (direction)" of the moving body 10 or the like refers to an orientation of the moving body 10 or the like in the coordinate system of the region AR, and indicates a yaw angle (rotation angle) of the moving body 10 in a case where the X direction is set to 0° when the moving body 10 or the like is viewed in the Z direction.

[0014]

(Waypoint)

In the region AR, a waypoint WP is set for each position (coordinates). A path (reference path R0 described later) along which the moving body 10 moves is set to connect the waypoints WP. That is, a path that connects the waypoints WP through which the moving body 10 is scheduled to pass is the reference path R0 of the moving body 10. The waypoint WP is set in accordance with a layout of the facility W. The waypoints WP are set, for example, in a matrix in the region AR.

[0015]

(Moving Body)

FIG. 2 is a schematic diagram of a configuration of the moving body. The

moving body 10 is a device that can automatically move. In the present embodiment, the moving body 10 is a nonholonomic system that cannot move laterally. In the present embodiment, the moving body 10 is a device that can transport a target object. Additionally, in the present embodiment, the moving body 10 is a forklift, and is, more specifically, a so-called automated guided vehicle (AGV) or an automated guided forklift (AGF). However, the moving body 10 is not limited to the forklift that transports the target object, and may be any device that can automatically move.

[0016]

As shown in FIG. 2, the moving body 10 includes a vehicle body 20, wheels 20A, straddle legs 21, a mast 22, a fork 24, sensors 26A, and a control device 28. The straddle legs 21 are a pair of shaft-shaped members provided at one end portion of the vehicle body 20 in a front-rear direction and protruding from the vehicle body 20. The wheels 20A are provided at tips of the straddle legs 21 and on the vehicle body 20. That is, three wheels 20A are provided in total, but the positions and the number of wheels 20A may be arbitrary. The mast 22 is mounted on the straddle legs 21 so as to be movable, and moves in the front-rear direction of the vehicle body 20. The mast 22 extends along an up-down direction (here, the Z direction) orthogonal to the front-rear direction. The fork 24 is mounted on the mast 22 to be movable in the Z direction. The fork 24 may also be able to move relative to the mast 22 in a lateral direction (direction intersecting the up-down direction and the front-rear direction) of the vehicle body 20. The fork 24 has a pair of forks 24A and 24B. The forks 24A and 24B extend from the mast 22 toward the front direction of the vehicle body 20. The fork 24A and the fork 24B are disposed spaced apart from each other in a lateral direction of the mast 22. Hereinafter, in the front-rear direction, a direction on a side on which the fork 24 is not provided in the moving body 10 will be referred to as a front direction, and a

direction on a side on which the fork 24 is provided will be referred to as a rear direction.

[0017]

The sensor 26A detects at least one of a position and an orientation of the object present around the vehicle body 20. It may also be said that the sensor 26A detects at least one of the position of the object relative to the moving body 10 and the orientation of the object relative to the moving body 10. In the present embodiment, the sensors 26A are provided at the tips of the straddle legs 21 in the front direction and on a rear direction side of the vehicle body 20. However, the positions at which the sensors 26A are provided are not limited to this example, and the sensors 26A may be provided at any position, and the number of sensors 26A provided may also be arbitrary.

[0018]

The sensor 26A is, for example, a sensor that emits laser light. The sensor 26A emits the laser light while performing scanning in one direction (here, the lateral direction), and detects the position and the orientation of the object based on reflected light of the emitted laser light. That is, the sensor 26A may be regarded as a so-called two-dimensional (2D)-light detection and ranging (LiDAR) sensor. However, the sensor 26A is not limited to the above-described sensor and may be a sensor that detects the object using any method. The sensor 26A may be, for example, a so-called three-dimensional (3D)-LiDAR that performs scanning in a plurality of directions, a so-called one-dimensional (1D)-LiDAR that does not perform scanning, or a camera.

[0019]

The control device 28 controls the movement of the moving body 10. The control device 28 will be described later.

[0020]

(Management Device)

FIG. 3 is a schematic block diagram of the management device. The management device 12 is a system that manages logistics in the facility W. Although the management device 12 is a warehouse control system (WCS) or a warehouse management system (WMS) in the present embodiment, the management device 12 is not limited to the WCS and the WMS, and may be any system, for example, a back-end system such as another production management system. The position at which the management device 12 is provided is arbitrary, and the management device 12 may be provided in the facility W or may be provided at a position remote from the facility W and manage the facility W from the remote position. The management device 12 is a computer and includes a communication unit 30, a storage unit 32, and a control unit 34 as shown in FIG. 3.

[0021]

The communication unit 30 is a module used by the control unit 34 for communicating with an external device such as the information processing device 14, and may include, for example, an antenna and the like. Although a communication method using the communication unit 30 is wireless communication in the present embodiment, the communication method may be arbitrary. The storage unit 32 is a memory that stores various types of information such as processing contents and programs of the control unit 34, and includes, for example, at least one of a main storage device, such as a random-access memory (RAM) or a read-only memory (ROM), and an external storage device, such as a hard disk drive (HDD).

[0022]

The control unit 34 is an arithmetic device and includes, for example, an arithmetic circuit such as a central processing unit (CPU). The control unit 34 includes a movement destination information setting unit 40. The control unit 34 reads out the

program (software) from the storage unit 32 and executes the program to implement the movement destination information setting unit 40, and executes processing of the movement destination information setting unit 40. The control unit 34 may execute the processing with a single CPU, or may be provided with a plurality of CPUs and execute the processing with the plurality of CPUs. In addition, the movement destination information setting unit 40 may be implemented by a hardware circuit. Furthermore, a program for the control unit 34 stored in the storage unit 32 may be stored in a recording medium that is readable by the management device 12.

[0023]

The movement destination information setting unit 40 sets movement destination information indicating a movement destination of the moving body 10. The setting of the movement destination information will be described later.

[0024]

The management device 12 may execute processing other than the processing of setting the movement destination information. For example, the management device 12 may also set information for controlling a mechanism (for example, an elevator, a door, or the like) other than the moving body 10 provided in the facility W.

[0025]

(Information Processing Device)

FIG. 4 is a schematic block diagram of the information processing device. The information processing device 14 is a device that is provided in the facility W and that processes information on the movement of the moving body 10. The information processing device 14 is, for example, a fleet control system (FCS), but is not limited to this, and may be any device that processes the information on the movement of the moving body 10. The information processing device 14 is a computer and includes a

communication unit 50, a storage unit 52, and a control unit 54 as shown in FIG. 4. The communication unit 50 is a module used by the control unit 54 and communicating with an external device such as the management device 12 and the moving body 10, and may include, for example, an antenna and the like. A communication method using the communication unit 50 is wireless communication in the present embodiment, but the communication method may be arbitrary. The storage unit 52 is a memory that stores various types of information such as processing contents and programs of the control unit 54, and includes, for example, at least one of a main storage device, such as a RAM or a ROM, and an external storage device, such as an HDD.

[0026]

The control unit 54 is an arithmetic device and includes, for example, an arithmetic circuit such as a CPU. The control unit 54 includes a reference path setting unit 60. The control unit 54 reads out the program (software) from the storage unit 52 and executes the program to implement the reference path setting unit 60, and executes processing of the reference path setting unit 60. The control unit 54 may execute the processing with one CPU, or may be provided with a plurality of CPUs and execute the processing with the plurality of CPUs. Further, at least a part of the reference path setting unit 60 may be implemented by a hardware circuit. Furthermore, a program for the control unit 54 stored in the storage unit 52 may be stored in a recording medium that is readable by the information processing device 14.

[0027]

The reference path setting unit 60 sets a reference path R0 of the moving body 10. A method of setting the reference path R0 will be described later.

[0028]

In the present embodiment, the management device 12 and the information

processing device 14 are separate devices, but may be integrated into one device. That is, the management device 12 may incorporate at least some functions of the information processing device 14, and the information processing device 14 may incorporate at least some functions of the management device 12.

