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Autonomous vehicle, conveyance object, and control method for autonomous vehicle

Abstract

An autonomous vehicle includes one or more sensors configured to obtain one or more images of a conveyance target that includes one or more markings; and a controller configured to control the autonomous vehicle. The controller includes one or more processors, and one or more memories storing one or more programs, which when executed, cause the one or more processors to identify the conveyance target based on a recognition result of the one or more markings included in the one or more images, and control conveyance of the conveyance target by the autonomous vehicle based on an identification result of the conveyance target.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
(1) This application is based on and claims priority to Japanese Patent Application No. 2023-012586, filed on Jan. 31, 2023, the entire contents of which are incorporated herein by reference.
BACKGROUND

1. Technical Field
(2) The present disclosure relates to: autonomous vehicles; conveyance objects, which are objects to be conveyed; and control methods for autonomous vehicles.
2. Description of the Related Art
(3) Autonomous vehicles, such as automatic guided vehicles and the like, can autonomously convey conveyance targets without being driven by users, e.g., shelving units, towing trollies, and the like, on which items are placed. When the autonomous vehicle accurately recognizes the outer dimensions of the conveyance target that is being conveyed, the autonomous vehicle can avoid collision with the surrounding objects and efficiently convey the conveyance target (see, for example, Japanese Laid-Open Patent Publication No. 2019-148881).
SUMMARY
(4) An autonomous vehicle according to one aspect of the present disclosure includes: one or more sensors configured to obtain one or more images of a conveyance target that includes one or more markings; and a controller configured to control the autonomous vehicle. The controller includes one or more processors, and one or more memories storing one or more programs, which when executed, cause the one or more processors to: identify the conveyance target based on a recognition result of the one or more markings included in the one or more images, and control conveyance of the conveyance target by the autonomous vehicle based on an identification result of the conveyance target.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** illustrates an example of a scenario in which an autonomous vehicle is used;
(2) FIGS. **2**A and **2**B are views illustrating an example of an external configuration of the autonomous vehicle;
(3) FIGS. **3**A and **3**B are views illustrating an example of configurations of an interior and a lower surface of the autonomous vehicle;
(4) FIGS. **4**A and **4**B are views illustrating a state in which the autonomous vehicle is docked with a shelving unit that is to be a conveyance target;
(5) FIG. **5** is a front view illustrating an example of a schematic configuration below a bottom shelf of the shelving unit;
(6) FIG. **6** is a view illustrating a positional relationship between casters of the shelving unit and a docking mechanism of the autonomous vehicle;
(7) FIGS. **7**A to **7**C are views illustrating an example of driving of the docking mechanism upon docking;
(8) FIG. **8** is a view illustrating an example of a display position of a barcode;
(9) FIG. **9** is a view illustrating an example of an image captured by a camera upon docking;
(10) FIG. **10** is a view illustrating an example of an image captured by a camera upon docking;
(11) FIG. **11** is a view illustrating an example of an image captured by a camera upon docking;
(12) FIG. **12** is a block diagram illustrating an example of a functional configuration of a controller;
(13) FIG. **13** is a view illustrating an example of a conveyance target management table;
(14) FIG. **14** is a block diagram illustrating an example of a functional configuration of a docking controller;
(15) FIG. **15** is a view illustrating an example of a sensor invalid region of a laser imaging detection and ranging (LiDAR) device;
(16) FIG. **16** is a view illustrating an example of a sensor invalid region of the camera;
(17) FIG. **17** is a flowchart illustrating an example of an autonomous traveling process;

(18) FIG. **18** is a flowchart illustrating an example of a conveyance target searching process; and
(19) FIG. **19** is a block diagram illustrating an example of a hardware configuration of the controller.

DETAILED DESCRIPTION

(20) The present disclosure provides an autonomous vehicle that can readily obtain information on the conveyance target.
(21) Embodiments will be described hereinafter with reference to the accompanying drawings. Note that in the present specification and drawings, the components having substantially the same functional configurations are given the same symbols, and duplicate description thereof will be omitted.
(22) Note in the following description that, an x direction, a y direction, and a z direction are directions that are perpendicular to each other. The x direction and the y direction are horizontal directions, and the z direction is a vertical direction. The x direction is a width direction of the autonomous vehicle. The y direction is a front-rear direction of the autonomous vehicle. The z direction is a height direction of the autonomous vehicle. Also, for the sake of convenience in the following, a positive x-direction side may be referred to as a right side, a negative x-direction side may be referred to as a left side, a positive y-direction side may be referred to as a rear side, a negative y-direction side may be referred to as a front side, a positive z-direction side may be referred to as an upper side, and a negative z-direction side may be referred to as a lower side.

EMBODIMENTS

(23) <Scenario in which Autonomous Vehicle is Used>
(24) First, a scenario in which the autonomous vehicle according to the embodiment is used will be described. FIG. **1** is a view illustrating an example of a scenario in which the autonomous vehicle is used. As illustrated in FIG. **1**, an autonomous vehicle **120** may be used in, for example, a scenario where a user **110** is relaxing on a sofa in a predetermined space **100**, such as a living room of a home.
(25) The scenario in FIG. **1** illustrates a case in which, for example, the user **110** has uttered a wake word and has subsequently uttered, “Bring me the laptop” to the autonomous vehicle **120** in order to use a laptop computer. In other words, FIG. **1** illustrates a case in which a voice-based conveyance instruction (hereinafter may be referred to as a voice instruction) is performed. In this case, the autonomous vehicle **120** may identify, from among caster-equipped shelving units **130** to **150** (examples of the conveyance object), the shelving unit **130**, as the conveyance target, that is conveying work tools **131**, such as a laptop computer, books, and the like, and may convey the shelving unit **130** to a position near the user **110** upon docking with the shelving unit **130**. Note that the autonomous vehicle **120** may be configured to follow a voice instruction that is given without a wake word.
(26) The autonomous vehicle **120** may also be configured to follow a conveyance instruction given by the user **110** who operates a dedicated application with an information process terminal, such as a smartphone, a tablet, or the like. Such a conveyance instruction is also known as a terminal-based conveyance instruction (hereinafter referred to as an operation instruction). In this case, the autonomous vehicle **120** connects to the information process terminal of the user **110** via a communication network, such as a wireless local area network (LAN), a near field communication, or the like, and receives a control signal indicating the conveyance instruction from the information process terminal.
(27) Using the autonomous vehicle **120** in this manner allows the user **110** to simply give a voice-based conveyance instruction or a terminal-based conveyance instruction to bring a laptop computer that is in a remote location to be within a grasping distance of the user. Thus, the user is able to obtain the laptop computer without having to move from the sofa.
(28) Note that the example of FIG. **1** illustrates a case in which the shelving unit **130** is standing by at the position of an anchor **170** in the predetermined space **100** at the point when the user **110** gave

the conveyance instruction. Furthermore, the example of FIG. **1** illustrates a case in which a trash can **160** is present as an obstacle on the shortest conveyance path used when the shelving unit **130**, which is standing by at the position of the anchor **170**, is conveyed to a position **172** near the user **110**.

(29) In such a case, the autonomous vehicle **120** may detect the trash can **160** during conveyance of the shelving unit **130**, and may convey the shelving unit **130** along a conveyance path that is indicated by a dotted arrow **171** to avoid collision with the trash can **160**.

(30) Further, although not illustrated in FIG. **1**, assuming a case in which, for example, after the autonomous vehicle **120** has conveyed the shelving unit **130** to the position **172** near the user **110** and the user **110** has taken the laptop computer out from the shelving unit **130**, the user **110** gives a voice instruction to the autonomous vehicle **120** by uttering, “Return the shelving unit back to its original place.” In this case, the autonomous vehicle **120** conveys the shelving unit **130** to the position of the anchor **170**. Note that the conveyance instruction to return the shelving unit back to its original place may be given by the terminal-based conveyance instruction.

(31) Further, although the example of FIG. **1** illustrated a case in which the autonomous vehicle **120** conveys the shelving unit **130** as the conveyance target, the autonomous vehicle **120** may identify and convey the shelving unit **140** or the shelving unit **150** depending on the contents of the conveyance instruction given by the user **110**. Furthermore, the example of FIG. **1** illustrated a case in which the autonomous vehicle **120** identified a position near the user **110** as the conveyance destination position of the shelving unit **130**. However, depending on the contents of the conveyance instruction given by the user **110**, a position near a predetermined disposed object (for example, a piece of furniture) in the predetermined space **100** or a given position in the predetermined space **100** may be identified as the conveyance destination position of the shelving unit **130** by the autonomous vehicle **120**.

(32) <External Configuration of Autonomous Vehicle>

(33) The external configuration of the autonomous vehicle **120** will be described next. FIG. **2**A is a view illustrating an example of the external configuration of the autonomous vehicle.

(34) As illustrated in FIG. **2**A, the autonomous vehicle **120** may have a rectangular cuboid shape as a whole, and its dimensions in a height direction (z-axis direction) and a width direction (x-axis direction) may be defined so as to allow the autonomous vehicle **120** to enter below the bottom shelf (the bottom) of a shelving unit to be a conveyance target (hereinafter may be referred to as a “conveyance-target shelving unit”). Note that the shape of the autonomous vehicle **120** is not limited to a rectangular cuboid.

(35) A locking device **211**, which is a component of a docking mechanism used to dock with the conveyance-target shelving unit, is disposed on an upper surface **210** of the autonomous vehicle **120**. A LiDAR device **212** is disposed on the upper surface **210** of the autonomous vehicle **120**. The measurement range of the LiDAR device **212** may cover the front-rear direction (y-axis direction) and the width direction (x-axis direction) at a position equal in height to the upper surface **210** of the autonomous vehicle **120**. An obstacle or the like that is present in the measurement range can be detected by using the measurement result of the LiDAR device **212**.

(36) A front RGB camera **221** and a time-of-flight camera (ToF camera) **222** are disposed at a front surface **220** of the autonomous vehicle **120**. Note that although the front RGB camera **221** of the present embodiment is disposed on the upper side with respect to the ToF camera **222**, the disposition position of the front RGB camera **221** is not limited to this position.

(37) When the autonomous vehicle **120** moves in the forward direction, the front RGB camera **221** captures and outputs color images of, for example, a shelving unit (for example, the shelving unit **130**) that is to be the conveyance target, a user (for example, the user **110**) who is near the conveyance destination, a disposed object that is near the conveyance destination, an obstacle (for example, the trash can **160**) on the conveyance path, and the like.

(38) The ToF camera **222** is an example of a range image sensor. In order to avoid multipath

interference, the ToF camera **222** is disposed facing upward on the front surface **220** of the autonomous vehicle **120** to an extent that the surface (a floor **240** illustrated in FIG. **2**B) on which the autonomous vehicle **120** travels is not included in the measurement range. An example of multipath interference is a state in which light emitted from a light source is reflected by another target object via the floor **240** and a reduction in measurement accuracy is caused due to the ToF camera **222** receiving the reflected light. In the present embodiment, an upward disposition angle θ of the ToF camera **222** on the front surface **220** of the autonomous vehicle **120** is approximately 50 degrees with respect to the floor **240**.

(39) Further, when the autonomous vehicle **120** moves in the forward direction, the ToF camera **222** captures a range image (depth image) of an obstacle or the like by setting at least an area to be passed by the docked shelving unit (that is, an area corresponding to the height of the docked shelving unit×the width of the docked shelving unit) as the measurement range, and outputs the captured range image (depth image). Note that in the present embodiment, the ToF camera **222** have a vertical angle of view θv of 70 degrees and a horizontal angle of view θh of 90 degrees.

(40) A drive wheel **231** and a non-drive wheel **232** are disposed on a lower surface **230** of the autonomous vehicle **120**, thereby supporting the autonomous vehicle **120**.

(41) The drive wheel **231** is disposed at both sides in the width direction (x-axis direction) (a total of two drive wheels **231** are disposed in the width direction). When the drive wheels **231** are each independently motor-driven, the drive wheels **231** may cause the autonomous vehicle **120** to move in a forward and backward direction (y-axis direction). The drive wheels **231** may also cause the autonomous vehicle **120** to turn about the z axis.

(42) The non-drive wheel **232** may be provided on each side in the width direction (x-axis direction) (that is, a total of two non-drive wheels may be provided along the width direction). Each of the non-drive wheels **232** may also be provided to be able to turn about the z axis with respect to the autonomous vehicle **120**. Note that the disposition positions and number of non-drive wheels **232** may be other than those described above.

(43) <Details of Configurations of Interior and Lower Surface of the Autonomous Vehicle>

(44) Details of the configurations of the interior and the lower surface of the autonomous vehicle will be described next. FIGS. **3**A and **3**B are views illustrating an example of the configurations of the interior and the lower surface of the autonomous vehicle.

(45) FIG. **3**A illustrates the interior of the autonomous vehicle **120** as viewed from directly above, with an upper cover of the autonomous vehicle **120** being removed. The components of the interior of the autonomous vehicle **120** will be described hereinafter with reference to FIG. **3**A.

(46) (a-1) First Control Circuit Board and Second Control Circuit Board

(47) The first control circuit board and the second control circuit board will be described first. As illustrated in FIG. **3**A, the autonomous vehicle **120** includes a first control circuit board **311** and a second control circuit board **312**. In the present embodiment, the first control circuit board **311** controls, for example, electronic devices, and the second control circuit board **312** controls, for example, drive devices. Note that, however, the division of the roles of the first control circuit board **311** and the second control circuit board **312** is not limited to this.

(48) Note that the example of FIG. **3**A illustrates a case in which the first control circuit board **311** and the second control circuit board **312** are provided separately. However, the first control circuit board **311** and the second control circuit board **312** may also be provided integrally as a single circuit board. Regardless of whether the first control circuit board **311** and the second control circuit board **312** are disposed separately or integrally, a device having both of the functions of the first control circuit board **311** and the functions of the second control circuit board **312** is referred to as the controller **310** in the present embodiment.