[0029]

(Control Device of Moving Body)

Hereinafter, the control device 28 of the moving body 10 will be described. FIG. 5 is a schematic block diagram of the control device of the moving body. The control device 28 is a device that controls the moving body 10. The control device 28 is a computer and includes a communication unit 70, a storage unit 72, and a control unit 74 as shown in FIG. 5. The communication unit 70 is a module used by the control unit 74 and communicating with an external device such as the information processing device 14, and may include, for example, an antenna and the like. A communication method using the communication unit 70 is wireless communication in the present embodiment, but the communication method may be arbitrary. The storage unit 72 is a memory that stores various types of information such as processing contents and programs of the control unit 74, and includes, for example, at least one of a main storage device, such as a RAM or a ROM, and an external storage device, such as an HDD.

[0030]

The control unit 74 is an arithmetic device and includes, for example, an arithmetic circuit such as a CPU. The control unit 74 includes a reference path acquisition unit 80, a movement control unit 82, a detection control unit 84, a reverse path acquisition unit 86, and an avoidance path acquisition unit 88. The control unit 74 reads out the program (software) from the storage unit 72 and executes the program to implement the reference path acquisition unit 80, the movement control unit 82, the

detection control unit 84, the reverse path acquisition unit 86, and the avoidance path acquisition unit 88, and executes processing of the reference path acquisition unit 80, the movement control unit 82, the detection control unit 84, the reverse path acquisition unit 86, and the avoidance path acquisition unit 88. The control unit 74 may execute the processing with one CPU, or may be provided with a plurality of CPUs and execute the processing with the plurality of CPUs. Further, at least a part of the reference path acquisition unit 80, the movement control unit 82, the detection control unit 84, the reverse path acquisition unit 86, and the avoidance path acquisition unit 88 may be implemented by a hardware circuit. Furthermore, a program for the control unit 74 stored in the storage unit 72 may be stored in a recording medium that is readable by the control device 28.

[0031]

The reference path acquisition unit 80 acquires information on the reference path R0. The movement control unit 82 controls a movement mechanism of the moving body 10, such as a drive unit or steering, to control the movement of the moving body 10. The detection control unit 84 acquires a detection result for an obstacle P from the sensor 26A. The reverse path acquisition unit 86 acquires a reverse path R1 for the moving body 10 to reverse when the obstacle P is detected. The avoidance path acquisition unit 88 acquires an avoidance path R2 for the moving body 10 to travel while avoiding the obstacle P after the moving body 10 reverses along the reverse path R1. The specific processing details thereof will be described later.

[0032]

(Processing of Movement Control System)

Hereinafter, the processing details of the movement control system 1 will be described.

[0033]

(Setting of Movement Destination Information)

The movement destination information setting unit 40 of the management device 12 sets the movement destination information indicating the movement destination of the moving body 10. In the present embodiment, the waypoint is set in advance for each position (coordinates) in the region AR. The movement destination information setting unit 40 may designate the position (coordinates) of the waypoint corresponding to the movement destination itself as the movement destination information. In addition, an identifier may be assigned to each of the waypoints, and the movement destination information setting unit 40 may designate an identifier of the waypoint corresponding to the movement destination as the movement destination information. The movement destination information setting unit 40 may set the movement destination information by any method. For example, the movement destination information setting unit 40 may acquire order information indicating the target object to be transported, a transport source, and a transport destination, and set the movement destination information based on the order information. The movement destination information setting unit 40 transmits the set movement destination information to the information processing device 14 via the communication unit 30.

[0034]

(Setting of Reference Path)

The reference path setting unit 60 of the information processing device 14 sets a reference path R0a of the moving body 10. In the present embodiment, the reference path setting unit 60 sets the reference path R0a based on the movement destination information. Specifically, the reference path setting unit 60 sets a path passing through each position within a predetermined distance range from each waypoint from a

movement source to the movement destination as the reference path R0a. A position of the movement source may be arbitrarily set, and, for example, the waypoint closest to a current position of the moving body 10 may be set as the movement source. For example, the reference path setting unit 60 sets the path passing through each position within the predetermined distance range from each waypoint from an initial position to the movement destination as the reference path R0a, based on the movement destination information and map information of the facility W.

[0035]

The reference path setting unit 60 transmits information on the set reference path R0a to the moving body 10. The reference path acquisition unit 80 of the moving body 10 acquires the information on the reference path R0a set by the information processing device 14. The moving body 10 moves along the reference path R0a. However, the reference path acquisition unit 80 of the moving body 10 may, based on the reference path R0a and information on vehicle specifications of the moving body 10, set a reference path R0b that the moving body 10 can follow as the reference path that the moving body 10 actually follows. In this case, the moving body 10 moves along the reference path R0b. The information on the vehicle specifications is, for example, specifications that affect a path along which the moving body 10 can move, such as a size or a minimum turning radius of the moving body 10. The expression "move along the reference path" does not necessarily mean moving strictly on the reference path, but means moving so as to follow the reference path as closely as possible, and includes movement at positions slightly offset from the reference path. The same applies to paths other than the reference path.

[0036]

In the above description, the information processing device 14 sets the reference

path R0a, and the moving body 10 sets the reference path R0b, but the reference paths R0a and R0b may be set by any entity. For example, the moving body 10 may set the reference path R0a, or the information processing device 14 may set the reference path R0b.

[0037]

Hereinafter, in a case where the reference path R0a and the reference path R0b are not distinguished from each other, in other words, in a case where either the reference path R0a or the reference path R0b may be referred to, the reference path will be referred to as the reference path R0 as appropriate.

[0038]

(Movement of Moving Body)

The movement control unit 82 of the moving body 10 moves the moving body 10 along the acquired reference path R0. The movement control unit 82 sequentially ascertains position information of the moving body 10 to move the moving body 10 to pass through the reference path R0. A method of acquiring the position information of the moving body 10 is arbitrary, but, for example, in the present embodiment, a detection body (not shown) is provided in the facility W, and the movement control unit 82 acquires the information on the position and the orientation of the moving body 10 based on the detection of the detection body. Specifically, the moving body 10 emits the laser light toward the detection body, receives the reflected light of the laser light reflected by the detection body, and detects its own position and orientation in the facility W. The method of acquiring the information on the position and the orientation of the moving body 10 is not limited to the method using the detection body, and, for example, simultaneous localization and mapping (SLAM) may be used.

[0039]

(Obstacle)

Here, since the reference path R0 is set to avoid a structure or the like installed in the facility W, the moving body 10 can move without interfering with the structure by moving along the reference path R0. However, the obstacle P may be temporarily located in the facility W, and, in a case where the obstacle P is present near the reference path R0, the moving body 10 may collide with the obstacle P, or the moving body 10 may stop to avoid the collision with the obstacle P. Therefore, in the present embodiment, the moving body 10 detects the obstacle P by the sensor 26A during the movement, and in a case where there is a possibility of interfering with the obstacle P, the moving body 10 temporarily stops, reverses along the reverse path R1, and resumes traveling along the avoidance path R2 for avoiding the obstacle P. The details are described below. Here, the obstacle P may refer to any object, and may be a person.

[0040]

(Detection of Obstacle)

FIG. 6 is a schematic diagram showing an example of the detection of the obstacle. The detection control unit 84 of the moving body 10 causes the sensor 26A to detect the obstacle P located on a traveling direction (first direction) side of the moving body 10 while the moving body 10 is moving, and determines whether or not the obstacle P is present on the traveling direction side of the moving body 10 based on a detection result of the sensor 26A. In the present embodiment, the detection control unit 84 causes the sensor 26A to detect the traveling direction side of the moving body 10 at predetermined intervals while the moving body 10 is moving along the reference path R0, to detect whether or not the obstacle P is present. FIG. 6 shows an example in which the moving body 10 moves along the reference path R0 with a Y1 direction, which is one direction along the Y direction, as the traveling direction (first direction).

The detection control unit 84 causes the sensor 26A to detect whether or not the obstacle P is present on the Y1 direction side of the moving body 10 when the moving body 10 is moving along the reference path R0 in the Y1 direction. FIG. 6 shows an example in which the obstacle P is detected on the Y1 direction side of the moving body 10 when the moving body 10 is located at the waypoint WP1 on the reference path R0. That is, in FIG. 6, the waypoint WP1 is the position of the moving body 10 when the obstacle P is detected.

[0041]

In a case where the obstacle P is detected on the Y1 direction side of the moving body 10 by the sensor 26A, the detection control unit 84 may determine that the obstacle P is present. However, the detection control unit 84 is not limited thereto, and may determine whether or not the moving body 10 interferes with the obstacle P detected by the sensor 26A in a case where the moving body 10 continues moving as it is, based on the detection result of the sensor 26A, and determine that the obstacle P is present in a case where it is determined that the interference occurs. A method of determining the interference may be arbitrary. For example, the detection control unit 84 may identify a position of the obstacle P from the detection result of the sensor 26A and determine that the moving body 10 interferes with the obstacle P in a case where the position of the obstacle P is within a predetermined distance range from the reference path R0.

[0042]

(Stopping of Moving Body)

FIG. 7 is a schematic diagram showing an example of stopping of the moving body. In a case where the obstacle P is present on the traveling direction side of the moving body 10, the movement control unit 82 of the moving body 10 stops the moving body 10. That is, in a case where it is determined that the obstacle P is present, the

movement control unit 82 starts control of stopping the moving body 10, to stop the moving body 10. As a result, the moving body 10 stops at a position on a side (second direction side) opposite to the traveling direction with respect to the obstacle P. In the example of FIG. 6, the obstacle P is detected (it is determined that the obstacle P is present) at the waypoint WP1 when the moving body 10 is moving along the reference path R0 in the Y1 direction, and thus the movement control unit 82 starts the control of stopping the moving body 10 in a case where the moving body 10 is located at the waypoint WP1. Therefore, as shown in the example of FIG. 7, the moving body 10 stops at a waypoint WP2 that is a position on the reference path R0 on the Y1 direction side with respect to the waypoint WP1 and on a Y2 direction side (second direction side) with respect to the obstacle P.

[0043]

(Setting of Reverse Path)

FIG. 8 is a schematic diagram showing an example of the reverse path. In a case where the obstacle P is present on the traveling direction side of the moving body 10, the reverse path acquisition unit 86 of the moving body 10 acquires the reverse path R1. The reverse path R1 is a path that returns to the second direction (Y2 direction) opposite to the traveling direction (Y1 direction). More specifically, the reverse path R1 is a path from a position at which the moving body 10 is stopped (position on the Y2 direction side with respect to the obstacle P) to the Y2 direction.

[0044]

In the present embodiment, the reverse path acquisition unit 86 sets the reverse path R1 based on the reference path R0. Specifically, the reverse path acquisition unit 86 sets a predetermined position on the Y2 direction side (side away from the obstacle P) with respect to the position at which the moving body 10 is stopped, as a reverse

position. The reverse path acquisition unit 86 sets a path from the position at which the moving body 10 is stopped to the reverse position based on the reference path R0, as the reverse path R1. While the reverse position may be set arbitrarily, in the present embodiment, the reverse path acquisition unit 86 may set the reverse position based on the position of the moving body 10 when the obstacle P is detected. For example, the reverse path acquisition unit 86 may set a position within a predetermined distance range from the position of the moving body 10 when the obstacle P is detected, as the reverse position.

[0045]

A method of setting the reverse path R1 based on the reference path R0 may be arbitrary. For example, the reverse path acquisition unit 86 may set a path extending toward the Y2 direction along the reference path R0, as the reverse path R1. That is, in this case, the reverse path R1 is along the reference path R0, whereas the traveling direction is opposite to the direction of the reference path R0. In the present example, the reverse path acquisition unit 86 sets the waypoint WP closest to the position of the moving body 10 when the obstacle P is detected, among the waypoints WP on the reference path R0, as the reverse position. Then, the reverse path acquisition unit 86 sets a path along the reference path R0 from the position at which the moving body 10 is stopped to the reverse position, as the reverse path R1. In the example of FIG. 8, the reverse path acquisition unit 86 sets a path along the reference path R0 from the waypoint WP2 that is the position at which the moving body 10 is stopped to the waypoint WP1 closest to the position at which the moving body 10 is stopped, as the reverse path R1.

[0046]

In addition, the moving body 10 moves along the reference path R0, but actually

may move away from the reference path R0 due to a detection error of a self-position or the like. Therefore, for example, the reverse path acquisition unit 86 may set a path extending toward the Y2 direction along an actual movement trajectory of the moving body 10, as the reverse path R1. The movement trajectory refers to a path (trajectory) on which the moving body 10 actually moves when moving along the reference path R0. That is, in this case, the reverse path R1 is along the movement trajectory, whereas the traveling direction is in a direction opposite to the movement trajectory. When the moving body 10 moves along the movement trajectory, the reverse path acquisition unit 86 acquires time-series positions of the moving body 10 that moves along the reference path R0, connects the positions, and sets a path extending toward the Y2 direction as the reverse path R1. More specifically, the reverse path acquisition unit 86 sets a path along the movement trajectory from the position at which the moving body 10 is stopped to the reverse position by designating the position of the moving body 10 when the obstacle P is detected as the reverse position, as the reverse path R1. Since the movement trajectory is a trajectory of the moving body 10 when moving along the reference path R0, it can be said that, in the present example as well, the reverse path acquisition unit 86 sets the reverse path R1 based on the reference path R0.

[0047]

A timing of setting the reverse path R1 may be arbitrary, and the reverse path R1 may be set after the moving body 10 is stopped. Further, for example, the reverse path R1 may be set after the obstacle P is detected and before the moving body 10 is stopped. In this case, the position at which the moving body 10 is stopped may be estimated based on the speed of the moving body 10 or the like, and the reverse path R1 may be set from the estimated position.

[0048]

In addition, in the above description, the reverse path acquisition unit 86 of the moving body 10 sets the reverse path R1, but the reverse path R1 may be set by any entity. For example, the information processing device 14 may set the reverse path R1 by the same method as in the above description based on the reference path R0, and the reverse path acquisition unit 86 of the moving body 10 may acquire the reverse path R1 from the information processing device 14.

[0049]

(Movement along Reverse Path)

The movement control unit 82 of the moving body 10 moves the moving body 10 along the reverse path R1. That is, the movement control unit 82 moves the moving body 10 from the position (waypoint WP2 in the example of FIG. 8) at which the moving body 10 is stopped to the reverse position (waypoint WP1 in the example of FIG. 8) in the Y2 direction along the reverse path R1.

[0050]

(Setting of Avoidance Path)

FIG. 9 is a schematic diagram showing an example of the avoidance path. In a case where the obstacle P is present on the traveling direction side of the moving body 10, the avoidance path acquisition unit 88 of the moving body 10 acquires the avoidance path R2. The avoidance path R2 is a path extending from the reverse position toward the Y1 direction while avoiding the obstacle P. In the present embodiment, the avoidance path acquisition unit 88 sets a path extending toward the Y1 direction with respect to the obstacle P without interfering with the obstacle P, based on the position of the obstacle P, as the avoidance path R2. A method of setting the avoidance path R2 may be arbitrary, but, for example, the avoidance path R2 may be set by performing optimization calculation with a constraint condition that the interference with the

obstacle P does not occur. More specifically, it is preferable that the avoidance path acquisition unit 88 sets a path that extends from the reverse position toward the Y1 direction while avoiding the obstacle P and that merges into the reference path R0 on the Y1 direction side with respect to the obstacle P, as the avoidance path R2. For example, in the example of FIG. 9, the avoidance path R2 expands in the X direction toward the Y1 direction from the reverse position to a position at which the obstacle P is present, and returns to the side opposite to the X direction toward the Y1 direction on the Y1 direction side with respect to the obstacle P to merge into the reference path R0.

[0051]

A timing of setting the avoidance path R2 may be arbitrary, and the avoidance path R2 may be set after the moving body 10 arrives at the reverse position. In addition, for example, the avoidance path R2 may be set after the obstacle P is detected and before the moving body 10 is stopped, or the avoidance path R2 may be set after the moving body 10 is stopped and before the moving body 10 arrives at the reverse position.

[0052]

In addition, in the above description, the avoidance path acquisition unit 88 of the moving body 10 sets the avoidance path R2, but the avoidance path R2 may be set by any entity. For example, the information processing device 14 may set the avoidance path R2 by the same method as in the above description based on the position of the obstacle P, and the avoidance path acquisition unit 88 of the moving body 10 may acquire the avoidance path R2 from the information processing device 14.