(49) (a-2) Docking Mechanism

(50) The docking mechanism will be described next. As illustrated in FIG. **3**A, the autonomous vehicle **120** includes the locking device **211** that is movable upward and downward, as a docking

mechanism for docking with a shelving unit that is to be the conveyance target. Note that although the docking mechanism according to the present embodiment uses a solenoid locking device, the raising and lowering of the locking device may be performed by an electromagnetic actuator other than a solenoid or by another type of actuator, such as a rack and pinion mechanism, a trapezoidal thread mechanism, or a pneumatic drive mechanism.
(51) A specific configuration of the locking device **211** is disclosed in, for example, the following Reference Document 1. [Reference Document 1] Japanese Laid-Open Patent Publication No. 2022-144293
(52) In the present embodiment, the locking device **211** is disposed at the center position in the width direction (x-axis direction) of the drive wheels **231** provided such that one drive wheel is on each side in the width direction (x-axis direction). In addition, the locking device **211** is disposed on the rotational axes of the drive wheels **231** (see the chain lines in FIGS. **3**A and **3**B).
(53) The locking device **211** includes a compression coil spring. When a solenoid is turned on, the locking device **211** is moved downward, causing the compression coil spring to contract. When the solenoid is turned off, the locking device **211** moves upward (in the z-axis direction; toward the front side of the drawing in the case of FIG. **3**A) by the compression force of the compression coil spring. Note that the controller **310** controls the solenoid to be turned on or off.
(54) The locking device **211** determines whether or not the recess of the locking device **211** can be engaged with a projection (described below in detail) attached to a conveyance-target shelving unit when the autonomous vehicle **120** enters below the bottom shelf of the conveyance-target shelving unit.
(55) The autonomous vehicle **120** may turn off the solenoid when it is determined that the locking device **211** can be moved upward. Note that although the photoreflector is used to detect the state in which the locking device **211** and the projection are facing each other in the present embodiment, the detection may be performed by a method using a component other than the photoreflector. A method using a component other than the photoreflector is, for example, a method using a camera, a physical switch, a magnetic sensor, an ultrasonic sensor, or the like.
(56) Consequently, the locking device **211** is moved to the projection, and the locking device **211** is engaged with the projection. As a result, the docking of the autonomous vehicle **120** with the conveyance-target shelving unit is completed.
(57) Note that, as described above, the drive wheels **231** are provided such that one drive wheel is on each side in the width direction (x-axis direction), and the locking device **211** is provided at the center position of the drive wheels **231** in the width direction (x-axis direction). In other words, the locking device **211** is provided symmetrically in the width direction. Thus, when entering below the bottom shelf of the conveyance-target shelving unit, the autonomous vehicle **120** can enter in a forward direction or in a backward direction.
(58) When the solenoid is turned on to move the locking device **211** downward in a state in which the autonomous vehicle **120** is docked with the conveyance-target shelving unit, the autonomous vehicle **120** is undocked from the conveyance-target shelving unit.
(59) (a-3) Various Input and Output Devices
(60) Various input and output devices will be described next. As illustrated in FIG. **3**A, in addition to the LiDAR device **212**, the front RGB camera **221**, and the ToF camera **222** that are described above, the autonomous vehicle **120** includes various types of input and output devices, such as a rear RGB camera **320**, microphones **301** to **304**, and loudspeakers **305** and **306**.
(61) As the disposition positions, the disposition directions, the measurement ranges, the measurement targets, and the like of the LiDAR device **212**, the front RGB camera **221**, and the ToF camera **222** have already been described, description thereof will be omitted here.
(62) When the autonomous vehicle **120** moves in the backward direction, the rear RGB camera **320** captures and outputs color images of, for example, the conveyance-target shelving unit (for example, the shelving unit **130**), an obstacle in the periphery of the conveyance-target shelving

unit, and the like.
(63) Note that the front RGB camera **221** and the rear RGB camera **320** may output grayscale images instead of color images. The front RGB camera **221** and the rear RGB camera **320** may be a stereo camera.
(64) The microphones **301** to **304** are examples of audio input devices. The microphones **301** to **304** are provided at the four corners (two on the front side and two on the rear side) of the autonomous vehicle **120** to detect sound from the respective directions. By providing the microphones **301** to **304** at the four corners of the autonomous vehicle **120** in this manner, the direction in which the user **110** who gave the voice instruction is present can be determined with respect to the current position and orientation of the autonomous vehicle **120**, thus allowing estimation of the position of the user **110**.
(65) The loudspeakers **305** and **306** are examples of audio output devices, and provide a voice output in the lateral direction of the autonomous vehicle **120**. The loudspeakers **305** and **306** provide, for example, a voice output to confirm the contents of a task recognized by the autonomous vehicle **120** in response to a voice instruction given by the user **110**.
(66) FIG. **3**B illustrates the lower surface of the autonomous vehicle **120**. The components of the lower surface of the autonomous vehicle **120** will be described hereinafter with reference to FIG. **3**B.
(67) (b-1) Drive Wheels
(68) The drive wheel **231** will be described first. As illustrated in FIG. **3**B, the autonomous vehicle **120** includes the drive wheels **231** that are provided such that one drive wheel is present on each side in the width direction (x-axis direction). As described above, the drive wheel **231** may be each independently motor-driven to move the autonomous vehicle **120** in the forward-backward direction (y-axis direction) and to cause the autonomous vehicle **120** to turn about the z axis.
(69) Specifically, the autonomous vehicle **120** can be moved in the forward direction by rotating both of the drive wheels **231** forward, and the autonomous vehicle **120** can be moved in the backward direction by reversing both of the drive wheels **231**. Further, the autonomous vehicle **120** can turn by rotating one of the drive wheels **231** forward and rotating the other in reverse.
(70) Note that as described above, the rotational axis of one of the drive wheels **231** and the rotational axis of the other are coaxially formed, and the locking device **211** is provided on the co-axis at the center position between one drive wheel **231** and the other drive wheel **231**. Therefore, when one drive wheel **231** is rotated forward and the other drive wheel **231** is rotated in reverse, the autonomous vehicle **120** is able to turn about the locking device **211**.
(71) (b-2) Non-Drive Wheels
(72) The non-drive wheel **232** will be described next. As illustrated in FIG. **3**B, the autonomous vehicle **120** includes the non-drive wheels **232** that are provided such that one non-drive wheel is on each side in the width direction (x-axis direction). As described above, each of the non-drive wheels **232** is provided so as to be able to turn about the z axis. Thus, for example, when the autonomous vehicle **120** is to make a turn after moving in the forward direction or the backward direction, the non-drive wheels **232** can be oriented to immediately follow in the direction of the turn. Furthermore, for example, when the autonomous vehicle **120** is to move in the forward direction or the backward direction after making a turn, the non-drive wheels **232** can be oriented to immediately follow in the forward or backward direction.
(73) <Outline of Docking>
(74) The outline of the docking will be described next. FIGS. **4**A and **4**B are views illustrating a state in which the autonomous vehicle is docked with the conveyance-target shelving unit. FIG. **4**A is a view illustrating a state immediately before the autonomous vehicle **120** is docked with the conveyance-target shelving unit **130** that is standing by at the position of the anchor **170**.
(75) As illustrated in FIG. **4**A, the shelving unit **130** includes three shelves. Frame guides **410** and **420** are attached on the underside of a bottom shelf **400** so as to be substantially parallel to each

other with a space corresponding to the width of the autonomous vehicle **120** provided therebetween. This configuration can define the entry direction when the autonomous vehicle **120** is to enter below the bottom shelf **400** of the conveyance-target shelving unit **130**. Further, the frame guides **410** and **420** may function as guides in the width direction when the autonomous vehicle **120** is to convey the conveyance-target shelving unit **130**, thereby preventing the shelving unit **130** from shifting in the width direction relative to the autonomous vehicle **120**.

(76) The entry direction is an entry direction that creates a state in which the autonomous vehicle **120** can convey the conveyance target. The state in which the autonomous vehicle **120** can convey the conveyance target includes a state in which the autonomous vehicle **120** is docked with the conveyance target. The state in which the autonomous vehicle **120** can convey the conveyance target also includes a state in which the autonomous vehicle can convey the conveyance target, for example, by pushing, lifting, gripping, loading, towing, or the like. The term "conveyance" includes transferring the conveyance target to a different place by the autonomous vehicle. Note that in the present embodiment, the expression "entry direction" is used because the autonomous vehicle **120** enters below the bottom shelf **400** for docking with the shelving unit **130**. However, in an embodiment that creates a state in which the autonomous vehicle **120** can convey the conveyance target without entry into the conveyance target, the expression "traveling direction" may be used.

(77) In addition, casters **431** to **434** may be rotatably attached to the feet of the shelving unit **130**. Such a configuration can allow the autonomous vehicle **120** to readily convey the docked shelving unit **130**.

(78) FIG. **4**B is a view illustrating a state after the autonomous vehicle **120** is docked with the conveyance-target shelving unit **130**. As illustrated in FIG. **4**B, the front surface **220** of the autonomous vehicle **120** juts out from the shelves of the shelving unit **130** in the forward direction, and is not covered by the shelves of the shelving unit **130**. However, depending on the shape or dimensions of the shelving unit **130**, the measurement range of at least one of the front RGB camera **221**, the ToF camera **222**, the LiDAR device **212**, or the rear RGB camera **320** may be obstructed by the components of the shelving unit **130** (e.g., the shelves, pillars, casters, and the like). Therefore, in the present embodiment, the shape and dimensions of the shelving unit **130** are identified, and an invalid region may be set in the measurement range of at least one of the front RGB camera **221**, the ToF camera **222**, the LiDAR device **212**, or the rear RGB camera **320**.

(79) Note that the measurement range of the LiDAR device **212** in the width direction may be obstructed by the frame guides **410** and **420** or the components of the shelving unit **130** in a state in which the autonomous vehicle **120** is docked with the shelving unit **130**.

(80) Therefore, the frame guides **410** and **420** of the shelving unit **130** are provided with openings **411** and **421** in order to reduce an area where the measurement range of the LiDAR device **212** in the width direction is obstructed.

(81) FIG. **5** is a front view illustrating a schematic configuration below the bottom shelf **400** of the shelving unit **130**. As illustrated in FIG. **5**, a projection **440** (an example of the coupling) is provided at the middle position between the pair of frame guides **410** and **420**, i.e., the center position of the bottom shelf **400** of the shelving unit **130** in the x direction, so as to project downward from the lower surface of the bottom shelf **400**. In the present embodiment, the projection **440** has, for example, a columnar shape, but is not limited to this shape.

(82) The above-described locking device **211** of the autonomous vehicle **120** is configured to be movable upward and downward. The locking device **211** is raised and mated with the projection **440**, thereby coupling the autonomous vehicle **120** and the shelving unit **130** to each other. That is, the locking device **211** (the docking mechanism) of the autonomous vehicle **120** and the projection **440** (the coupling) of the shelving unit **130** (the conveyance target) form a "coupling structure between the autonomous vehicle and the conveyance target" according to the present embodiment.

(83) <Relationship Between Positions of Casters of Shelving Unit and Position of Docking

Mechanism of Autonomous Vehicle>

(84) The positional relationship between the casters **431** to **434** that are rotatably attached to the shelving unit **130** and the docking mechanism of the autonomous vehicle **120** will be described next. FIG. **6** is a view illustrating the positional relationship between the casters of the shelving unit and the docking mechanism of the autonomous vehicle.

(85) The upper part of FIG. **6** is a state in which the autonomous vehicle **120** is docked with the shelving unit **130** as viewed from directly above the bottom shelf **400** of the shelving unit **130**. Note that, however, only the outer frame of the bottom shelf **400** is illustrated for the sake of descriptive convenience. Further, the lower part of FIG. **6** is a state in which the autonomous vehicle **120** is docked with the shelving unit **130** as viewed in the direction of the front surface **220** of the autonomous vehicle **120**.

(86) As illustrated in the upper part of FIG. **6**, the four casters **431** to **434** of the shelving unit **130** are rotatably attached at the corners of the bottom shelf **400**. Reference numerals **501** to **504** indicate the rotation ranges of the four wheels **431** to **434**, respectively. The respective center positions of the rotation ranges **501** to **504** are the respective centers of rotation of the casters **431** to **434**.

(87) As illustrated in the upper part of FIG. **6**, the projection **440** is provided on the underside of the bottom shelf **400** of the shelving unit **130**. The projection **440** is engaged with the recess of the locking device **211** that is moved upward.

(88) Engagement of the locking device **211**, having a recessed shape, with the projection **440**, having a projecting shape, can prevent the shelving unit **130** from shifting in the forward direction or the backward direction relative to the autonomous vehicle **120** when the autonomous vehicle **120** is to convey the shelving unit **130**. Note that in the drawing of the present embodiment, the locking device **211** in a state of being moved upward is indicated in black in order to clearly illustrate whether or not the locking device **211** is in a state of being moved upward.

(89) The center position of the projection **440** is provided to match the center position with respect to each of the respective centers of rotation of the four casters **431** to **434** of the shelving unit **130** (see the broken lines and the chain lines in FIG. **6**). Therefore, in a state in which the autonomous vehicle **120** is docked with the shelving unit **130**, the center position of the locking device **211** can also be the center position with respect to the respective centers of rotation of the four casters **431** to **434** of the shelving unit **130**.

(90) As described above, because the autonomous vehicle **120** is provided to rotate about the locking device **211** as the center, the shelving unit **130** may turn about the center position with respect to the respective centers of rotation of the four wheels **431** to **434** when the autonomous vehicle **120** turns. That is, the rotation range of the shelving unit **130** when the autonomous vehicle **120** turns can be the range indicated by reference numeral **520**.

(91) <Operation Example of Docking Mechanism>

(92) An operation example of the docking mechanism when the autonomous vehicle **120** is to dock with the shelving unit **130** will be described. Here, an operation example when the autonomous vehicle **120** is to dock with the shelving unit **130** that is standing by in the position of the anchor **170** will be described. FIGS. **7**A to **7**C are views illustrating the examples of the operation of the docking mechanism upon docking. In a similar manner to the upper part of FIG. **6**, FIGS. **7**A to **7**C each illustrate a state as viewed from directly above the bottom shelf **400** of the shelving unit **130**. Note that, however, only the outer frame of the bottom shelf **400** is illustrated for the sake of descriptive convenience.

(93) FIG. **7**A illustrates a state in which the autonomous vehicle **120** has moved to a position near the conveyance-target shelving unit **130** and has subsequently searched for the shelving unit **130** based on a color image captured by the front RGB camera **221**. In the present embodiment, the shelving unit **130** is searched for by extracting, from the color image, a marking that is provided to the shelving unit **130** in advance to identify the shelving unit **130**. Alternatively, the shelving unit

130 may be searched for based on the above in combination with the results by using a deep-learning-based object recognition model to perform instance segmentation or object recognition on the color image.

(94) Furthermore, FIG. **7**A illustrates a state in which the autonomous vehicle **120** has recognized the position and the orientation of the shelving unit **130** (the orientation of the frame guides **410** and **420**) and has turned 180 degrees with respect to the entry direction at the time of docking when the autonomous vehicle **120** has found the shelving unit **130**.

(95) The autonomous vehicle **120** that has turned 180 degrees starts the docking operation based on the color image captured by the rear RGB camera **320**.

(96) Specifically, after the locking device **211** is moved downward by turning on the solenoid, the autonomous vehicle **120** starts moving in the backward direction and enters between the frame guide **410** and the frame guide **420** below the bottom shelf **400**.

(97) FIG. **7**B illustrates a state in which the autonomous vehicle **120** has entered between the frame guide **410** and the frame guide **420** by moving in the backward direction. During the entry, the autonomous vehicle **120** determines whether or not the locking device **211** can be engaged with the projection **440**. The determination as to whether or not the locking device **211** can be engaged with the projection **440** can be performed, for example, based on the measurement results of the photoreflector included in the locking device **211**.

(98) FIG. **7**C illustrates a state in which the locking device **211** can be engaged with the projection **440**. In the state as illustrated in FIG. **7**C, the autonomous vehicle **120** turns off the solenoid to cause the locking device **211** to move upward and be engaged with the projection **440**. As a result, the docking of the autonomous vehicle **120** with the shelving unit **130** is completed.