[0053]

(Movement along Avoidance Path)

In a case where the movement control unit 82 moves the moving body 10 to the reverse position along the reverse path R1, the movement control unit 82 moves the

moving body 10 along the avoidance path R2. As a result, the moving body 10 can resume the movement to the Y1 direction side while avoiding the obstacle P, so that it is possible to continue the movement while appropriately avoiding the obstacle P. In a case where the avoidance of the obstacle P is completed by moving along the avoidance path R2, the movement control unit 82 may cause the moving body 10 to return to the reference path R0 and continue the movement along the reference path R0.

[0054]

In addition, in the present embodiment, the moving body 10 may continue to detect the obstacle P by the sensor 26A during the movement along the avoidance path R2, and the avoidance path acquisition unit 88 may update the avoidance path R2 based on the position of the obstacle P detected by the sensor 26A. When the avoidance path R2 is updated, the movement control unit 82 updates the avoidance path R2 and moves the moving body 10 along the updated avoidance path R2. Therefore, the avoidance path R2 updated based on a more accurate position of the obstacle P can be used, and the obstacle P can be more appropriately avoided.

[0055]

(Processing Flow)

A control flow of the moving body described above will be described. FIG. 10 is a flowchart showing the control flow of the moving body. As shown in FIG. 10, while the moving body 10 is moving along the reference path R0, the detection control unit 84 causes the sensor 26A to detect the obstacle P (step S10). The detection control unit 84 acquires the detection result of the sensor 26A, and determines whether or not the obstacle P is present on the traveling direction side of the moving body 10 (step S12), and when the obstacle P is not present (step S12; No), the processing returns to step S10, and the movement along the reference path R0 is continued. On the other hand, when

the obstacle P is present (step S12; Yes), the moving body 10 is stopped by the movement control unit 82 (step S14), and the reverse path acquisition unit 86 sets the reverse path R1 based on the reference path R0 (step S16). Then, the moving body 10 moves along the reverse path R1 by the movement control unit 82 (step S18), and when the moving body 10 does not arrive at the reverse position (step S20; No), the processing returns to step S18, and the movement along the reverse path R1 is continued until the moving body 10 arrives at the reverse position. When the moving body 10 arrives at the reverse position (step S20; Yes), the avoidance path acquisition unit 88 sets the avoidance path R2 (step S22), and the moving body 10 moves along the avoidance path R2 by the movement control unit 82 (step S24).

[0056]

(Effects)

As described above, in the present embodiment, in a case where the obstacle P is detected, the moving body 10 is temporarily stopped, and then reversed along the reverse path R1. As a result, the obstacle can be appropriately avoided. More specifically, it is also conceivable to switch the path to the avoidance path for avoiding the obstacle P without stopping and reversing in a case where the obstacle P is detected. However, in this case, because time is required from detecting the obstacle P until generating the avoidance path and switching the path to the avoidance path, there is a risk of approaching the obstacle P too closely and of being unable to appropriately avoid the obstacle P. In addition, in a case where a detection range of the sensor 26A is not set to be sufficiently wide, it is also assumed that the obstacle P cannot be detected until the moving body 10 is very close to the obstacle P, and there is also a concern that the obstacle P cannot be appropriately avoided. On the other hand, in the present embodiment, in a case where the obstacle P is detected, the moving body 10 is stopped

and reversed, so that the moving body 10 can move (in the present embodiment, the movement along the avoidance path R2) to avoid the obstacle P from a position sufficiently away from the obstacle P, so that the obstacle can be appropriately avoided. Further, in the present embodiment, since the reverse path R1 is set based on the reference path R0 used by the moving body 10 so far, the reverse path R1 has a low probability of interfering with other obstacles and the like. Therefore, according to the present embodiment, the moving body can reverse without interfering with other obstacles, and can more appropriately avoid the obstacle. Furthermore, because setting the reverse path R1 does not require additional steps such as detecting other obstacles, it is possible to reverse appropriately while keeping the calculation load low.

[0057]

(Second Embodiment)

Next, a second embodiment will be described. The second embodiment is different from the first embodiment in that the avoidance path R2 is set based on subgoals. In the second embodiment, description is omitted for portions whose configuration is common with the first embodiment.

[0058]

(Setting of Subgoals)

In the second embodiment, in a case where it is determined that the obstacle P is present, the avoidance path acquisition unit 88 sets subgoals S based on the detection result of the sensor 26A. The subgoal S is a position (coordinates) assumed not to interfere with the obstacle P. The avoidance path acquisition unit 88 sets a plurality of subgoals S having different positions. The avoidance path acquisition unit 88 may set the subgoal S by any method based on the detection result of the sensor 26A, but, for example, sets a position different from the position of the obstacle P detected by the

sensor 26A as the subgoal S. Hereinafter, a setting example of the subgoal S will be described.

[0059]

FIGS. 11 to 13 are schematic diagrams showing examples of a method of setting the subgoals. For example, as shown in FIG. 11, the avoidance path acquisition unit 88 may set, as the subgoal S, each position that is spaced by a distance ΔL in a cross direction (in the example of FIG. 11, X direction) crossing the traveling direction (Y1 direction in the example of FIG. 11) of the reference path R0 from each position on the reference path R0. However, in this case, among the positions on the reference path R0, at the position within a predetermined distance range from the position of the obstacle P detected by the sensor 26A, a position spaced by the distance ΔL from the position of the obstacle P detected by the sensor 26A is set as the subgoal S without setting a position spaced by the distance ΔL from a position on the reference path R0 as the subgoal S. That is, in the example of FIG. 6, the avoidance path acquisition unit 88 sets, as the subgoal S, each position spaced by the distance ΔL from each position on the reference path R0 outside the predetermined distance range from the position of the obstacle P in the cross direction and a position spaced by the distance ΔL from the position of the obstacle P in the cross direction. The distance ΔL may be arbitrarily set and is preferably a constant length for each position, but is not limited thereto, and may be a different length for each position.

[0060]

In addition, for example, as shown in FIG. 12, the avoidance path acquisition unit 88 may set, as the subgoal S, a set of positions (preferably, midpoint positions) between the obstacle detected by the sensor 26A in the cross direction (X direction in the example of FIG. 12) crossing the traveling direction (Y1 direction in the example of

FIG. 15) of the reference path R0. In the example of FIG. 12, the obstacle P is detected on the traveling direction side of the reference path R0, and the walls W as obstacles are detected on both sides in the cross direction. In this case, in a section where the obstacle P is not present and the walls W are present on both sides among sections toward the traveling direction side of the reference path R0, the avoidance path acquisition unit 88 sets each position (each midpoint position in the present example) between the walls W on both sides on the cross direction side as the subgoal S. In addition, in a section where the obstacle P is present among the sections toward the traveling direction side of the reference path R0, the avoidance path acquisition unit 88 sets each position (each midpoint position in the present example) between the walls W and the obstacle P in the cross direction as the subgoal S.

[0061]

In addition, for example, as shown in FIG. 13, in a case where it is determined that the obstacle P moves, the avoidance path acquisition unit 88 may set an obstacle region ARP1 in which the obstacle P may be present due to its movement. In this case, the avoidance path acquisition unit 88 may set the positions arranged toward the traveling direction of the reference path R0, which are positions outside the obstacle region ARP1, as the subgoals S. A method of determining that the obstacle P moves may be arbitrary, and, for example, the avoidance path acquisition unit 88 may identify a shape of the obstacle P from the detection result of the sensor 26A, and determine that the obstacle P moves in a case where the shape satisfies a predetermined condition. In addition, the avoidance path acquisition unit 88 may treat all the detected obstacles P as moving bodies without determining whether or not the detected obstacles P will move. The avoidance path acquisition unit 88 may set the obstacle region ARP1 by any method based on the position of the obstacle P detected by the sensor 26A. For example, the

avoidance path acquisition unit 88 may set a region having, as an outer periphery, positions that are a predetermined distance away from the position of the obstacle P detected by the sensor 26A, as the obstacle region ARP1.

[0062]

(Setting of Basis Path)

FIG. 14 is a schematic diagram showing an example of setting a basis path. The avoidance path acquisition unit 88 sets a basis path R2a based on the subgoals S set by the avoidance path acquisition unit 88. The basis path R2a refers to a path used for setting the avoidance path R2. The avoidance path acquisition unit 88 sets a path passing through a position within a predetermined distance range from the subgoals S, as the basis path R2a. In the present embodiment, since the plurality of subgoals S are set, it can be said that the avoidance path acquisition unit 88 sets a path passing through each position within a predetermined distance range from each subgoal S, as the basis path R2a. In the example of FIG. 14, the basis path R2a passes through each subgoal S, but the basis path R2a is not limited thereto, and may be a path passing through a position that is a predetermined distance away from each subgoal S.

[0063]

The avoidance path acquisition unit 88 may set the basis path R2a by any method based on the subgoals S, but, in the present embodiment, the basis path R2a is set by using a method having a lower calculation load than a calculation load in setting the avoidance path R2 described later. More specifically, the avoidance path acquisition unit 88 sets the basis path R2a based on the subgoals S and motion characteristics of the moving body 10. Here, the motion characteristics may be regarded as a constraint condition based on the motion characteristics of the moving body 10. That is, it can be said that the avoidance path acquisition unit 88 sets a path

passing through the positions within a predetermined distance range from the subgoals S while satisfying the constraint condition based on the motion characteristics of the moving body 10, as the basis path R2a. The motion characteristics of the moving body 10 refer to, for example, a minimum turn radius, an upper limit speed, and the like of the moving body 10.

[0064]

In the present embodiment, it is preferable that the avoidance path acquisition unit 88 sets the basis path R2a without using the position information of the obstacle P identified from the detection result of the sensor 26A. That is, it is preferable that the avoidance path acquisition unit 88 sets the basis path R2a without using the constraint condition that the interference with the obstacle P identified from the detection result of the sensor 26A does not occur. By not applying the constraint condition that the interference with the obstacle P does not occur, the calculation load can be reduced, and the basis path R2a can be calculated in a shorter calculation time.

[0065]

For example, the avoidance path acquisition unit 88 may set the basis path R2a by using the Pure Pursuit method or the Dynamic Window Approach.

[0066]

(Setting of Avoidance Path)

FIG. 15 is a schematic diagram showing an example of setting the avoidance path. The avoidance path acquisition unit 88 sets the avoidance path R2 that can avoid the obstacle P based on the basis path R2a and the detection result of the sensor 26A acquired by the detection control unit 84. That is, the avoidance path acquisition unit 88 sets the avoidance path R2 that does not interfere with the obstacle P detected by the sensor 26A, based on information on the basis path R2a and the position information of

the obstacle P detected by the sensor 26A. Here, the avoidance path R2 can be calculated from only the position information of the obstacle P, but, in the present embodiment, since the avoidance path R2 can be calculated based also on the basis path R2a by using the information on the basis path R2a, an appropriate avoidance path R2 can be set while reducing the calculation time.

[0067]

In the present embodiment, the avoidance path acquisition unit 88 sets the avoidance path R2 by performing optimization calculation with the constraint condition that the interference with the obstacle P does not occur, using the basis path R2a as an initial solution. Furthermore, it is preferable that the avoidance path acquisition unit 88 sets the avoidance path R2 by performing optimization calculation such that the basis path R2a is used as an initial solution and the constraint condition that interference with the obstacle P does not occur and the constraint condition based on the motion characteristics of the moving body 10 are satisfied. That is, the avoidance path acquisition unit 88 sets the avoidance path R2 by performing optimization calculation using the basis path R2a as an initial solution, with the constraint condition that the moving body 10 is not located within a predetermined distance range from the position of the obstacle P identified from the detection result of the sensor 26A and the constraint condition that the motion characteristics of the moving body 10 are satisfied. Accordingly, it is possible to set an appropriate avoidance path R2 that does not interfere with the obstacle P while satisfying the motion characteristics of the moving body 10, while shortening the calculation time. Here, the initial solution is a base solution in the optimization calculation. That is, by searching for an optimal solution from the basis path R2a which is the initial solution, convergence to the optimal solution can be accelerated, enabling an appropriate avoidance path R2 to be set while shortening

calculation time.

[0068]

For example, the avoidance path acquisition unit 88 may set the avoidance path R2 using methods such as a primal-dual interior-point method or sequential quadratic programming.

[0069]

(Modification Example 1 of Second Embodiment)

Next, a modification example 1 of the second embodiment will be described. The present example is different from the second embodiment in that a region AR1 surrounded by a point cloud M, which is the detection result of the sensor 26A, is set as a non-interference region, and the subgoals S or the avoidance path R2 is set. In the present example, description is omitted for portions whose configuration is common with the second embodiment.

[0070]

FIGS. 16 and 17 are schematic diagrams showing setting of the non-interference region. In the present example, the detection control unit 84 causes the sensor 26A to emit the laser light. The detection control unit 84 acquires the point cloud M based on the detection result of the reflected light received by the sensor 26A. That is, the point cloud M can be said to be measurement points indicating positions at which the laser light is applied (positions at which the laser light is reflected). In the present embodiment, the sensor 26A receives the reflected light from different positions around the moving body 10 because the sensor 26A emits the laser light while scanning in the lateral direction (horizontal direction orthogonal to the Z direction). Therefore, it can be said that the detection control unit 84 acquires a plurality of point clouds M indicating the obstacles around the moving body 10 by one scanning with the laser light. That is,

as shown in FIG. 16, a line connecting a position of the sensor 26A to the point cloud M is referred to as a line L1, a virtual line passing through the sensor 26A and having a fixed direction relative to the moving body 10 is referred to as a line L2, and a deviation amount in an angle of the line L1 with respect to the line L2 is referred to as an azimuth angle θ between the sensor 26A and the point cloud M. In this case, it can be said that the detection control unit 84 acquires the plurality of point clouds M having different values of the azimuth angle θ. In the example of FIG. 16, two obstacles P are present on the traveling direction side of the reference path R0 with respect to the moving body 10, and the walls W are present on both sides of the reference path R0 in the traveling direction. Therefore, in the example of FIG. 16, the detection control unit 84 acquires the point clouds M indicating the positions of the walls W on both sides and the point clouds M indicating the positions of the obstacles P.

[0071]

As shown in FIG. 17, the detection control unit 84 calculates a line L3 connecting each point cloud M in an order of a magnitude of the azimuth angle θ from the position of the sensor 26A. That is, the line L3 includes a line connecting the position of the sensor 26A to a point cloud M1 at which the azimuth angle θ is smallest (in the example of FIG. 17, the azimuth angle θ is most negative), a line connecting each point cloud M in ascending order of the azimuth angle θ, and a line connecting the position of the sensor 26A to a point cloud M2 at which the azimuth angle θ is largest (in the example of FIG. 17, the azimuth angle θ is most positive). The detection control unit 84 sets an inner side of the region AR1 surrounded by the line L3 calculated in this way as the non-interference region.

[0072]

In the present example, at least one of the subgoals S and the avoidance path R2

is set based on the non-interference region set in this way. For example, in a case where the subgoals S are set based on the non-interference region, the avoidance path acquisition unit 88 sets the subgoals S to be located in the non-interference region. In this case, the avoidance path acquisition unit 88 may set the positions located within the non-interference region and arranged toward the traveling direction of the moving body 10, as the subgoals S. In addition, for example, in a case where the avoidance path R2 is set based on the non-interference region, the avoidance path acquisition unit 88 sets the avoidance path R2 such that the moving body 10 is located within the non-interference region (is not located outside the non-interference region). That is, the avoidance path R2 may be set by treating a fact that the moving body 10 is located within the non-interference region as the constraint condition that the interference with the obstacle P does not occur, and performing optimization calculation using the basis path R2a as the initial solution and satisfying a constraint condition that the moving body 10 is located within the non-interference region and the constraint condition based on the motion characteristics of the moving body 10.

[0073]

By setting the non-interference region in this way and setting the subgoals S or the avoidance path R2, for example, calculation such as ray tracing is not required, and calculation time of the subgoals S or of the avoidance path R2 can be shortened. In addition, for example, even in a case where there are a plurality of obstacles P, the non-interference region that does not interfere with the obstacles P can be set, so that an appropriate path that can avoid the plurality of obstacles P can be set.