(99) <Searching Method of Conveyance Target>

(100) In the present embodiment, the autonomous vehicle **120** searches for the shelving unit **130** based on one or more markings provided to the shelving unit **130** in advance. The autonomous vehicle **120** recognizes the markings from one or more images including the one or more markings obtained by a sensor. The sensor in the present embodiment includes at least one of the front RGB camera **221**, the ToF camera **222**, the LiDAR device **212**, or the rear RGB camera **320**.

(101) The marking in the present embodiment includes a code in which information is encoded and a mark (figure) that does not represent specific information. Examples of the code include one-dimensional codes, such as barcodes and the like, two-dimensional codes, such as QR codes (registered trademark), color codes (e.g., chameleon codes (registered trademark)), and the like, numerical or character sequences in which Arabic numerals, alphabets, or the like are arranged, and augmented reality (AR) markings, and the like. The code may be a given symbol recognizable from the image, and can be appropriately selected in accordance with a required quantity of information, recognition accuracy, and the like. The mark may be, for example, a figure that itself does not have a quantity of information, such as a reference mark. Each mark can be given a meaning in its position, color, shape, size, or the like.

(102) The markings are disposed at predetermined positions of the shelving unit **130**. The predetermined positions are, for example, positions at which the markings are capturable by the front RGB camera **221** or the rear RGB camera **320** in the entry direction in which the autonomous vehicle **120** docks with the shelving unit **130**.

(103) FIG. **8** is a view illustrating an example of a display position of the marking. FIG. **8** illustrates the lower surface of the bottom shelf **400** of the shelving unit **130** as viewed from directly below. As illustrated in FIG. **8**, the marking in the present embodiment includes four barcodes **451** to **454**, and are disposed on the underside of the bottom shelf **400** of the shelving unit **130**. Note that a direction of the upper side toward the lower side on the drawing in FIG. **8** corresponds to the entry direction of the autonomous vehicle **120**.

(104) Of the barcodes **451** to **454**, the barcodes **451** and **452**, serving as a set, are displayed on a plate **461** vertically attached to the lower surface of the bottom shelf **400** of the shelving unit **130**.

Similarly, of the barcodes **451** to **454**, barcodes **453** and **454**, serving as another set, are displayed on a plate **462** vertically attached to the lower surface of the bottom shelf **400** of the shelving unit **130**.
(105) The barcodes **451** to **454** are formed on media, such as seals or the like (hereinafter may be referred to as “display media”), and the display media are attached to the plates **461** and **462** for display. The barcodes **451** to **454** may be formed on two display media set by set, or may be separately formed on four display media. That is, the markings may be individually formed on display media, or the markings may be formed on display media as sets. The display media may be anything, such as a paper sheet, a wood piece, a resin sheet, a resin panel, or the like, as long as the conveyance-target shelving unit **130** can have one or more markings. Also, depending on a type of the display media, the barcodes **453** and **454** (described below in detail) displayed on the rear surface of the plate **461** and the barcodes **451** and **452** (described below in detail) displayed on the rear surface of the plate **462** may be formed.
(106) A material or an attachment method of the display media may be appropriately selected in accordance with the material, shape, surface status (roughness), and the like of the plate. For example, the barcode is printed on a paper sheet, a resin sheet, or the like, and the printed product is attached to the plate. In this state, the plate may be wrapped with a sheet having high light transmissivity, thereby attaching the printed product to the plate. Alternatively, the barcode may be directly printed on the surface of the plate. In this case, the plate itself functions as the display medium.
(107) Further, the barcode may be formed by engraving the plate with laser beams.
(108) Alternatively, a slit may be formed in the plate, and a medium provided with the barcode is formed may be inserted into the slit, thereby displaying the barcode. The barcode may be displayed by directly printing the barcode on the shelving unit **130** or by engraving the shelving unit **130** so as to have the barcode (e.g., on or in the bottom or side surface of the bottom shelf **400**). A member in which the barcode is to be displayed may have a given shape, such as a cylindrical shape, a prismatic shape, or a spherical shape, in addition to the plate shape.
(109) The plates **461** and **462** are disposed along the entry direction of the autonomous vehicle **120**. The plates **461** and **462** are attached such that the surfaces thereof displaying the barcodes are oriented to the incoming side in the entry direction. The plate **461** and the plate **462** are disposed at symmetrical positions with the projection **440** interposed therebetween.
(110) Thus, the barcodes **451** and **452** disposed frontward in the traveling direction (hereinafter may be referred to as “frontward barcodes **451** and **452**”) are arranged in a direction intersecting the entry direction. Similarly, the barcodes **453** and **454** disposed rearward in the traveling direction (hereinafter may be referred to as “rearward barcodes **453** and **454**”) are arranged in a direction intersecting the entry direction. Note that the direction intersecting the entry direction includes a direction orthogonal to the entry direction. The barcode **451** and the barcode **453** are arranged along the entry direction. Similarly, the barcode **452** and the barcode **454** are arranged along the entry direction.
(111) The frontward barcodes **451** and **452** may be configured to express a smaller quantity of information than the rearward barcodes **453** and **454**. In the example of FIG. **8**, the frontward barcodes **451** and **452** each indicate 2-digit information, and the rearward barcodes **453** and **454** each indicate 4-digit information. Therefore, in the example of FIG. **8**, the barcodes **451** to **454** can express 12-digit information. The quantity of information expressed by each barcode is an example and may be appropriately determined in consideration of a required quantity of information and a recognizable range.
(112) When the barcodes **451** to **454** are displayed with the same area, the frontward barcodes **451** and **452** can be displayed at a lower resolution than in the rearward barcodes **453** and **454**. This increases the recognition rate of the frontward barcodes **451** and **452**, and the frontward barcodes **451** and **452** can be recognized from a farther location.

(113) The rearward barcodes **453** and **454** may be a barcode that cannot be captured by the front RGB camera **221** or the rear RGB camera **320** unless the autonomous vehicle **120** approaches the shelving unit **130**. In this case, the rearward barcodes **453** and **454** are recognized from a near location. Therefore, the rearward barcodes **453** and **454** can be increased in the resolution and the quantity of information.
(114) The autonomous vehicle **120** can also enter below the bottom shelf **400** of the shelving unit **130** in a direction opposite to the entry direction. Therefore, the markings may be disposed so as to be captured in the same manner from both of the entry direction and the opposite direction. In the example of FIG. **8**, the barcodes **451** and **452** may be displayed on the front surface of the plate **461**, and the barcodes **453** and **454** may be displayed on the rear surface thereof. Similarly, the barcodes **453** and **454** may be displayed on the front surface of the plate **462**, and the barcodes **451** and **452** may be displayed on the rear surface thereof.
(115) Further, the markings may display information different between the frontward barcodes and the rearward barcodes. The autonomous vehicle **120** recognizes codes different between entry in the entry direction and entry in the opposite direction, and thus can recognize the entry direction.
(116) Limitation may be imposed on the barcodes disposed leftward and rightward such that the barcode in a predetermined direction indicates a relatively great value. For example, the leftward barcode may be limited to indicate a greater value than does the rightward barcode, or the rightward barcode may be limited to indicate a greater value than does the leftward barcode. For example, when two or more shelving units are standing by side by side, the autonomous vehicle **120** may recognize two barcodes of different shelving units (that is, the autonomous vehicle **120** may recognize, as a set of barcodes, the rightward barcode of the leftward shelving unit and the leftward barcode of the rightward shelving unit). In this case, unless the above limitation is satisfied, the combination of codes may be discarded as an invalid combination. At this time, the distance between the two barcodes may be measured, and if the measured distance is not within a predetermined range, the combination of codes may be discarded as an invalid combination.
(117) The limitation imposed on the two or more barcodes is not limited to the difference in the magnitude of values. For example, information to be included in a code disposed at a specific position may be limited to only a part of information that can be expressed by the code. A range of information to be included in a certain code may be determined by information to be included in another code to be disposed in combination.
(118) The markings include identification information for identifying the shelving unit **130**. The identification information may be, for example, a serial number that uniquely identifies the shelving unit **130**. The identification information may be, for example, a stock keeping unit (SKU). In the example of FIG. **8**, the two frontward barcodes **451** and **452** indicate the last four digits of the serial number, and the one rearward barcode **453** indicates the first four digits of the serial number.
(119) The markings may include additional information on the shelving unit **130**. The additional information may be, for example, a checksum of the identification information, information indicating the front and back of the shelving unit **130**, attribute information of the shelving unit **130**, a conveyance condition of the shelving unit **130**, or the like. The attribute information may be, for example, the type of the shelving unit **130**, the shape thereof, the outer dimensions thereof, the mass thereof, the number of shelves thereof (the number of shelves thereof), the position of the center of gravity thereof, the type of the casters, the shape thereof, the presence or absence of an electrical contact thereof, functions thereof (indicating functions that can be realized via an electrical contact, such as communication and power supply), an expiration date (provided in a rental contract, in which the number of days for approved use is limited), or the like. The conveyance condition may be, for example, a sensor invalid region, a usable sensor type, a conveyance speed, or the like. The conveyance condition may be determined, for example, based on the identification information. The additional information is not limited to the above, and given

information can be set within a range allowable in terms of the quantity of information. In the example of FIG. **8**, the barcode **454** indicates 4-digit additional information, and a checksum of the identification information is set as the additional information.

(120) The markings (barcodes **451** to **454**) provided to the shelving unit **130** are differently seen from the front RGB camera **221** in accordance with the distance between the autonomous vehicle **120** and the shelving unit **130**. FIG. **9** to FIG. **11** are diagrams each illustrating an example of an image captured by the front RGB camera **221** when the autonomous vehicle **120** is docked with the shelving unit **130**.

(121) FIG. **9** is an example of an image when the autonomous vehicle **120** reaches a position near the conveyance-target shelving unit **130** and starts searching. As illustrated in FIG. **9**, when there is a distance between the autonomous vehicle **120** and the shelving unit **130**, only the frontward barcodes **451** and **452** are captured by the front RGB camera **221**. The autonomous vehicle **120** recognizes the last four digits of the serial number indicated by the barcodes **451** and **452** and identifies the shelving unit **130**. If the shelving unit **130** can be identified by the last four digits of the serial number, the autonomous vehicle **120** starts entry below the bottom shelf **400** of the shelving unit **130**. Note that the autonomous vehicle **120** may turn 180 degrees and enter in the backward direction, or may enter in the forward direction without turning. The case in which the shelving unit **130** can be identified indicates a case in which there are one or more shelving units **130** with matching last four digits in the serial numbers.

(122) FIG. **10** is an example of an image when the autonomous vehicle **120** approaches the shelving unit **130** and enters below the bottom shelf **400**. As illustrated in FIG. **10**, when the autonomous vehicle **120** approaches the shelving unit **130**, the rear RGB camera **320** captures the rearward barcodes **453** and **454** in addition to the frontward barcodes **451** and **452**. The autonomous vehicle **120** recognizes the 8-digit serial number indicated by the barcodes **451** to **453** and identifies the shelving unit **130** again. When the shelving unit **130** can be identified, the autonomous vehicle **120** determines whether or not the serial number of the shelving unit matches the serial number of a shelving unit identified as the conveyance target. When the recognized serial number is different from the serial number of the conveyance-target shelving unit, the autonomous vehicle **120** stops docking. If the recognized serial number matches the serial number of the conveyance-target shelving unit, the autonomous vehicle **120** proceeds with entering below the bottom shelf **400** of the shelving unit **130**.

(123) FIG. **11** is an example of an image when the autonomous vehicle **120** enters below the bottom shelf **400** of the shelving unit **130**. As illustrated in FIG. **11**, when the autonomous vehicle **120** enters below the bottom shelf **400** of the shelving unit **130**, the frontward barcodes **451** and **452** are out of the angle of view of the rear RGB camera **320**, and only the rearward barcodes **453** and **454** are captured by the rear RGB camera **320**. Thus, when the autonomous vehicle **120** recognizes the frontward barcodes **451** and **452**, the autonomous vehicle **120** stores the last four digits of the serial number in a memory.

(124) Subsequently, the autonomous vehicle **120** continues to enter below the bottom shelf **400** of the shelving unit **130** until completion of docking. Upon completion of docking, the autonomous vehicle **120** obtains a specification of the shelving unit **130** based on the serial number of the shelving unit **130**. The specification of the shelving unit **130** includes, for example, at least one of the shape of the shelving unit **130** or the outer dimensions thereof. For example, information in which the serial number of the shelving unit **130** and the specification thereof are associated with each other may be stored in advance in the memory of the autonomous vehicle **120**, and the specification of the shelving unit **130** may be obtained by reading out that information. Also, for example, information in which the serial number of the shelving unit **130** and the specification thereof are associated with each other may be stored in an external server, and the specification of the shelving unit **130** may be obtained from the external server based on the serial number of the shelving unit **130**. Further, when the markings include additional information indicating the shape

and outer dimensions of the shelving unit **130**, the specification of the shelving unit **130** may be obtained from the recognition results of the barcodes. While conveying the shelving unit **130** to the position of the conveyance destination, the autonomous vehicle **120** avoids obstacles in consideration of the specification of the shelving unit **130**.
(125) <Functional Configuration of Controller>
(126) The functional configuration of the controller **310** will be described next. FIG. **12** is a diagram illustrating an example of the functional configuration of the controller. A control program is installed in the controller **310**, and when the program is executed, the controller **310** functions as a conveyance instruction obtainment part **801**, a conveyance target identification part **802**, a conveyance target position identification part **803**, a docking controller **804**, a conveyance destination identification part **805**, a conveyance destination position identification part **806**, and a conveyance controller **807**. The controller **310** also includes a conveyance target storage part **810** and an environment map storage part **811**.
(127) The conveyance instruction obtainment part **801** is configured to obtain the conveyance instruction given by the user **110**. When the conveyance instruction obtainment part **801** is to obtain a voice instruction, the conveyance instruction obtainment part **801** recognizes a wake word uttered by the user **110** from the audio data detected by the microphones **301** to **304**, and obtains a voice instruction following the wake word. When the conveyance instruction obtainment part **801** is to obtain an operation instruction, the conveyance instruction obtainment part **801** receives a control signal, indicating the conveyance instruction, from the information process terminal of the user **110**. The conveyance instruction obtainment part **801** notifies the conveyance target identification part **802** and the conveyance destination identification part **805** of the obtained conveyance instruction.
(128) The conveyance target identification part **802** is configured to analyze the conveyance instruction notified by the conveyance instruction obtainment part **801** and identify an item to be conveyed by the autonomous vehicle **120** (e.g., a laptop computer). The conveyance target identification part **802** refers to a conveyance target management table stored in the conveyance target storage part **810** and identify, as the conveyance target, a shelving unit on which the identified item is placed (e.g., the shelving unit **130**). Moreover, the conveyance target identification part **802** notifies the conveyance target position identification part **803** of the identified conveyance-target shelving unit.
(129) Note that when the obtained conveyance instruction includes a word indicating the conveyance-target shelving unit instead of the item to be conveyed, the conveyance target identification part **802** directly identifies the conveyance-target shelving unit (e.g., the shelving unit **130**) and notifies the conveyance target position identification part **803** of the conveyance-target shelving unit.
(130) The conveyance target position identification part **803** is configured to refer to the conveyance target management table stored in the conveyance target storage part **810** and identify the current position of the conveyance-target shelving unit notified by the conveyance target identification part **802**. The conveyance target position identification part **803** also notifies the docking controller **804** of coordinates indicating the position of the identified conveyance-target shelving unit (e.g., coordinates indicating the position of the anchor **170**).
(131) The docking controller **804** is configured to move the autonomous vehicle **120** based on the coordinates indicating the position of the conveyance-target shelving unit, notified by the conveyance target position identification part **803**, and based on the coordinates indicating the current position of the autonomous vehicle **120**, thereby controlling the autonomous vehicle **120** to be docked with the conveyance-target shelving unit. Upon completion of docking of the autonomous vehicle **120** with the conveyance-target shelving unit, the docking controller **804** notifies the conveyance controller **807** of the completion of docking.
(132) The conveyance destination identification part **805** is configured to analyze the conveyance

instruction notified by the conveyance instruction obtainment part **801** and identify the position of the conveyance destination of the conveyance-target shelving unit (e.g., a position near the user **110**). The conveyance destination identification part **805** also notifies the conveyance destination position identification part **806** of the identified position of the conveyance destination.
(133) The conveyance destination position identification part **806** is configured to refer to an environment map stored in the environment map storage part **811** and identify the coordinates indicating the position of the conveyance destination when the position of the conveyance destination notified by the conveyance destination identification part **805** is a position near an object (e.g., a piece of furniture) disposed in the predetermined space **100**. Note that the environment map registers the coordinates of the objects disposed in the predetermined space **100**.
(134) When the conveyance destination notified by the conveyance destination identification part **805** is a position near the user **110**, the conveyance destination position identification part **806** identifies the coordinates indicating the position of the conveyance destination based on: the direction in which the user **110** is present, determined based on one of the microphones **301** to **304** from which audio data indicating the voice instruction has been detected; and the current position and orientation of the autonomous vehicle **120** when the voice instruction has been obtained.
(135) Note that the autonomous vehicle **120** calculates its own position and orientation in the predetermined space **100** at predetermined cycles based on at least one of: the measurement results obtained by the LiDAR device **212**; the color image captured by the front RGB camera **221**; or the range image captured by the ToF camera **222**.
(136) Moreover, the conveyance destination position identification part **806** notifies the conveyance controller **807** of the coordinates indicating the identified position of the conveyance destination.
(137) The conveyance controller **807** is configured to control the autonomous vehicle **120** to move based on the coordinates indicating the position of the conveyance destination notified by the conveyance destination position identification part **806** when the conveyance controller **807** is notified of the completion of docking by the docking controller **804**.
(138) During the movement of the autonomous vehicle **120**, the conveyance controller **807** refers to the measurement results obtained by the LiDAR device **212**, the color image captured by the front RGB camera **221**, and the range image captured by the ToF camera **222**. The conveyance controller **807** may cause the autonomous vehicle **120** to move in the backward direction by referring to the measurement results obtained by the LiDAR device **212** and the color image captured by the rear RGB camera **320**. The conveyance controller **807** calculates the current position of the autonomous vehicle **120**, and controls the autonomous vehicle **120** to avoid collision upon detecting an obstacle on a conveyance path.
(139) After the autonomous vehicle **120** has reached the position of the conveyance destination, the conveyance controller **807** releases docking with the conveyance-target shelving unit and causes the autonomous vehicle **120** to move out from below the bottom shelf **400**.
(140) <Specific Example of Conveyance Target Management Table>
(141) A specific example of the conveyance target management table stored in the conveyance target storage part **810** will be described next. FIG. **13** is a view illustrating an example of the conveyance target management table.
(142) As illustrated in FIG. **13**, a conveyance target management table **900** is a table in which conveyance-target shelving units are associated with respective items placed on the shelves. The conveyance target management table **900** includes “SHELVING UNIT INFORMATION”, “ITEM”, and “TAG” as examples of information items. However, “ITEM” and “TAG” are not essential and are not necessarily included in the conveyance target management table **900**.
(143) “SHELVING UNIT INFORMATION” further includes “ID”, “TYPE”, “DIMENSIONS”, “INITIAL POSITION”, “RELEASE POSITION”, and “DOCKING POSITION”. However, “DOCKING POSITION” is not essential and is not necessarily included in “SHELVING UNIT

INFORMATION".
(144) Identification information identifying each shelving unit is stored as "ID". Information identifying the type of each shelving unit is stored as "TYPE". Outer dimensions of each shelving unit are stored as "DIMENSIONS". In FIG. **13**, "DIMENSIONS" is indicated in an orthogonal coordinate system, but a coordinate system may be changed in accordance with the shape of the shelving unit. For example, when the shelving unit has a columnar shape or an elliptical columnar shape, the outer dimensions thereof may be indicated in a cylindrical coordinate system. "INITIAL POSITION", "RELEASE POSITION", and "DOCKING POSITION" may include information indicating a posture (e.g., a yaw angle) in addition to the coordinates (x, y) indicating the position.
(145) "SHELVING UNIT INFORMATION" may also include other information in relation to the shelving unit **130**. Examples of the other information include the shape of the shelving unit **130**, the mass thereof, the number of shelves thereof, the position of the center of gravity thereof, the type of the casters, the shape thereof, the presence or absence of an electrical contact thereof, functions thereof, and the like.
(146) As "INITIAL POSITION", the coordinates indicating the position and posture of the shelving unit first recognized by the autonomous vehicle **120** during traveling in the predetermined space **100** are stored. Alternatively, as "INITIAL POSITION", the coordinates indicating the position and posture designated by the user **110** in advance (e.g., the position and posture of the anchor **170**) are stored.
(147) As "RELEASE POSITION", the coordinates indicating the position and posture at which the autonomous vehicle **120** released docking with the conveyance-target shelving unit last time are stored. As "DOCKING POSITION", the coordinates indicating the position and posture at which the autonomous vehicle **120** was docked with the conveyance-target shelving unit last time are stored. Note that the coordinates indicating each position are coordinates on the environment map. However, the name of a location preassigned on the environment map may be stored instead of the coordinates indicating each position.
(148) As "ITEM", information indicating an item placed on the conveyance-target shelving unit is stored. As "TAG", information indicating the type of a corresponding item is stored.
(149) In the case of the conveyance target management table **900** as illustrated in FIG. **13**, "SHELVING UNIT INFORMATION", "ITEM", and "TAG" are directly associated with each other. However, they may be indirectly associated with each other. "Indirectly associated" refers to, for example, indirectly associating information A and information B via information C by directly associating the information A with the information C and directly associating the information C with the information B when the information A and the information B are to be associated.
(150) The conveyance target management table **900** may be created in advance by the following method that is a non-limiting example. Specifically, when the user **110** has purchased a shelving unit, the user **110** may operate an application installed in the information process terminal and register information on the purchased shelving unit in "SHELVING UNIT INFORMATION". Alternatively, for example, when the autonomous vehicle **120** has found a new shelving unit during traveling in the predetermined space **100**, the user **110** may register information on the found shelving unit in "SHELVING UNIT INFORMATION". Similarly, the user **110** may operate an application installed in the information process terminal and register information in relation to "ITEM" and "TAG" in the registered "SHELVING UNIT INFORMATION".
(151) A predetermined conveyance destination may be set in the conveyance target management table **900**. The predetermined conveyance destination may be set from shelving unit to shelving unit, or may be set from item to item. The predetermined conveyance destination may be registered by the user **110** who operates an application installed in the information process terminal.
(152) <Functional Configuration of Docking Controller>
(153) The functional configuration of the docking controller **804** will be described next in more detail. FIG. **14** is a diagram illustrating an example of the functional configuration of the docking

controller.

(154) As illustrated in FIG. **14**, when the control program installed in the controller **310** is executed, the docking controller **804** functions as an image obtainment part **901**, an object recognition part **902**, a code recognition part **903**, an identification information generation part **904**, a position and posture controller **905**, an identification information verification part **906**, a specification identification part **907**, and an invalid region setting part **908**.

(155) The image obtainment part **901** is configured to obtain a color image output by the front RGB camera **221** or the rear RGB camera **320**. When the autonomous vehicle **120** is moving in the forward direction, the image obtainment part **901** obtains a color image output by the front RGB camera **221**. When the autonomous vehicle **120** is moving in the backward direction, the image obtainment part **901** obtains a color image output by the rear RGB camera **320**. The image obtainment part **901** notifies the object recognition part **902** and the code recognition part **903** of the obtained color image.

(156) When the marking provided to the shelving unit **130** is recognizable based on a range image captured by the ToF camera **222**, the image obtainment part **901** may obtain the range image captured by the ToF camera **222**. For example, when the marking is a barcode, the marking can be recognized based on the range image (infrared image) output by the ToF camera **222**. When the image obtainment part **901** has obtained the range image, the image obtainment part **901** notifies the code recognition part **903** of the obtained range image.

(157) The object recognition part **902** is configured to recognize an object captured in the color image notified by the image obtainment part **901** based on a trained object recognition model (e.g., a trained neural network). Note that the object recognition model is trained to recognize a region corresponding to the shelving unit from an input image. The training data for the object recognition model is data obtained by providing captured color images of conveyance-target shelving units with labels indicating regions corresponding to shelving units. When the object recognition part **902** recognizes the shelving unit **130** from the color image, the object recognition part **902** notifies the code recognition part **903** and the position and posture controller **905** of recognition results indicating a region corresponding to the shelving unit **130**.

(158) The object recognition part **902** may recognize an object based on the range image captured by the ToF camera **222**. The object recognition part **902** may recognize an object based on a grayscale image output by a camera different from the front RGB camera **221** and the rear RGB camera **320**. Also, a stereo camera may be used for recognizing an object.

(159) The code recognition part **903** is configured to extract an image of a recognition target range of the marking, from the color image or the range image notified by the image obtainment part **901**. Before extracting an image, the code recognition part **903** may control the position and posture of the autonomous vehicle **120** such that the marking is readily recognized. The position and posture at which the marking is readily recognized is, for example, a position and posture at which the shelving unit **130** are capturable from the front. When the code recognition part **903** is notified of the recognition results from the object recognition part **902**, the code recognition part **903** extracts an image of the recognition target range of the marking, from the region corresponding to the shelving unit indicated in the recognition results.

(160) The recognition target range of the marking is a range in which the marking provided to the shelving unit **130** can be included. The recognition target range of the marking may be set in advance in accordance with the type of the shelving unit **130**. In the present embodiment, because the shelving unit **130** includes the marking on the underside of the bottom shelf **400**, an image may be extracted in a range of from the floor **240** to the height of the bottom shelf **400**.

(161) When the marking is a barcode, the code recognition part **903** binarizes the extracted image through thresholding or the like, and converts the image into a monochrome image. At this time, the code recognition part **903** may correct the image based on the internal parameters and the like of the camera before the binarization. This can remove, for example, lens distortion and the like.

(162) The code recognition part **903** recognizes the barcode from the monochrome image. When the code recognition part **903** recognizes the barcode, the code recognition part **903** notifies the identification information generation part **904** and the position and posture controller **905** of the recognition results indicating the position and value of the barcode. Note that when the markings include additional information indicating the outer dimensions and the like of the shelving part **130**, the code recognition part **903** notifies the specification identification part **907** of the recognition results of the barcode.
(163) When the marking is a numerical or character sequence, the code recognition part **903** recognizes the numerical or character sequence from the extracted image. The recognition of the numerical or character sequence can be performed, for example, through optical character recognition (OCR) or the like. When the code recognition part **903** recognizes the numerical or character sequence, the code recognition part **903** notifies the identification information generation part **904** and the position and posture controller **905** of the recognition results indicating the position and value of the numerical or character sequence.
(164) When the marking is a figure, the code recognition part **903** recognizes the figure from the extracted image. The recognition of the figure can be performed based on, for example, a trained object recognition model (e.g., a trained neural network). When the code recognition part **903** recognizes the figure, the code recognition part **903** obtains a predetermined value based on information on the figure. Examples of the information on the figure include the position, color, shape, size, and the like of the figure. The code recognition part **903** notifies the identification information generation part **904** and the position and posture controller **905** of the recognition results indicating the position of the figure and the obtained value.
(165) Note that the code recognition part **903** may obtain the value from, for example, information associating the figure-related information with the value. The information associating the figure-related information with the value may be stored in advance in the memory of the autonomous vehicle **120**. Further, the information associating the figure-related information with the value may be stored in an external server, and the value may be obtained from the external server based on the recognition results of the figure.
(166) The code recognition part **903** may recognize the two or more markings based on one image. The code recognition part **903** may recognize the two or more markings based on the two or more images captured at different angles of view. Therefore, the recognition results obtained by the code recognition part **903** may be: the recognition results of one or more markings recognized from the same image; or the recognition results of one or more markings that include one or more markings recognized from one image and one or more markings recognized from another image.
(167) Further, when limitation is imposed on the sequence of the barcode, the code recognition part **903** determines whether or not the recognized barcode satisfies the limitation. For example, when limitation is imposed on two barcodes disposed leftward and rightward such that the leftward barcode indicates a greater value than the rightward barcode, the code recognition part **903** determines whether or not the values of the two recognized barcodes satisfy the limitation. Also, for example, when limitation is imposed on the distance between the two barcodes, the code recognition part **903** determines whether or not the distance is within a predetermined range (e.g., the distance between the leftward barcode and the rightward barcode is a 100 mm or the like) by measuring the distance between the two barcodes through triangulation or the like. If the limitation is not satisfied (i.e., if the rightward barcode indicates a greater value than the value of the leftward barcode, or if the distance between the two barcodes is not in the predetermined range), the code recognition part **903** discards the recognition results as false recognitions.
(168) The identification information generation part **904** generates identification information based on the recognition results of the barcodes notified by the code recognition part **903**. The identification information generation part **904** generates identification information according to different rules in accordance with the number of barcodes indicated in the recognition results and

the number of digits of each value.

(169) When the recognition results indicate two 2-digit barcodes, it can be considered that the frontward barcodes **451** and **452** have been recognized. This situation may occur when the autonomous vehicle **120** is located at a position that is away from the shelving part **130** by a distance equal to or more than a certain distance. In this case, the identification information generation part **904** combines the values of the two barcodes to generate the last four digits of the identification information. At this time, the identification information generation part **904** stores the last four digits of the identification information in the memory of the autonomous vehicle **120**.

(170) When the recognition results indicate four barcodes, it can be considered that all of the barcodes **451** to **454** have been recognized. This situation may occur when the autonomous vehicle **120** is located at a position that is in a distance shorter than a certain distance from the shelving unit **130**. In this case, the identification information generation part **904** combines the values of three barcodes corresponding to the barcodes **451** to **453** to generate 8-digit identification information.