[0074]

FIG. 18 is a schematic diagram showing another example of the setting of the non-interference region. In the present embodiment, since the sensor 26A is caused to

perform the detection at the predetermined intervals, the detection control unit 84 acquires a set of point clouds M acquired by one scanning for each detection of the sensor 26A (for each position of the moving body 10). In this case, for each of a plurality of sets of point clouds M acquired for each detection, the detection control unit 84 sets the region AR1 surrounded by the line L3 using the above-described method, based on one set of point clouds M. For example, in the example of FIG. 18, a region AR1a set from the point cloud M acquired by detection at a certain time and a region AR1b set from the point cloud M acquired by detection at another time are shown. The detection control unit 84 may set the non-interference region based on each set region AR1. A method of setting the non-interference region based on each of the regions AR1 may be arbitrary. For example, the detection control unit 84 divides an entire region (region AR) into a plurality of unit regions, and counts the number of times each unit region is located in the region AR1 for each region AR1. The detection control unit 84 may set a group of unit regions in which the number of times the unit region is located in the region AR1 is equal to or greater than a predetermined threshold value, as the non-interference region.

[0075]

In this way, by setting the non-interference region based on the region AR1 for each detection of the sensor 26A, it is possible to set the non-interference region from the accumulated detection results, and it is possible to set the non-interference region that is assumed not to interfere with the obstacle P with higher accuracy.

[0076]

(Modification Example 2 of Second Embodiment)

Next, a modification example 2 of the second embodiment will be described. The present example is different from the second embodiment in that some point clouds

M, which are the detection results of the sensor 26A, are thinned out, and remaining point clouds M are used as point clouds for analysis to set the subgoals S or the avoidance path R2. In the present example, description is omitted for portions whose configuration is common with the second embodiment. The present example can also be applied to the modification example 1 of the second embodiment.

[0077]

FIG. 19 is a schematic diagram showing an example of a method of extracting the point cloud for analysis. In the present example, the detection control unit 84 extracts the point cloud for analysis from among the acquired point clouds M based on a distance from the moving body 10 to the point clouds M. It is preferable that the detection control unit 84 extracts the point cloud M close to the moving body 10 (reference path R0) as the point cloud for analysis. Specifically, as shown in FIG. 19, the detection control unit 84 sets segmented regions ARD by dividing the region AR in which the moving body 10 is assumed to move into a plurality of regions. Although the segmented regions ARD may be arbitrarily set, the detection control unit 84 may set, for example, as shown in FIG. 19, a plurality of segmented regions ARD by dividing a region on the traveling direction side of the reference path R0 from the position of the moving body 10 at each predetermined distance in the traveling direction of the reference path R0. The detection control unit 84 extracts, as a nearby point cloud Ma, the point cloud M closest to the moving body 10 (reference path R0) from among the point clouds M in the segmented regions ARD. The detection control unit 84 performs this processing for each segmented region ARD to extract the nearby point cloud Ma for each segmented region ARD. In the example of FIG. 19, for each of the segmented regions ARD, the detection control unit 84 extracts the point cloud M closest to the moving body 10 (reference path R0) among the plurality of point clouds M located on

one side in the cross direction (X direction in the example of FIG. 19) with respect to the moving body 10 (reference path R0) and the point cloud M closest to the moving body 10 (reference path R0) among the plurality of point clouds M located on the other side in the cross direction with respect to the moving body 10 (reference path R0), as the nearby point clouds Ma of the segmented region ARD.

[0078]

The detection control unit 84 sets the extracted nearby point cloud Ma as the point cloud for analysis. In the present example, at least one of the subgoals S and the avoidance path R2 is set based on the point cloud for analysis set in this way. That is, in the present example, the point clouds M other than the point cloud M extracted as the point cloud for analysis are not used for calculation of at least one of the subgoals S and the avoidance path R2. For example, as in the second embodiment, the position of the obstacle P may be identified based on the point cloud for analysis, and the subgoals S or the avoidance path R2 may be set. In addition, for example, the non-interference region may be set based on the point cloud for analysis as in the modification example 1 of the second embodiment, and the subgoals S or the avoidance path R may be set. Some point clouds M acquired in this way are extracted as the point clouds for analysis and used for the subgoals S or the avoidance path R2, so that it is possible to reduce a dimensionality in calculation and to reduce the calculation time.

[0079]

Furthermore, the detection control unit 84 may extract positions (for example, center positions) between the adjacent nearby point clouds Ma as auxiliary point clouds Mb, and set the nearby point clouds Ma and the auxiliary point clouds Mb as the point clouds for analysis. In this case, for example, the detection control unit 84 may calculate a distance between the adjacent nearby point clouds Ma, and set the auxiliary

point clouds Mb between the adjacent nearby point clouds Ma when the distance is equal to or greater than a predetermined threshold value. As described above, by setting the auxiliary point clouds Mb at the positions at which the nearby point clouds Ma are spaced from each other, it is possible to suppress a decrease in calculation accuracy while reducing the calculation time.

[0080]

(Third Embodiment)

Next, a third embodiment will be described. The third embodiment is different from the first embodiment in that it is determined whether or not to stop and reverse the moving body 10 in a case where it is determined that the obstacle P is present. In the third embodiment, description is omitted for portions whose configuration is common with the first embodiment. The third embodiment can also be applied to the second embodiment and the modification examples thereof.

[0081]

In the third embodiment, the movement control unit 82 determines whether or not a position (detection position) of the moving body 10 in a case where the obstacle P is detected and a position of the detected obstacle P satisfy a predetermined relationship. In a case where the detection position and the position of the obstacle P satisfy the predetermined relationship, the movement control unit 82 stops the moving body 10 and moves the moving body 10 along the reverse path R1. That is, in the third embodiment, in a case where the detection position and the position of the obstacle P satisfy the predetermined relationship, the moving body 10 is stopped, the reverse path R1 is set, and the moving body 10 is moved along the reverse path R1. On the other hand, in the third embodiment, in a case where the detection position and the position of the obstacle P do not satisfy the predetermined relationship, at least one of stopping the moving body

10 or moving the moving body 10 along the reverse path R1 is not executed.

[0082]

The predetermined relationship here may be any relationship, but may refer to a relationship where the detection position and the position of the obstacle P are within a predetermined distance range. That is, for example, in a case where the detection position and the position of the obstacle P are sufficiently spaced from each other to the extent that the avoidance path R2 that can avoid the obstacle P without stopping and reversing can be set, it may be determined that the predetermined relationship is not satisfied, and in a case where the detection position and the position of the obstacle P are close to each other to the extent that the avoidance path R2 that can avoid the obstacle P without stopping and reversing cannot be set, it may be determined that the predetermined relationship is satisfied. The movement control unit 82 may determine whether or not the predetermined relationship is satisfied based on the detection position, the position of the obstacle P, and the moving speed of the moving body 10. That is, since the distance in which the moving body 10 travels until stopping varies with the moving speed of the moving body 10, by determining, also based on the travel speed of the moving body 10, whether the predetermined relationship is satisfied, it is possible to more appropriately determine whether to stop and reverse the moving body 10.

[0083]

More specifically, in the present embodiment, in a case where the detection position and the position of the obstacle P satisfy a first condition, the movement control unit 82 does not stop and reverse the moving body 10. That is, in this case, the moving body 10 sets the avoidance path R2 without stopping and without moving along the reverse path R1, and switches the path from the reference path R0 to the avoidance path R2 to move along the avoidance path R2. That is, in this case, the movement is

continued by seamlessly switching the path from the reference path R0 to the avoidance path R2. The first condition may be any condition, but may refer to a condition in which the detection position and the position of the obstacle P are spaced from each other to the extent that the obstacle P can be avoided without stopping and reversing.

[0084]

On the other hand, in a case where the detection position and the position of the obstacle P do not satisfy the first condition but satisfy a second condition, the movement control unit 82 stops the moving body 10 but does not reverse the moving body 10. That is, in this case, the moving body 10 sets the avoidance path R2 without moving along the reverse path R1 after stopping, and moves along the avoidance path R2 from the stop position. The second condition may be any condition, but may refer to a condition in which the detection position and the position of the obstacle P are spaced from each other to the extent that the obstacle P can be avoided without reversing but stopping is necessary. It is preferable that a distance (threshold value distance) between the detection position and the position of the obstacle P when determining whether or not the second condition is satisfied is longer than a distance (threshold value distance) between the detection position and the position of the obstacle P when determining whether or not the first condition is satisfied.