(171) When the recognition results indicate two 4-digit barcodes, it can be considered that the rearward barcodes **453** and **454** have been recognized. This situation may occur when the autonomous vehicle **120** has already entered below the bottom shelf **400** of the shelving unit **130**. In this case, the identification information generation part **904** combines the last four digits of the identification information stored in the memory of the autonomous vehicle **120** and the first four digits of the identification information corresponding to the barcode **453** to generate 8-digit identification information. At this time, the identification information generation part **904** notifies the identification information verification part **906** of the 8-digit identification information.

(172) The identification information generation part **904** identifies the shelving unit including the recognized barcodes based on the generated identification information. Specifically, the identification information generation part **904** identifies the shelving unit by collating the generated identification information with the "ID" of the shelving unit information stored in the conveyance target management table **900**. When the identification information generation part **904** generates the last four digits of the identification information, the identification information generation part **904** collates the last four digits with the last four digits of "ID". When the identification information generation part **904** generates 8-digit identification information, the identification information generation part **904** collates the 8-digit identification information with all of the digits of "ID".

(173) In the present embodiment, because the identification information is eight digits, the shelving unit cannot be accurately identified even if the collation is performed only with the last four digits. However, in terms of a limited number of shelving units present in the predetermined space **100** in which the autonomous vehicle **120** can perform conveyance, the shelving unit can be identified even with only the last four digits in many cases. For example, when there are two conveyance-target shelving units in the predetermined space **100**, the probability of overlapping of the last four digits between the shelving units is about 0.02%. For example, when there are ten conveyance-target shelving units in the predetermined space **100**, the probability of overlapping of the last four digits between the shelving units is about 1.1%. Even if a shelving unit having different first four digits of identification information is identified, when the autonomous vehicle **120** approaches the shelving unit **130** for docking, all of the barcodes can be recognized and collation of the 8-digit identification information can be performed.

(174) Further, when the shelving unit identified based on the identification information is the shelving unit identified as the conveyance target, the identification information generation part **904** notifies the position and posture controller **905** and the specification identification part **907** of the identification information. When the shelving unit cannot be identified based on the identification information or when the shelving unit identified based on the identification information is a shelving unit different from the shelving unit identified as the conveyance target, the identification information generation part **904** notifies the position and posture controller **905** of that result.

(175) The position and posture controller **905** estimates relative position and posture between the autonomous vehicle **120** and the shelving unit **130** based on the recognition results of the barcodes notified by the code recognition part **903**. When the recognition results indicate the positions of two barcodes, the position and posture controller **905** can calculate the distance between the autonomous vehicle **120** and the shelving unit **130** through triangulation using those positions.
(176) When the recognition results of the barcodes indicate the position of one barcode, the position and posture controller **905** may calculate the distance between the autonomous vehicle **120** and the shelving unit **130** through triangulation using the left end and the right end of the barcode.
(177) The position and posture controller **905** can calculate the deviation of the angle from the entry direction based on the positions of the two barcodes and the range image captured by the ToF camera **222**.
(178) Further, when the identification information is notified by the identification information generation part **904**, the position and posture controller **905** performs entry below the bottom shelf **400** of the shelving unit **130** based on the relative position and posture between the autonomous vehicle **120** and the shelving unit **130**. When the identification information generation part **904** notifies that the shelving unit cannot be identified, the position and posture controller **905** stops docking with the shelving unit identified as the conveyance target.
(179) Subsequently, the position and posture controller **905** performs control to change the position or posture of the autonomous vehicle **120** in order to search for the conveyance-target shelving unit **130**. Specifically, first, the position and posture controller **905** searches for another shelving unit present near the current position while changing the position or posture of the autonomous vehicle **120**. If another shelving unit has been found, the position and posture controller **905** returns the process to the code recognition part **903**, and recognizes the barcode of the found shelving unit. If the shelving unit can be identified with the last four digits of the identification information recognized from the found shelving unit, the autonomous vehicle **120** starts docking with that shelving unit.
(180) The identification information verification part **906** verifies the validity of the identification information notified by the identification information generation part **904**. The validity of the identification information may be verified based on: compliance with a numbering rule of identification information; the sequences of the barcodes satisfying a predetermined limitation; the distance between the barcodes being within a predetermined range; identification information being issued in an approved manner; or identification information indicating a shelving unit that the user is permitted to use.
(181) Note that the identification information verification part **906** does not need to verify that the sequences of the barcodes satisfy the predetermined limitation or that the distance between the barcodes is within the predetermined range if the code recognition part **903** has already determined this condition.
(182) The compliance with the numbering rule of the identification information is verified by calculating a checksum from the identification information. The checksum used for verification is set in, for example, additional information included in the marking provided to the shelving unit **130**.
(183) The fact that the identification information has been issued in an approved manner is verified based on shipping information managed by a manufacturer, a seller, a manager, or the like (hereinafter collectively referred to as a “manufacturer or the like”) of the autonomous vehicle or the shelving unit. The shipping information may be stored in the memory of the autonomous vehicle **120** or may be stored in a management system installed in the manufacturer or the like.
(184) The shipping information is managed, for example, as follows. First, the manufacturer or the like of the autonomous vehicle assigns a range of identification information for each stock keeping unit issued by the manufacturer or the like of the shelving unit. The manufacturer or the like of the shelving unit then assigns each of the manufactured shelving units with identification information

within the range assigned to the stock keeping unit. The identification information and the stock keeping unit assigned to the shelving unit are managed in a database by the manufacturer or the like of the autonomous vehicle. The manufacturer or the like of the autonomous vehicle distributes the shipping information extracted from the database to the autonomous vehicle **120**. The autonomous vehicle **120** may be configured to refer to the database via a network.

(185) The shipping information includes identification information for identifying a conveyance-target shelving unit, information indicating whether or not the shelving unit has already been shipped, and the like. In accordance with a usage form (e.g., a subscription service, rental, lease, or the like) in which the user of the shelving unit, the period of use, or the like is limited, information indicating the user intended to use the shelving unit, information indicating the period of use of the shelving unit, or the like may be included.

(186) When the shipping information is stored in the memory of the autonomous vehicle **120**, the identification information verification part **906** collates the identification information notified by the identification information generation part **904** with the identification information stored in the shipping information. When the identification information matches the identification information of the shipped shelving unit, the identification information verification part **906** determines that the identification information is valid. When the identification information does not match any identification information or matches the identification information of an unshipped shelving unit, the identification information verification part **906** determines that the identification information is invalid.

(187) When the shipping information includes information indicating the user or information indicating the expiration date of use, the identification information verification part **906** also verifies these pieces of information. For example, when the identification information is identification information of a shelving unit used by a user different from the user **110** or when the current date and time has passed the expiration date of use, the identification information verification part **906** determines that the identification information is invalid.

(188) When the shipping information is stored in the management system of the manufacturer or the like, the identification information verification part **906** connects to the management system via a communication network, and transmits a verification request of the identification information notified by the identification information generation part **904**, to the management system. The management system verifies the validity of the identification information by collating the received identification information with the shipping information.

(189) When the identification information indicates an unshipped shelving unit, the docking controller **804** stops docking with the shelving unit identified as the conveyance target. Subsequently, the controller **310** outputs an utterance for notifying that the identification information is invalid, to the user **110** via the loudspeakers **305** and **306**. For example, the controller **310** outputs an utterance saying "an invalid shelving unit has been found" to the user **110** via the loudspeakers **305** and **306**. The controller **310** may also output a voice for notifying the reason why the identification information is invalid, such as "shipping information of the shelving unit cannot be confirmed", "the identified shelving unit is used by a different user", or "the expiration date of use of the shelving unit has passed", in accordance with the verification result of the identification information verification part **906**.

(190) The controller **310** may display a notification that the identification information is invalid, on the information process terminal of the user **110**. For example, the controller **310** transmits a control signal for displaying a message, such as "an invalid shelving unit has been found" to the information process terminal of the user **110**. Similarly, the controller **310** may transmit a control signal for displaying the reason why the identification information is invalid, to the information process terminal of the user **110**.

(191) The specification identification part **907** is configured to identify the specification of the shelving unit **130**. The specification of the shelving unit **130** includes the shape and outer

dimensions of the shelving unit **130**. The shape of the shelving unit **130** includes, for example, the positions of the casters **431** to **434**. The specification identification part **907** notifies the invalid region setting part **908** of the specification of the identified shelving unit **130**.
(192) For example, the specification identification part **907** identifies the shape and outer dimensions of the shelving unit **130** by reading out "TYPE" and "DIMENSIONS" stored in the conveyance target management table **900** based on the identification information notified by the identification information generation part **904**. Note that the shape of the shelving unit **130** may be determined in advance in accordance with "TYPE" of the shelving unit **130**.
(193) For example, when the shape and outer dimensions of the shelving unit **130** are set in the additional information, the specification identification part **907** may identify the shape and outer dimensions of the shelving unit **130** by obtaining the shape and outer dimensions of the shelving unit **130** from the recognition results of the barcodes notified by the code recognition part **903**.
(194) The invalid region setting part **908** is configured to set a sensor invalid region in the measurement range of at least one of the LiDAR device **212**, the front RGB camera **221**, the rear RGB camera **320**, or the ToF camera **222** based on the type and outer dimensions of the shelving unit **130** notified by the specification identification part **907**. In a state in which the autonomous vehicle **120** is docked with the shelving unit **130**, a part of the shelving unit **130** (e.g., the casters **431** to **434**) may interfere with the measurement range of at least one of the LiDAR device **212**, the front RGB camera **221**, or the ToF camera **222**. In this case, the autonomous vehicle **120** falsely recognizes that an obstacle is present very near the shelving unit **130**, and cannot correctly determine a conveyance path. It is possible to avoid false recognition of an obstacle by invalidating the region of the measurement range with which a part of the shelving unit **130** may interfere, based on the type and outer dimensions of the shelving unit **130**.
(195) The sensor invalid region may be set in advance for each conveyance-target shelving unit. For example, the autonomous vehicle **120** stores, in the memory, information in which the identification information of the shelving unit and the sensor invalid region are associated with each other. The specification identification part **907** reads out information for setting the sensor invalid region from the memory based on the identification information notified by the identification information generation part **904**. The sensor invalid region may be defined, for example, with setting information of the sensor, conditions in relation to a recognition operation of the sensor, and the like.
(196) Further, for example, information in which the identification information of the shelving unit and the sensor invalid region are associated with each other may be stored in an external server, and the autonomous vehicle **120** may obtain the sensor invalid region of the shelving unit **130** from the external server based on the identification information notified by the identification information generation part **904**.
(197) The sensor invalid region may be set for each entry direction of each shelving unit. That is, for each shelving unit, a sensor invalid region upon entry from the front thereof and a sensor invalid region upon entry from the back thereof may be set.
(198) FIG. **15** is a view illustrating an example of the sensor invalid region set in the LiDAR device **212**. As illustrated in FIG. **15**, the LiDAR device **212** is disposed on the upper surface **210** of the autonomous vehicle **120**, and has a measurement range **600** in the front-rear direction (y-axis direction) and the width direction (x-axis direction). The invalid region setting part **908** estimates the positions of the casters **431** to **434** based on the type of the shelving unit **130**, and sets sensor invalid regions **611** to **614** corresponding to the casters **431** to **434**, respectively, in directions in which the LiDAR device **212** can detect the casters **431** to **434**.
(199) FIG. **16** is a view illustrating an example of the sensor invalid region set for the front RGB camera **221** or the rear RGB camera **320**. As illustrated in FIG. **16**, in the front RGB camera **221** or the rear RGB camera **320**, the angle of view of the camera is the measurement range **600**. The invalid region setting part **908** estimates the positions of the shelf and the casters based on the type

of the shelving unit **130**, and sets the sensor invalid region **615** in a region including the shelf **400** and the casters **431** and **433**.

(200) Similarly, the sensor invalid region can be set in the measurement ranges of the ToF camera **222** and the microphones **301** to **304**.

(201) The front RGB camera **221** or the rear RGB camera **320**, for which the sensor invalid region has been set, sets a pixel value of the sensor invalid region to an invalid value (e.g., zero) or to a pixel value therearound. The LiDAR device **212** or the ToF camera **222**, for which the sensor invalid region has been set, sets the measurement result of the sensor invalid region to an invalid value. Further, in the case in which the sensor invalid region is set for the front RGB camera **221**, the ToF camera **222**, or the rear RGB camera **320**, when the recognition result obtained by the object recognition part **902** is within the sensor invalid region, that recognition result may be rejected.

(202) Note that the invalid region setting part **908** may set the sensor invalid region based on the recognition result obtained by the object recognition part **902** instead of the sensor invalid region corresponding to the type of the shelving unit **130** identified based on the identification information. For example, when the object recognition part **902** recognizes the casters **431** to **434** of the shelving unit **130** from the color image, the sensor invalid region may be set in the measurement range with which the casters **431** to **434** may interfere. The invalid region setting part **908** may set the sensor invalid region by combining the positions of the casters estimated from the identification information with the positions of the casters recognized from the color image.

(203) <Flow of Autonomous Traveling Process>

(204) A flow of an autonomous traveling process by the autonomous vehicle **120** will be described next. FIG. **17** is a flowchart illustrating an example of the autonomous traveling process.

(205) In step S**1**, the conveyance instruction obtainment part **801** of the controller **310** obtains a conveyance instruction given by the user **110**. The conveyance instruction obtainment part **801** may obtain a voice instruction or an operation instruction.

(206) When the conveyance instruction obtainment part **801** obtains a voice instruction, the conveyance instruction obtainment part **801** recognizes a wake word uttered by the user **110** from the audio data detected by the microphones **301** to **304**, and analyzes the audio data detected following the recognized wake word. Note that the wake word is set in advance in the autonomous vehicle **120**, but the user **110** can change the wake word to a given word. Next, the conveyance instruction obtainment part **801** notifies the conveyance target identification part **802** and the conveyance destination identification part **805** of the voice instruction obtained as a result of analyzing the audio data.

(207) When the conveyance instruction obtainment part **801** obtains an operation instruction, the conveyance instruction obtainment part **801** receives a control signal from the information process terminal of the user **110** and analyzes the control signal. Next, the conveyance instruction obtainment part **801** notifies the conveyance target identification part **802** and the conveyance destination identification part **805** of the operation instruction obtained as a result of analyzing the control signal.

(208) In step S**2**, the conveyance target identification part **802** of the controller **310** recognizes an item or shelving unit to be conveyed, based on the conveyance instruction notified by the conveyance instruction identification part **801**. The conveyance destination identification part **805** of the controller **310** recognizes the position of the conveyance destination based on the conveyance instruction notified by the conveyance instruction obtainment part **801**. Thus, the controller **310** recognizes a task of conveying the item to the position of the conveyance destination.

(209) For example, when the conveyance instruction obtainment part **801** obtains a voice instruction, such as “Bring me the laptop”, the conveyance target identification part **802** recognizes a “laptop computer” as the item to be conveyed, and the conveyance destination identification part

805 recognizes a “position near the user **110**” as the position of the conveyance destination. Thus, the controller **310** recognizes the recognized task as a task of conveying the “laptop computer” to the “position near the user **110**”.
(210) When the conveyance destination is not designated by the conveyance instruction, the conveyance target identification part **802** may recognize a predetermined conveyance destination as the position of the conveyance destination. For example, the predetermined destination may be stored in advance in the memory of the autonomous vehicle **120**. Further, for example, the predetermined destination may be registered in advance in the conveyance target management table **900** from shelving unit to shelving unit or from item to item.
(211) At this time, the controller **310** may output a voice corresponding to the recognized task to the user **110** via the loudspeakers **305** and **306**. For example, when the controller **310** recognizes a task of conveying a “laptop computer”, which is the item to be conveyed, to a “position near the user **110**”, which is the position of the conveyance destination, the controller **310** outputs an utterance, such as “the laptop will be conveyed to the user” is output to the user **110** via the loudspeakers **305** and **306**.
(212) The controller **310** analyzes the audio data detected by the microphones **301** to **304** to determine a direction in which the user **110** has uttered the voice (in other words, a direction in which the user **110** is present).
(213) The controller **310** stores, in the memory, the determination result of the direction in which the user **110** is present, together with information indicating coordinates of the position of the autonomous vehicle **120** and the direction of the autonomous vehicle **120** on an environment map (e.g., a map of the predetermined space **100**) created in advance.
(214) In step S**3**, the conveyance target identification part **802** of the controller **310** identifies a conveyance-target shelving unit based on the task recognized in step S**2**. Specifically, if the conveyance-target shelving unit is identified in the task, the conveyance target identification part **802** identifies the conveyance-target shelving unit. Otherwise, the conveyance target identification part **802** refers to the conveyance target management table **900** and identifies, as a conveyance target, a shelving unit associated with an item to be conveyed. In the present embodiment, because the laptop computer is managed in association with the shelving unit **130**, the autonomous vehicle **120** identifies the shelving unit **130** as the conveyance target.
(215) In step S**4**, the conveyance target position identification part **803** of the controller **310** identifies coordinates indicating the position of the conveyance-target shelving unit by referring to the conveyance target management table **900**. For example, when the conveyance-target shelving unit is the shelving unit **130**, coordinates (x2, y2, θ2) of the “RELEASE POSITION” are identified as the position of the shelving unit **130**. This is because the coordinates (x2, y2, θ2) of the release position are the position at which the autonomous vehicle **120** released the docking with the shelving unit **130** last time, and thus the probability that the shelving unit **130** is present at that position is high.
(216) Note that the conveyance target position identification part **803** may identify coordinates (x1, y1, θ1) of the “INITIAL POSITION” in the conveyance target management table **900** as the coordinates indicating the position of the conveyance-target shelving unit.
(217) In step S**4**, the docking controller **804** of the controller **310** controls the drive wheels **231** to move the autonomous vehicle **120** to the position of the conveyance-target shelving unit **130**. At this time, the docking controller **804** detects obstacles using the front RGB camera **221**, the ToF camera **222**, and the LiDAR device **212**, and controls the autonomous vehicle **120** to move while avoiding collision with the detected obstacles.
(218) At this time, the autonomous vehicle **120** is not docked with the shelving unit **130**. Thus, the obstacle that would contact the shelving unit **130** if the shelving unit **130** were docked, is not recognized as an obstacle unless the obstacle contacts the autonomous vehicle **120**.
(219) In step S**6**, when the autonomous vehicle **120** reaches a position near the conveyance-target

shelving unit **130**, the conveyance target identification part **802** of the controller **310** analyzes the color image obtained from the front RGB camera **221** or the rear RGB camera **320** while moving the autonomous vehicle **120** and searches for the shelving unit **130**. Here, the description will be continued assuming that the conveyance target identification part **802** has found the shelving unit **130** as a result of the search.

(220) <<Conveyance Target Searching Process>>

(221) The process (step S**6** in FIG. **17**) in which the autonomous vehicle **120** searches for the conveyance-target shelving unit **130** will be described in more detail. FIG. **18** is a flowchart illustrating an example of the conveyance target searching process.

(222) In step S**6-1**, the image obtainment part **901** of the docking controller **804** obtains a color image output from the front RGB camera **221** or the rear RGB camera **320**. The image obtainment part **901** transmits the obtained color image to the object recognition part **902** and the code recognition part **903**.

(223) In step S**6-2**, the object recognition part **902** of the docking controller **804** receives the color image from the image obtainment part **901**. Next, the object recognition part **902** recognizes the object captured in the color image based on a trained object recognition model.

(224) In step S**6-3**, the object recognition part **902** of the docking controller **804** determines whether or not the shelving unit **130** is recognized from the color image (in other words, whether or not the recognition result includes a region corresponding to the shelving unit **130**). If the shelving unit **130** is recognized from the color image (YES), the object recognition part **902** transmits the recognition result of the shelving unit **130** to the code recognition part **903** and the position and posture controller **905**, and causes the process to proceed to step S**6-5**. When the shelving unit **130** is not recognized from the color image (NO), the object recognition part **902** causes the process to proceed to step S**6-4**.

(225) In step S**6-4**, the position and posture controller **905** of the docking controller **804** changes at least one of the position and the posture of the autonomous vehicle **120** such that a range captured by the front RGB camera **221** is changed. For example, the position and posture controller **905** controls the drive wheels **231** to move the autonomous vehicle **120** in the forward direction or in the backward direction. Further, for example, the position and posture controller **905** controls the drive wheels **231** to cause the autonomous vehicle **120** to make a turn.

(226) In step S**6-5**, the code recognition part **903** of the docking controller **804** receives the color image from the image obtainment part **901**. The code recognition part **903** receives the recognition result of the shelving unit **130** from the object recognition part **902**. Next, the code recognition part **903** extracts an image of a recognition target range of the barcode from the color image. Subsequently, the code recognition part **903** binarizes the extracted image through thresholding or the like, and converts the image into a monochrome image. The code recognition part **903** recognizes the barcode from the monochrome image.

(227) In step S**6-6**, the code recognition part **903** of the docking controller **804** determines whether or not the barcode is recognized from the monochrome image. If the barcode is recognized from the monochrome image (YES), the code recognition part **903** transmits the barcode recognition result to the identification information generation part **904** and the position and posture controller **905**. When the barcode is not recognized from the monochrome image (NO), the code recognition part **903** causes the process to proceed to step S**6-7**.

(228) In step S**6-7**, the position and posture controller **905** of the docking controller **804** receives the recognition result of the shelving unit **130** from the object recognition part **902**. Next, the position and posture controller **905** controls the drive wheels **231** to move the autonomous vehicle **120** to a position and posture at which the barcode of the shelving unit **130** can be recognized.

(229) Subsequently, the docking controller **804** executes steps S**6-5** and S**6-6** again at a new position. In this manner, the autonomous vehicle **120** repeatedly executes the movement of the position and the recognition of the barcode until the barcode is recognized.

(230) When the position and posture controller **905** recognizes the barcode, the position and posture control part **102** adjusts the entry direction of the autonomous vehicle **120** based on the barcode recognition result. For example, when an angle has been found to be deviated from the entry direction into the shelving unit **130** based on the barcode recognition result, the position and posture controller **905** performs control to change the position and posture of the autonomous vehicle **120** so as to face the shelving unit **130** straight.
(231) In step S**6-8**, the identification information generation part **904** of the docking controller **804** receives the barcode recognition result from the code recognition part **903**. Next, the identification information generation part **904** generates identification information based on the barcode recognition result.
(232) In step S**6-9**, the identification information generation part **904** of the docking controller **804** collates the identification information generated in step S**6-8** with the identification information stored in the conveyance target management table **900**. Next, the identification information generation part **904** determines whether or not the shelving unit **130** is uniquely identified. If the shelving unit **130** is uniquely identified (YES), the identification information generation part **904** transmits the identification information to the position and posture controller **905** and the specification identification part **907**, and causes the process to proceed to step S**6-11**. Note that the case in which the shelving unit **130** is uniquely identified includes a case in which the 8-digit identification information matches one shelving unit **130**. When the shelving unit **130** is not uniquely identified (NO), the identification information generation part **904** causes the process to proceed to step S**6-10**.
(233) In step S**6-10**, the identification information generation part **904** of the docking controller **804** determines whether or not all of the barcodes have been recognized. In other words, the identification information generation part **904** determines whether or not all of the digits of the identification information have been recognized (in the present embodiment, whether or not the recognized identification information is eight digits). When all of the barcodes have been recognized (in the present embodiment, when the identification information is eight digits) (YES), the identification information generation part **904** causes the process to proceed to step S**6-13**. When not all of the barcodes have been recognized (in the present embodiment, when the identification information is four digits) (NO), the identification information generation part **904** causes the process to proceed to step S**6-11**.
(234) In step S**6-11**, the position and posture controller **905** of the docking controller **804** controls the drive wheels **231** to move the autonomous vehicle **120** in the entry direction into the shelving unit **130**. Subsequently, the docking controller **804** executes steps S**6-5** to S**6-10** again at a new position. In this manner, the autonomous vehicle **120** repeatedly enters the shelving unit **130** and identifies the shelving unit **130** until the shelving unit **130** is identified.
(235) In step S**6-9**, although it is determined that the shelving unit **130** is uniquely identified when the 8-digit identification information matches one shelving unit **130**, it may be determined that the shelving unit **130** is uniquely identified when the last four digits of the identification information match one shelving unit **130**. In this case, before the execution of step S**6-12**, the autonomous vehicle **120** may be moved in the entry direction into the shelving unit **130**, and the recognition process of the remaining codes may be executed.
(236) In step S**6-12**, the identification information verification part **906** of the docking controller **804** receives the identification information from the identification information generation part **904**. Next, the identification information verification part **906** verifies the validity of the identification information. When the identification information is valid (YES), the identification information verification part **906** causes the process to proceed to step S**6-14**. When the identification information is invalid (NO), the identification information verification part **906** causes the process to proceed to step S**6-13**.
(237) In step S**6-13**, the controller **310** stops docking with the shelving unit identified as the

conveyance target. Next, the controller **310** outputs an utterance for notifying that the docking with the shelving unit **130** has failed, to the user **110** via the loudspeakers **305** and **306**. The controller **310** may transmit a control signal for displaying a message notifying that the docking has failed, to the information process terminal of the user **110**.
(238) In step S**6-14**, the specification identification part **907** of the docking controller **804** receives the barcode recognition result from the code recognition part **903**. The specification identification part **907** receives identification information from the identification information generation part **904**. Next, the specification identification part **907** identifies the specification of the shelving unit **130** based on the barcode recognition result or the identification information. The specification identification part **907** transmits the identified specification of the shelving unit **130** to the invalid region setting part **908**.
(239) In step S**6-14**, the invalid region setting part **908** of the docking controller **804** receives the specification of the shelving unit **130** from the specification identification part **907**. Next, the invalid region setting part **908** obtains information on a sensor invalid region to be set in the measurement range of at least one of the LiDAR device **212**, the front RGB camera **221**, the ToF camera **222**, or the rear RGB camera **320** based on the specification of the shelving unit **130**.
(240) The description will be made with reference to FIG. **17**. In step S**7**, the docking controller **804** of the controller **310** causes the autonomous vehicle **120** to enter below the bottom shelf **400** of the shelving unit **130** that has been found. The autonomous vehicle **120** may enter in the forward direction or may enter in the backward direction after turning 180 degrees. Note that the docking controller **804** recognizes the space below the bottom shelf **400** of the shelving unit **130** using the rear RGB camera **320** even while the autonomous vehicle **120** is entering in the backward direction, and the docking controller **804** controls the movement of the autonomous vehicle **120** while adjusting the positional relationship with the bottom shelf **400**.
(241) In step S**8**, the docking controller **804** of the controller **310** determines that the locking device **211** has moved to a position at which the locking device **211** can be engaged with the projection **440**.
(242) When the autonomous vehicle **120** moves to a position at which the locking device **211** can be engaged with the projection **440**, the docking controller **804** turns off the solenoid to move the locking device **211** upward and engage the locking device **211** with the projection **440**. Thus, the autonomous vehicle **120** completes docking with the conveyance-target shelving unit **130**.
(243) When the docking is completed, the docking controller **804** updates the coordinates indicating “DOCKING POSITION”, stored in the conveyance target management table **900**, to the coordinates of the position at which the conveyance-target shelving unit **130** is actually docked.
(244) For example, when docking with the conveyance-target shelving unit **130** is performed at the position of coordinates (x4, y4, θ4), the docking controller **804** updates the coordinates (x3, y3, θ3) to (x4, y4, θ4) regarding “DOCKING POSITION” of the shelving unit **130** in the conveyance target management table **900**.
(245) In step S**9**, the invalid region setting part **908** of the controller **310** sets the sensor invalid region in the measurement range of at least one of the LiDAR device **212**, the front RGB camera **221**, the ToF camera **222**, or the rear RGB camera **320** based on the information on the sensor invalid region obtained in step S**6-14**.
(246) In step S**10**, the conveyance destination position identification part **806** of the controller **310** identifies the coordinates of the position of the conveyance destination of the docked shelving unit **130** based on the task recognized in step S**2**. For example, in the case of a task of conveying a “laptop computer” to a “position near the user **110**”, the conveyance destination position identification part **806** identifies coordinates indicating a position near the user **110** as coordinates indicating the position of the conveyance destination of the docked shelving unit **130**.
(247) When the position near the user **110** is identified as the position of the conveyance destination, the conveyance destination position identification part **806** estimates the position at

which the user **110** is highly likely to be present, based on the information stored in the memory in step S**2**. The conveyance destination position identification part **806** also identifies coordinates, on the environment map, indicating a position near the estimated position. The information stored in the memory in step S**2** is the coordinates indicating the position of the autonomous vehicle **120** on the environment map, the information indicating the orientation of the autonomous vehicle **120**, and the determination result of the direction in which the user **110** is present.

(248) In step S**11**, the conveyance controller **807** of the controller **310** controls the drive wheels **231** to move the autonomous vehicle **120** to the position of the conveyance destination (a position near the user **110**). At this time, the conveyance controller **807** detects obstacles using the front RGB camera **221**, the ToF camera **222**, and the LiDAR device **212**, and controls the autonomous vehicle **120** to move while avoiding collision with the detected obstacles.

(249) At this time, the autonomous vehicle **120** is already docked with the shelving unit **130**. Thus, the autonomous vehicle **120** moves while avoiding not only the obstacles that contact the autonomous vehicle **120**, but also the obstacles that do not contact the autonomous vehicle **120** but contact the shelving unit **130**. At this time, the autonomous vehicle **120** determines whether or not there is a contact with another object in the width direction, the front-rear direction, and the height direction in consideration of the specification of the shelving unit **130** identified by the specification identification part **907**. Thus, the autonomous vehicle **120** can determine a conveyance path while avoiding the obstacles with high accuracy.

(250) In step S**12**, the docking controller **804** of the controller **310** releases the docking at the time of reaching the position of the conveyance destination (e.g., a position near the user **110**). The docking controller **804** updates the coordinates indicating the "RELEASE POSITION", stored in the conveyance target management table **900**, to the coordinates of the position at which the docking with the conveyance-target shelving unit **130** is actually released.