[0085]

In addition, in a case where the detection position and the position of the obstacle P do not satisfy both the first condition and the second condition, the movement control unit 82 stops and reverses the moving body 10. That is, in this case, the moving body 10 moves to the reverse position along the reverse path R1 after stopping, and moves along the avoidance path R2 from the reverse position.

[0086]

As described above, by switching whether or not to stop and reverse in accordance with the positional relationship between the detection position and the position of the obstacle P, the obstacle P can be appropriately avoided in accordance with the situation. That is, for example, in a case where the distance from the obstacle P is sufficiently large, the obstacle P can be avoided while suppressing an increase in the movement time by not stopping or reversing the moving body 10.

[0087]

In the present embodiment, the movement control unit 82 may determine whether or not the avoidance path R2 can be set based on the position of the obstacle P, and not reverse the moving body 10 even in a case where the avoidance path R2 cannot be set. That is, in a case where it is clear that the obstacle P cannot be avoided, such as a case where the passage is blocked by the obstacle P, the movement control unit 82 determines that the avoidance path R2 cannot be set, and stops the moving body 10, but may not cause the moving body 10 to move along the reverse path R1. In this case, for example, the moving body 10 may transmit information indicating that the avoidance path R2 cannot be set to the information processing device 14, and the information processing device 14 may set another reference path R0 that passes through a path on which the obstacle P is not located. The moving body 10 may acquire information on the other reference path R0 and move along the reference path R0.

[0088]

(Fourth Embodiment)

Next, a fourth embodiment will be described. The fourth embodiment is different from the first embodiment in the reverse position, which is the end point of the reverse path R1. In the fourth embodiment, description is omitted for portions whose configuration is common with the first embodiment. The fourth embodiment can also

be applied to the second embodiment and the modification examples thereof, and the third embodiment.

[0089]

FIGS. 20 and 21 are schematic diagrams showing examples of the reverse position. In the fourth embodiment, any of a position corresponding to the position (detection position) of the moving body when detecting the obstacle P, a position (intermediate position) between the detection position and the position of the obstacle P, and a position (remote position) farther from the obstacle P than the detection position is set as the reverse position.

[0090]

In a case where the position corresponding to the detection position is set as the reverse position, the reverse path acquisition unit 86 may set, as in the first embodiment, the waypoint WP closest to the detection position among the waypoints WP on the reference path R0, as the reverse position, or may set the detection position itself as the reverse position. By setting the position corresponding to the detection position as the reverse position in this way, it is possible to sufficiently move the moving body 10 away from the obstacle P, and the avoidance path R2 can be appropriately set.

[0091]

In a case where the intermediate position is set as the reverse position, the reverse path acquisition unit 86 may set any position between the detection position and the position of the obstacle P in the Y1 direction as the reverse position (intermediate position). For example, the reverse path acquisition unit 86 may set the waypoint WP between the waypoint WP closest to the detection position and the waypoint WP closest to the position of the obstacle P among the waypoints WP on the reference path R0, as the reverse position (intermediate position). In the example of FIG. 20, a waypoint

WP4 between the waypoint WP1 closest to the detection position and the waypoint WP2 closest to the position of the obstacle P is set as the reverse position (intermediate position). By setting the intermediate position as the reverse position in this way, the avoidance path R2 can be appropriately set without moving the moving body 10 too far away from the obstacle P.

[0092]

In a case where the remote position is set as the reverse position, the reverse path acquisition unit 86 may set any position farther from the obstacle P than the detection position (any position on the Y2 direction side with respect to the detection position), as the reverse position (remote position). For example, the reverse path acquisition unit 86 may set the waypoint WP on the Y2 direction side with respect to the waypoint WP closest to the detection position among the waypoints WP on the reference path R0, as the reverse position (remote position). In the example of FIG. 21, a waypoint WP5 on the Y2 direction side with respect to the waypoint WP1 closest to the detection position is set as the reverse position (remote position). By setting the remote position as the reverse position in this way, it is possible to sufficiently move the moving body 10 away from the obstacle P, and the avoidance path R2 can be appropriately set.

[0093]

A method of determining the reverse position may be arbitrary, but the reverse path acquisition unit 86 may determine whether to set the position based on the detection position, the intermediate position, or the remote position as the reverse position based on the position of the detection position and the position of the obstacle P. For example, in a case where the detection position and the position of the obstacle P satisfy the first condition, the reverse path acquisition unit 86 may set the intermediate position as the reverse position. The first condition may be any condition, but may refer to a condition

in which the detection position and the position of the obstacle P are spaced from each other to the extent that the obstacle P can be avoided without reversing to the detection position. In addition, in a case where the detection position and the position of the obstacle P do not satisfy the first condition but satisfy a second condition, the reverse path acquisition unit 86 may set the position based on the detection position as the reverse position. The second condition may be any condition, but may refer to a condition in which the detection position and the position of the obstacle P are spaced from each other to the extent that the obstacle P can be avoided without reversing to a position farther than the detection position. In addition, in a case where the detection position and the position of the obstacle P do not satisfy both the first condition and the second condition, the reverse path acquisition unit 86 may set the reverse position as the remote position. That is, in this case, since the detection position is relatively close to the position of the obstacle P, the obstacle P can be appropriately avoided by reversing to a position farther than the detection position.

[0094]

(Fifth Embodiment)

Next, a fifth embodiment will be described. The fifth embodiment is different from the first embodiment in that the avoidance path R2A of another moving body 10A is set based on the avoidance path R2 of the moving body 10. In the fifth embodiment, description is omitted for portions whose configuration is common with the first embodiment. The fifth embodiment can also be applied to the second embodiment and the modification examples thereof, the third embodiment, and the fourth embodiment.

[0095]

FIG. 22 is a schematic diagram showing the avoidance path of another moving body. In the fifth embodiment, the moving body 10 (first moving body) for which the

avoidance path R2 is set transmits information on the avoidance path R2 to the information processing device 14. A method of setting the avoidance path R2 of the moving body 10 is the same as the method described in the above-described embodiment or modification examples.

[0096]

In the fifth embodiment, as an example, a case will be described where a reference path R0A is set for the moving body 10A other than the moving body 10, and a scheduled time period for the moving body 10A to pass through the reference path R0A is set later than a scheduled time period for the moving body 10 to pass through the reference path R0. In this case, the information processing device 14 determines whether or not the reference path R0A of the moving body 10A satisfies a predetermined condition. Here, the predetermined condition refers to the fact that the reference path R0A passes through a position of the obstacle P detected by the moving body 10 within a predetermined distance range. Further, it is preferable that the predetermined condition refers to the fact that the reference path R0A overlaps the reference path R0 in the vicinity of the obstacle P detected by the moving body 10. For example, in this case, when the reference path R0A passes through, among the waypoints WP through which the reference path R0 passes, the waypoint WP (in the example of FIG. 22, the waypoint WP1) on the Y2 direction side with respect to the position of the obstacle P and within the predetermined distance range from the position of the obstacle P, and the waypoint WP (in the example of FIG. 22, the waypoint WP3) on the Y1 direction side with respect to the position of the obstacle P and within the predetermined distance range from the position of the obstacle P, the reference path R0A may overlap the reference path R0.

[0097]

In a case where the reference path R0A of the moving body 10A satisfies the predetermined condition, the information processing device 14 transmits the information on the avoidance path R2 of the moving body 10 to the moving body 10A. For example, the information processing device 14 may transmit the information on the avoidance path R2 of the moving body 10 itself to the moving body 10A. The avoidance path acquisition unit 88 of the moving body 10A sets the avoidance path R2A for avoiding the obstacle P based on the information on the avoidance path R2 of the moving body 10 acquired from the information processing device 14. The starting point of the avoidance path R2A may be the waypoint WP on the reference path R0A on the Y1 direction side with respect to the position of the obstacle P and within the predetermined distance range from the position of the obstacle P, and the end point of the avoidance path R2A may be the waypoint WP on the reference path R0A on the Y2 direction side with respect to the position of the obstacle P and within the predetermined distance range from the position of the obstacle P. For example, the avoidance path acquisition unit 88 of the moving body 10A may set a path overlapping the avoidance path R2 of the moving body 10 (in the example of FIG. 22, the avoidance path R2 extending from the waypoint WP1 to the waypoint WP3) as the avoidance path R2A.