(251) For example, when the docking with the conveyance-target shelving unit **130** is released at the position of coordinates (x5, y5, θ5), the docking controller **804** updates the coordinates (x2, y2, θ2) to (x5, y5, θ5) regarding "RELEASE POSITION" of the shelving unit **130** in the conveyance target management table **900**.

(252) Note that the docking controller **804** may search for the user **110** by analyzing a color image obtained from the front RGB camera **221** at the time of reaching the position of the conveyance destination. When the user **110** can be searched for, the docking controller **804** may release the docking.

(253) In step S**13**, the conveyance controller **807** of the controller **310** confirms the presence or absence of a forward or backward obstacle using the front RGB camera **221**, the ToF camera **222**, and the LiDAR device **212**. Then, the conveyance controller **807** causes the autonomous vehicle **120** to exit the space below the bottom shelf **400** of the shelving unit **130** in whichever direction (in the forward direction or in the backward direction) is free of obstacles.

(254) When there are obstacles in both forward and backward directions, the conveyance controller **807** causes the autonomous vehicle **120** to stand by for a certain period of time, and confirms again whether or not there is an obstacle in a forward or backward direction. That is, the conveyance controller **807** alternately repeats the standby and the confirmation of the presence or absence of an obstacle in the front-rear direction.

(255) Note that when it is confirmed that there are obstacles in both forward and backward directions even after repeating the confirmation and the standby a predetermined number of times, the conveyance controller **807** may cause the autonomous vehicle **120** to stand by on the spot. In the above description, the presence or absence of a forward or backward obstacle is confirmed after the release of docking. However, the autonomous vehicle **120** may be configured to stand by on the spot or exit the space in a predetermined direction immediately after the release of docking without confirming the presence or absence of an obstacle.

MODIFIED EXAMPLES

(256) In the above embodiment, the conveyance target conveyed by the autonomous vehicle **120** is a caster-equipped shelving unit on which items or the like are placed. However, for example, the conveyance target may be a pot with casters, a home appliance with casters, or the like.
(257) In the above embodiment, the autonomous vehicle **120** is docked with the caster-equipped shelving unit and conveys the caster-equipped shelving unit. However, the autonomous vehicle **120** may convey a conveyance target without docking therewith. For example, the autonomous vehicle **120** may be a robot including an arm and configured to convey the conveyance target by pushing, pulling, gripping, lifting, or the like using the arm and the like. The robot may be a robot configured to tow or lift, thereby conveying the conveyance target.
(258) In the above embodiment, the autonomous vehicle **120** is an automatic guided vehicle configured to convey an item used by the user **110** to be within a grasping distance of the user **110** in response to a conveyance instruction given by the user **110**. However, the task executed by the autonomous vehicle **120** is not limited to the conveyance of an item. The autonomous vehicle **120** may be, for example, a household robot configured to perform household tasks, such as cleaning, a transport robot configured to transport luggage, equipment, and the like in a factory, a warehouse, or the like, an automatic vehicle configured to travel on a public or private road, a transport drone configured to fly while holding an item or the like.
(259) In the above embodiment, the marking provided to the shelving unit **130** is a total of four barcodes, i.e., two frontward ones and two rearward ones in the traveling direction. However, the number and disposition of the codes for the marking are not limited to these. For example, the marking may be only two frontward barcodes in the traveling direction. Further, for example, the marking may be one frontward barcode and one rearward barcode in the traveling direction.
(260) In the above embodiment, the two barcodes disposed frontward in the traveling direction and arranged in the direction intersecting the traveling direction are such that the rightward one is the third and fourth digits from the back of the identification information and the leftward one is the first and second digits from the back of the identification information, but these may be reversed. That is, the rightward barcode may be the first and second digits from the back of the identification information, and the leftward barcode may be the third and fourth digits from the back of the identification information.
(261) In the above embodiment, the autonomous vehicle **120** controls the conveyance of the shelving unit **130** by the autonomous vehicle **120** based on the identification information of the shelving unit **130**. The control of the conveyance based on the identification information is a concept including the following as a non-limiting example. For example, the control includes determining, based on the identification information, whether or not the conveyance target is one identified based on the instruction of the user and conveying the conveyance target if the conveyance target is the identified one, and otherwise not conveying the conveyance target. Also, for example, the control includes not only the control during the conveyance but also the control related to the determination as to whether to convey. Further, for example, the control includes changing the conveyance condition based on the identification result. An example of the control of changing the conveyance condition is setting of a sensor invalid region.
(262) In the above embodiment, the barcode is used as the marking provided to the conveyance target. However, the marking is not limited to the barcode. Given markings may be set such that the quantity of information obtained from a rearward marking in the entry direction is greater than the quantity of information obtained from a frontward marking in the entry direction. Such a marking may be provided to a conveyance target to be conveyed by means different from docking. That is, the same concept is applicable to an autonomous vehicle configured to convey a conveyance target by means different from docking.
(263) In the above embodiment, the sensor invalid region identified based on the marking recognition result is set. However, the mode of the sensor invalid region may be changed in accordance with the marking recognition result. In this case, two or more modes in relation to the

setting of the sensor invalid region may be set in advance, and one of the modes may be selected in accordance with the marking recognition result.
(264) In the above embodiment, the sensor invalid region is set based on the marking recognition result. However, the setting other than the sensor invalid region may be changed as the conveyance condition. Examples of the conveyance condition other than the sensor invalid region include a sensor used during conveyance, an object recognition method, a conveyance speed, and the like.
(265) In the above embodiment, the conveyance condition is changed based on the marking recognition result. However, the conveyance condition may be changed based on identification information based on one other than the marking. An example of the identification information based on one other than the marking is an electronic device capable of transmitting information, such as radio frequency identification (RFID). That is, an electronic device capable of transmitting information may be built in the conveyance target, and the conveyance condition of the conveyance target may be changed based on the result obtained by recognizing the electronic device with the autonomous vehicle.
(266) In the above embodiment, all of the two or more markings provided to the conveyance target are of the same type. However, two or more markings including two or more types of markings may be provided to the conveyance target. For example, the frontward marking in the entry direction may be a barcode, and the rearward marking in the entry direction may be a two-dimensional code. Even when the frontward marking and the rearward marking are of different types, the quantity of information expressed by the frontward marking may be set to be smaller than the quantity of information expressed by the rearward marking.
(267) In the above embodiment, the validity of the conveyance target is verified based on the marking recognition result. However, the validity of the conveyance target may be verified based on the object recognition result in addition to the marking recognition result.
SUMMARY
(268) As is clear from the above description, the autonomous vehicle **120** according to the embodiment includes the one or more sensors configured to obtain one or more images of the conveyance target that includes one or more markings, and the controller **310** configured to control the autonomous vehicle **120**. The controller **310** identifies the conveyance target based on the recognition result of the one or more markings included in the one or more images, and controls the conveyance of the conveyance target by the autonomous vehicle **120** based on the identification result of the conveyance target.
(269) The autonomous vehicle **120** according to the embodiment is an autonomous vehicle configured to convey the conveyance target, and may include: a camera configured to obtain an image of the conveyance target; and a controller configured to identify the conveyance target based on two or more markings recognized from the image.
(270) The controller **310** may determine whether or not the conveyance target is a conveyance target identified based on the instruction given by the user, based on the identification result.
(271) The one or more markings may be disposed at positions at which the one or more images can be obtained using the sensor in the traveling direction in which the autonomous vehicle **120** brings the conveyance target into a conveyable state. The one or more markings may include: one or more markings disposed frontward in the traveling direction; and one or more markings disposed rearward in the traveling direction. The quantity of information obtained by recognizing the one or more markings disposed rearward in the traveling direction may be greater than the quantity of information obtained by recognizing the one or more markings disposed frontward in the traveling direction.
(272) The controller **310** may determine whether or not the conveyance target matches the conveyance target identified using the recognition result of the one or more markings disposed frontward, and then determine whether or not the conveyance target matches the conveyance target identified using the recognition result of the one or more markings disposed rearward.

(273) The controller **310** may determine whether to continue the control for causing the autonomous vehicle **120** to bring the conveyance target into a conveyable state, based on the recognition result of the one or more markings disposed frontward. The controller **310** may determine whether to continue the control for causing the autonomous vehicle **120** to bring the conveyance target into a conveyable state, based on the recognition result of the one or more markings disposed rearward.
(274) The controller **310** may recognize a positional relationship with the conveyance target based on the recognition result of the one or more markings disposed frontward, and may perform control to move the autonomous vehicle in the traveling direction based on the positional relationship.
(275) The one or more markings may include information other than the identification information of the conveyance target, and the controller **310** may control the conveyance of the conveyance target by the autonomous vehicle **120** using the information other than the identification information.
(276) The controller **310** may partially invalidate data obtained by the one or more sensors included in the autonomous vehicle **120** based on the recognition result of the one or more markings, and may convey the conveyance target using the partially invalidated data. When a part of the conveyance target is in the measurement range of the one or more sensors, the controller **310** may invalidate data corresponding to the part of the conveyance target. The one or more sensors may be a sensor configured to obtain one or more images, a ToF camera, a LiDAR sensor, and a microphone.
(277) The controller **310** may verify the validity of the identification information. The controller **310** may verify the validity by collating the identification information with the registered identification information of the conveyance target. The one or more markings may include a first marking and a second marking, and the controller **310** may verify the validity based on at least one of a relationship between information obtained by recognizing the first marking and information obtained by recognizing the second marking, and a distance between the first marking and the second marking.
(278) The autonomous vehicle **120** may dock with the conveyance target and convey the conveyance target.
(279) The display medium according to the embodiment is a display medium configured for a conveyance target to be conveyed by the autonomous vehicle **120** to include one or more markings. The one or more markings are formed on the display medium and include identification information of the conveyance target. The identification information is used for control of conveyance of the conveyance target by the autonomous vehicle **120**.
(280) The display medium according to the embodiment may be a display medium configured for the conveyance object to include: one or more markings disposed frontward in the traveling direction in which the autonomous vehicle **120** brings the conveyance object into a conveyable state; and one or more markings disposed rearward in the traveling direction in which the autonomous vehicle **120** brings the conveyance object into the conveyable state. The quantity of information obtained by the autonomous vehicle **120** that recognizes the one or more markings disposed rearward in the traveling direction may be greater than the quantity of information obtained by the autonomous vehicle **120** that recognizes the one or more markings disposed frontward in the traveling direction.
(281) The display medium according to the embodiment may be a display medium configured for the conveyance target to include: a first marking and a second marking as the one or more markings disposed frontward; and a third marking and a fourth marking as the one or more markings disposed rearward. The first marking and the third marking are arranged along the traveling direction, and the second marking and the fourth marking are arranged along the traveling direction. The first marking and the second marking are arranged along a direction intersecting the traveling direction, and the third marking and the fourth marking are arranged along the direction

intersecting the traveling direction.
(282) The display medium according to the embodiment may be a display medium configured for the conveyance target to include one or more markings disposed frontward and one or more markings disposed rearward in a second traveling direction that is opposite to the traveling direction and in which the autonomous vehicle **120** brings the conveyance object into a state conveyable.
(283) The conveyance object according to the embodiment is a conveyance object to be conveyed by the autonomous vehicle **120**. The conveyance object includes one or more markings. The one or more markings include identification information of the conveyance object. The identification information is used for control of conveyance of the conveyance object by the autonomous vehicle **120**.
(284) The conveyance object according to the embodiment may include one or more markings disposed frontward and one or more markings disposed rearward in a direction for the autonomous vehicle **120** to be in a state capable of conveying the conveyance object. The quantity of information obtained by the autonomous vehicle **120** that recognizes the one or more markings disposed rearward may be greater than the quantity of information obtained by the autonomous vehicle **120** that recognizes the one or more markings disposed frontward.
(285) The conveyance object according to the embodiment may include: a first marking and a second marking as the one or more markings disposed frontward; and a third marking and a fourth marking as the one or more markings disposed rearward. The first marking and the third marking are arranged along the traveling direction, and the second marking and the fourth marking are arranged along the traveling direction. The first marking and the second marking are arranged along a direction intersecting the traveling direction, and the third marking and the fourth marking are arranged along the direction intersecting the traveling direction.
(286) The conveyance object according to the embodiment may include one or more markings disposed frontward and one or more markings disposed rearward in a second traveling direction that is opposite to the traveling direction and in which the autonomous vehicle **120** brings the conveyance object into a state conveyable.
(287) The two or more markings may indicate different information. The markings may be such that the quantity of the information of at least one marking is different from the quantity of the information of another marking. The markings may indicate identification information for identifying the conveyance target. The markings may include information indicating a shape of the conveyance target. The information indicating the shape of the conveyance target includes at least one of the shape or the outer dimensions of the conveyance target, and may include other information.
(288) The two or more markings may be displayed at predetermined positions of the conveyance target. The markings may be arranged at positions that are capturable by the front RGB camera **221** or the rear RGB camera **320** in the entry direction in which the autonomous vehicle **120** brings the shelving unit **130** into a conveyable state.
(289) The two or more markings may include a first marking and a second marking. The first marking and the second marking may be arranged along the entry direction. The first marking and the second marking may be arranged along a direction intersecting the entry direction. The quantity of information of the second marking may be greater than the quantity of information of the first marking.
(290) The two or more markings may include a first marking, a second marking, a third marking, and a fourth marking. The first marking and the second marking may be arranged along the entry direction, and the third marking and the fourth marking may be arranged along the entry direction. The first marking and the third marking may be arranged along a direction intersecting the entry direction, and the second marking and the fourth marking may be arranged along a direction intersecting the entry direction.