[0098]

The movement control unit 82 of the moving body 10A moves the moving body 10A to the starting point (in the example of FIG. 22, the waypoint WP1) of the avoidance path R2A along the reference path R0A, and then switches the path to the avoidance path R2A to move the moving body 10A from the starting point to the end point (in the example of FIG. 22, the waypoint WP3) of the avoidance path R2A along the avoidance path R2A. Then, the moving body 10A returns to the reference path R0A to continue the movement. That is, in this case, the moving body 10A avoids the obstacle P by

using the avoidance path R2A without stopping and reversing in front of (on the Y2 direction side of) the obstacle P.

[0099]

As described above, in the fifth embodiment, information on the moving body 10 that has detected the obstacle P is shared with the moving body 10A that passes through the vicinity of the obstacle P later, and the moving body 10A can avoid the obstacle P without stopping and reversing. As a result, the moving body 10A can shorten the time for avoiding the obstacle P.

[0100]

In the above description, the moving body 10A sets the avoidance path R2A of the moving body 10A by using the information on the avoidance path R2 itself as the information on the avoidance path R2 of the moving body 10, but the present disclosure is not limited to this. For example, the moving body 10A may acquire information on the non-interference region (see the modification examples of the second embodiment) that is a region that does not interfere with the obstacle P, which is set by the moving body 10, as the information on the avoidance path R2 of the moving body 10. In this case, the avoidance path acquisition unit 88 of the moving body 10A may set the avoidance path R2A using the non-interference region set by the moving body 10 by the same method as in the modification examples of the second embodiment.

[0101]

(Effects)

A first aspect of the present disclosure relates to a control method of a moving body 10 that automatically moves, the control method including: a step of moving the moving body 10 along a reference path R0; a step of causing a sensor 26A provided on the moving body 10 to detect an obstacle P located on a side toward a first direction (Y1

direction) that is a traveling direction of the moving body 10 when the moving body 10 is moving along the reference path R0; a step of stopping the moving body 10 in a case where the obstacle P is present on the side toward the Y1 direction; a step of setting a reverse path R1 that returns to a second direction (Y2 direction) opposite to the Y1 direction based on the reference path R0; and a step of moving the stopped moving body 10 along the reverse path R1. According to the present disclosure, in a case where the obstacle P is detected, the moving body 10 is stopped and reversed, so that it is possible to move to avoid the obstacle P from a position sufficiently away from the obstacle P, and thus the obstacle can be appropriately avoided. Further, in the present embodiment, since the reverse path R1 is set based on the reference path R0 used by the moving body 10 so far, the moving body 10 can reverse without interfering with other obstacles, and can more appropriately avoid the obstacle.

[0102]

A second aspect of the present disclosure relates to the control method according to the first aspect, in which, in the step of setting the reverse path R1, a path that extends toward the Y2 direction along the reference path R0 is set as the reverse path R1. According to the present disclosure, since the reverse path R1 is set in this way, the moving body can reverse without interfering with other obstacles, and can more appropriately avoid the obstacle.

[0103]

A third aspect of the present disclosure relates to the control method according to the first aspect, in which, in the step of setting the reverse path R1, a path that extends toward the Y2 direction along a movement trajectory on which the moving body 10 has actually moved along the reference path R0 is set as the reverse path R1. According to the present disclosure, since the reverse path R1 is set in this way, the moving body

can reverse without interfering with other obstacles, and can more appropriately avoid the obstacle.

[0104]

A fourth aspect of the present disclosure relates to the control method according to any one of the first to third aspects, in which, in a case where a position of the moving body 10 when the obstacle P is detected and a position of the obstacle P satisfy a predetermined relationship, the moving body 10 is stopped and then moved along the reverse path R1. According to the present disclosure, it is possible to appropriately avoid the obstacle.

[0105]

A fifth aspect of the present disclosure relates to the control method according to any one of the first to fourth aspects, in which, in the step of moving the moving body 10 along the reverse path R1, the moving body 10 is moved to a predetermined reverse position, and the control method further includes: a step of setting an avoidance path R2 that extends from the reverse position toward the Y1 direction while avoiding the obstacle P based on a position of the obstacle P; and a step of moving the moving body 10 that has moved to the reverse position, along the avoidance path R2. According to the present disclosure, it is possible to appropriately avoid the obstacle.

[0106]

A sixth aspect of the present disclosure relates to the control method according to the fifth aspect, in which, in the step of setting the reverse path R1, a position corresponding to a detection position that is a position of the moving body 10 when the obstacle P is detected, a position (intermediate position) between the detection position and the position of the obstacle P, or a position (remote position) farther from the obstacle P than the detection position is set as the reverse position. According to the

present disclosure, the reverse position is set in accordance with the situation, so that the obstacle can be appropriately avoided.

[0107]

A seventh aspect of the present disclosure relates to the control method according to the fifth or sixth aspect, further including: a step of setting, in a case where a moving body (second moving body) 10A different from a moving body 10 (first moving body) that has moved along the avoidance path R2 passes through a predetermined distance range from the obstacle P, an avoidance path R2A for the moving body 10A based on the avoidance path R2 for the moving body 10; and a step of moving the moving body 10A along the avoidance path R2A without stopping the moving body 10A and reversing the moving body 10A. According to the present disclosure, the information on the moving body 10 that has detected the obstacle P is shared with the moving body 10A that passes through the vicinity of the obstacle P later, and the moving body 10A can avoid the obstacle P without stopping and reversing.

[0108]

An eighth aspect of the present disclosure relates to a program for causing a computer to execute a control method of a moving body 10 that automatically moves, the program causing the computer to execute: a step of moving the moving body 10 along a reference path R0; a step of causing a sensor 26A provided on the moving body 10 to detect an obstacle P located on a side toward a first direction (Y1 direction) that is a traveling direction of the moving body 10 when the moving body 10 is moving along the reference path R0; a step of stopping the moving body 10 in a case where the obstacle P is present on the side toward the Y1 direction; a step of setting a reverse path R1 that returns to a second direction (Y2 direction) opposite to the Y1 direction based on the reference path R0; and a step of moving the stopped moving body 10 along the reverse

path R1. According to the present disclosure, it is possible to appropriately avoid the obstacle.

[0109]

A ninth aspect of the present disclosure relates to a moving body 10 that automatically moves, including: a movement control unit 82 that moves the moving body 10 along a reference path R0; a detection control unit 84 that causes a sensor 26A provided on the moving body 10 to detect an obstacle P located on a side toward a first direction (Y1 direction) that is a traveling direction of the moving body 10 when the moving body 10 is moving along the reference path R0; and a reverse path acquisition unit 86 that acquires a reverse path R1 that returns to a second direction (Y2 direction) opposite to the Y1 direction, the reverse path R1 being set based on the reference path R0. The movement control unit 82 stops the moving body 10 in a case where the obstacle P is present on the side toward the Y1 direction, and moves the stopped moving body 10 along the reverse path R1. According to the present disclosure, it is possible to appropriately avoid the obstacle.

[0110]

While the embodiments of the present disclosure have been described above, the present disclosure is not limited to the foregoing embodiments. Further, the above-described components include components that can be readily conceived by those skilled in the art, components that are substantially identical, and components falling within the so-called scope of equivalents. Furthermore, the above-described components can be combined as appropriate. Furthermore, various omissions, replacements, or modifications of the above-described components can be made without departing from the gist of the above-described embodiments.

Reference Signs List

[0111]

10: moving body

12: management device

14: information processing device

26A: sensor

80: reference path acquisition unit

82: movement control unit

84: detection control unit

86: reverse path acquisition unit

88: avoidance path acquisition unit

P: obstacle

R0: reference path

R1: reverse path

R2: avoidance path