(291) The quantity of information of the third marking may be greater than the quantity of information of the first marking. The quantity of information of the fourth marking may be greater than the quantity of information of the second marking.
(292) The controller **310** included in the autonomous vehicle **120** may cause the autonomous vehicle **120** to travel in the entry direction upon recognizing the first marking and the second marking, and may generate identification information based on the two or more markings upon recognizing the third marking and the fourth marking from the image. The controller **310** included in the autonomous vehicle **120** may recognize the one or more markings disposed frontward in the entry direction and the one or more markings disposed rearward in the entry direction, and may control the autonomous vehicle **120** to move so as to bring the conveyance target into a conveyable state.
(293) The controller **310** included in the autonomous vehicle **120** may recognize a positional relationship with the shelving unit **130** based on the first marking and the second marking, and may control the autonomous vehicle **120** to move in the entry direction based on the positional relationship. The controller **310** may recognize the positional relationship through triangulation using the first marking and the second marking.
(294) The controller **310** included in the autonomous vehicle **120** may convey the shelving unit **130** based on the information of the shelving unit **130** identified based on the two or more markings. The information of the shelving unit **130** may be information indicating the shape of the shelving unit **130**. The information of the shelving unit **130** may be information in relation to processing of an image.
(295) The autonomous vehicle **120** may further include a sensor configured to obtain data in relation to an object within a measurement range. When a part of the shelving unit **130** is in the measurement range, the controller **310** may invalidate data in relation to the position of that part of the shelving unit **130** based on the information of the shelving unit **130**. The sensor may be a camera, a ToF camera, a LiDAR device, and a microphone.
(296) The controller **310** included in the autonomous vehicle **120** may verify the validity of the identification information. The controller **310** may collate the identification information with the registered identification information of the shelving unit **130**.
(297) The conveyance object according to the embodiment is the shelving unit **130** to be conveyed by the autonomous vehicle **120**, and includes two or more markings displayed at positions that are capturable by a camera included in the autonomous vehicle **120** in the entry direction of the autonomous vehicle **120**.
(298) The display medium according to the embodiment includes a marking displayed, in the shelving unit **130** to be conveyed by the autonomous vehicle **120**, at a position that is capturable by a camera included in the autonomous vehicle **120** in the entry direction of the autonomous vehicle **120**.
(299) Thus, according to an embodiment of the present disclosure, it is possible to provide an autonomous vehicle that can readily obtain information on the conveyance target.
(300) Therefore, according to an embodiment of the present disclosure, the shape, the outer dimensions, and the like of the conveyance target can be identified. Thus, even if the autonomous vehicle **120** is docked with the shelving unit **130**, it is possible to avoid collision with surrounding objects and efficiently convey the conveyance target.
(301) Further, according to an embodiment of the present disclosure, the invalid region is set in the information obtained by the sensor based on information (e.g., specification and the like) in relation to the conveyance target. Thus, after the shelving unit **130** is detected by the sensor, an appropriate operation can be executed.
(302) According to an embodiment of the present disclosure, unique identification information is assigned to the conveyance-target shelving unit.
(303) Thus, it is verified whether or not the identification information is valid, and a false

counterfeit or the like can be detected.
(304) Further, according to an embodiment of the present disclosure, the intended concept can be realized by displaying the optically recognizable marking on the conveyance target. Thus, it is possible to identify the conveyance target conveniently and inexpensively.
OTHER EMBODIMENTS
(305) A part or all of the controller **310** in the above-described embodiment may be configured by hardware, or may be configured by information processing of software (program) executed by a central processing unit (CPU), a graphics processing unit (GPU), or the like. In the case of being configured by information processing of software, software that realizes at least a part of the functions of the controller **310** in the above-described embodiment may be stored in a non-transitory storage medium, such as a compact disc-read only memory (CD-ROM), a universal serial bus (USB) memory, or the like, and at least one processor may read the software to execute information processing of the software. The software may be downloaded via a communication network. Furthermore, all or a part of the processing of software may be implemented in a circuit, such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), or the like, and information processing by the software may be executed by hardware.
(306) The storage medium storing the software may be a removable medium, such as an optical disk, or a fixed storage medium, such as a hard disk or a memory. The storage medium may be provided in the interior of the controller **310** (a main storage device, an auxiliary storage device, or the like), or may be provided in the controller **310**.
(307) FIG. **19** is a block diagram illustrating an example of the hardware configuration of the controller **310**. The controller **310** may be implemented, for example, as a computer that includes a processor **701**, a main storage device **702** (memory), an auxiliary storage device **703** (memory), a network interface **704**, and a device interface **705**, which are connected via a bus **706**.
(308) The controller **310** of FIG. **19** includes each of components by one, but may include two or more same components.
(309) Various calculations of the controller **310** may be executed by parallel processing using one or more processors or using two or more computers connected via a network. Further, various calculations may be distributed to two or more calculation cores in the processor **701** and executed by parallel processing. In addition, a part or all of the processes, means, and the like of the present disclosure may be realized by at least one of a processor and a storage device provided on the Cloud capable of communicating with the controller **310** via the network interface **704**.
(310) The processor **701** may be an electronic circuit (a process circuit, a processing circuit, a processing circuitry, a CPU, a GPU, a FPGA, an ASIC, or the like) that performs at least one of control and calculation of the controller **310**. The processor **701** may be a general-purpose processor, a dedicated processing circuit designed to execute a specific calculation, and a semiconductor device including both the general-purpose processor and the dedicated processing circuit. The processor **701** may include an optical circuit or may include a calculation function based on quantum computing.
(311) The processor **701** may perform calculation based on data or software input from each device or the like of the internal configuration of the controller **310**, and may output a calculation result or a control signal to each device or the like. The processor **701** may control each component of the controller **310** by executing an operating system (OS) of the controller **310**, an application, or the like.
(312) The controller **310** may be implemented by one or more processors **701**. The processor **701** may refer to one or more electronic circuits disposed on one chip, or may refer to one or more electronic circuits disposed on two or more chips or two or more devices. When two or more electronic circuits are used, the electronic circuits may communicate with each other in a wired or wireless manner.
(313) The main storage device **702** may store instructions for executing the processor **701**, various

data, and the like, and information stored in the main storage device **702** may be read out by the processor **701**. The auxiliary storage device **703** is a storage device other than the main storage device **702**. Note that these storage devices mean given electronic components capable of storing electronic information, and may be semiconductor memories. The semi-conductor memory may be either a volatile memory or a non-volatile memory. The storage device for storing various data and the like in the controller **310** in the above-described embodiment may be realized by the main storage device **702** or the auxiliary storage device **703**, or may be realized by an internal memory built in the processor **701**. For example, the conveyance target storage part **810** or the environment map storage part **811** in the above-described embodiment may be realized by the main storage device **702** or the auxiliary storage device **703**.
(314) When the controller **310** is configured by at least one storage device (memory) and at least one processor connected (coupled) to the at least one storage device, at least one processor may be connected to one storage device. At least one storage device may be connected to one processor.
(315) Further, the configuration may include a configuration in which at least one processor of the two or more processors is connected to at least one storage device of the two or more storage devices. A configuration in which the storage device is integrated with the processor (e.g., cache memories including a L1 cache and a L2 cache) may be included.
(316) The network interface **704** is an interface for connecting to a communication network **740** in a wireless or wired manner. The network interface **704** may be an appropriate interface, such as an interface conforming to an existing communication standard. The network interface **704** may exchange information with an external device **730** connected via the communication network **740**. The communication network **740** may be, for example, a wide area network (WAN), a local area network (LAN), a personal area network (PAN), or any combination thereof, and may be a given network in which information is exchanged between the controller **310** and the external device **730**. Examples of the WAN include the Internet and the like. Examples of the LAN include IEEE802.11, Ethernet (registered trademark), and the like. Examples of the PAN include Bluetooth (registered trademark), near field communication (NFC), and the like.
(317) The device interface **705** is an interface, such as a USB that is directly connected to an external device **750**.
(318) An external device **730** is a device connected to the controller **310** via a network. The external device **730** may be, for example, an information process terminal of the user **110** or an external server that stores various information used by the autonomous vehicle **120**. The external device **750** is a device that is directly connected to the controller **310**.
(319) The external device **730** or the external device **750** may be, for example, an input device. The input device is, for example, a device, such as a camera, a microphone, a motion capture, various sensors, a keyboard, a mouse, a touch panel, or the like, and provides obtained information to the controller **310**. The external device **730** or the external device **750** may also be, for example, a device including an input part, a memory, and a processor, such as a personal computer, a tablet terminal, a smartphone, or the like.
(320) In the present embodiment, the input device is an electronic device, such as a camera (the front RGB camera **221**, the ToF camera **222**, or the rear RGB camera **320**), a microphone (the microphones **301** to **304**), various sensors (the LiDAR device **212**), or the like, and gives obtained information to the controller **310**.
(321) The external device **730** or the external device **750** may be a storage device (memory). For example, the external device **730** may be a network storage or the like, and the external device **750** may be a storage, such as an HDD or the like.
(322) The external device **730** or the external device **750** may be a device having a function of a part of the components of the controller **310**. That is, the controller **310** may transmit a part or all of the processing results to the external device **730** or the external device **750**, or may receive a part or all of the processing results from the external device **730** or the external device **750**.

(323) In the present specification (including the claims), if the expression “at least one of a, b, and c” or “at least one of a, b, or c” is used (including similar expressions), any one of a, b, c, a-b, a-c, b-c, or a-b-c is included. Multiple instances may also be included in any of the elements, such as a-a, a-b-b, and a-a-b-b-c-c. Further, the addition of another element other than the listed elements (i.e., a, b, and c), such as adding d as a-b-c-d, is included.
(324) In the present specification (including the claims), in a case in which an expression such as “data as an input”, “using data”, “based on data”, “according to data”, or “in accordance with data” (including similar expressions) is used, such a case may, unless otherwise noted, encompass a case in which data themselves are used and a case in which data obtained by processing data (e.g., data obtained by adding noise, normalized data, feature extracted from data, and intermediate representation of data) are used. If it is described that any result can be obtained “based on data as an input”, “using data”, “based on data”, “according to data”, or “in accordance with data” (including similar expressions), unless otherwise noted, a case in which the result is obtained based on only the data is included, and a case in which the result is obtained affected by another data other than the data, factors, conditions, and/or states is included. If it is described that “data are output” (including similar expressions), unless otherwise noted, a case in which data themselves are used as an output is included, and a case in which data obtained by processing data in some way (e.g., data obtained by adding noise, normalized data, feature extracted from data, and intermediate representation of various data) are used as an output is included.
(325) In the present specification (including the claims), if the terms “connected” and “coupled” are used, the terms are intended as non-limiting terms that include any of direct, indirect, electrically, communicatively, operatively, and physically connected/coupled. Such terms should be interpreted according to a context in which the terms are used, but a connected/coupled form that is not intentionally or naturally excluded should be interpreted as being included in the terms without being limited.
(326) In the present specification (including the claims), if the expression “A configured to B” is used, a case in which a physical structure of the element A has a configuration that can perform the operation B, and a permanent or temporary setting/configuration of the element A is configured/set to actually perform the operation B may be included. For example, if the element A is a general-purpose processor, the processor may have a hardware configuration that can perform the operation B and be configured to actually perform the operation B by setting a permanent or temporary program (i.e., an instruction). If the element A is a dedicated processor or a dedicated arithmetic circuit, a circuit structure or the like of the processor may be implemented so as to actually perform the operation B irrespective of whether the control instruction and the data are actually attached.
(327) In the present specification (including the claims), if a term indicating containing or possessing (e.g., “comprising/including” and “having”) is used, the term is intended as an open-ended term, including an inclusion or possession of an object other than a target object indicated by the object of the term. If the object of the term indicating an inclusion or possession is an expression that does not specify a quantity or that suggests a singular number (i.e., an expression using “a” or “an” as an article), the expression should be interpreted as being not limited to a specified number.
(328) In the present specification (including the claims), even if an expression such as “one or more” or “at least one” is used in a certain description, and an expression that does not specify a quantity or that suggests a singular number (i.e., an expression using “a” or “an” as an article) is used in another description, it is not intended that the latter expression indicates “one”. Generally, an expression that does not specify a quantity or that suggests a singular number (i.e., an expression using “a” or “an” as an article) should be interpreted as being not necessarily limited to a particular number.
(329) In the present specification, if it is described that a particular advantage/result is obtained in a particular configuration included in an embodiment, unless there is a particular reason, it should be

understood that that the advantage/result may be obtained in another embodiment or other embodiments including the configuration. It should be understood, however, that the presence or absence of the advantage/result generally depends on various factors, conditions, states, and/or the like, and that the advantage/result is not necessarily obtained by the configuration. The advantage/result is merely an advantage/result that results from the configuration described in the embodiment when various factors, conditions, and/or states are satisfied, and is not necessarily obtained in the claimed invention that defines the configuration or a similar configuration.
(330) In the present specification (including the claims), if multiple hardware performs predetermined processes, each of the hardware may cooperate to perform the predetermined processes, or some of the hardware may perform all of the predetermined processes. Additionally, some of the hardware may perform some of the predetermined processes while other hardware may perform the remainder of the predetermined processes. In the present specification (including the claims), if an expression such as "one or more hardware perform a first process and the one or more hardware perform a second process" (including similar expressions) is used, the hardware that performs the first process may be the same as or different from the hardware that performs the second process. That is, the hardware that performs the first process and the hardware that performs the second process may be included in the one or more hardware. The hardware may include an electronic circuit, a device including an electronic circuit, or the like.
(331) In the present specification (including the claims), if multiple storage devices (memories) store data, each of the multiple storage devices may store only a portion of the data or may store an entirety of the data. Also, a configuration in which some of the multiple storage devices store data may be included.
(332) Although the embodiments of the present disclosure have been described in detail above, the present disclosure is not limited to the individual embodiments described above. Various additions, modifications, substitutions, partial deletions, and the like may be made without departing from the conceptual idea and spirit of the invention derived from the contents defined in the claims and the equivalents thereof. For example, in the embodiments described above, when numerical values or mathematical formulae are used for description, these are used for illustrative purposes and do not limit the scope of the present disclosure. Additionally, the orders of operations described in the embodiments are illustrative and do not limit the scope of the present disclosure.

Claims

1. An autonomous vehicle, comprising: one or more sensors configured to obtain one or more images of a conveyance target that includes one or more markings; and a controller configured to control the autonomous vehicle, the controller including one or more processors, and one or more memories storing one or more programs, which when executed, cause the one or more processors to: identify the conveyance target based on a recognition result of the one or more markings included in the one or more images, and control conveyance of the conveyance target by the autonomous vehicle based on an identification result of the conveyance target.
2. The autonomous vehicle according to claim 1, wherein the one or more programs, when executed, cause the one or more processors to: determine, based on the identification result, whether or not the conveyance target is a conveyance target identified based on an instruction given by a user.
3. The autonomous vehicle according to claim 1, wherein the one or more markings are disposed at one or more positions at which the one or more images are capturable by the one or more sensors in a traveling direction of the autonomous vehicle in which the autonomous vehicle brings the conveyance target into a conveyable state, and the one or more markings include one or more markings disposed frontward in the traveling direction, and one or more markings disposed rearward in the traveling direction.

4. The autonomous vehicle according to claim 3, wherein a quantity of information obtained by recognizing the one or more markings disposed rearward is greater than a quantity of information obtained by recognizing the one or more markings disposed frontward.
5. The autonomous vehicle according to claim 3, wherein the one or more programs, when executed, cause the one or more processors to: determine, based on the recognition result of the one or more markings disposed frontward, whether or not the conveyance target matches a conveyance target identified based on an instruction given by a user, and then determine, based on the recognition result of the one or more markings disposed rearward, whether or not the conveyance target matches the identified conveyance target.
6. The autonomous vehicle according to claim 3, wherein the one or more programs, when executed, cause the one or more processors to: determine, based on the recognition result of the one or more markings disposed frontward, whether to continue control for causing the autonomous vehicle to bring the conveyance target into the conveyable state.
7. The autonomous vehicle according to claim 3, wherein the one or more programs, when executed, cause the one or more processors to: recognize a positional relationship with the conveyance target based on the recognition result of the one or more markings disposed frontward, and perform control to move the autonomous vehicle in the traveling direction based on the positional relationship.
8. The autonomous vehicle according to claim 1, wherein the one or more programs, when executed, cause the one or more processors to: partially invalidate data obtained by the one or more sensors included in the autonomous vehicle based on the recognition result of the one or more markings, and convey the conveyance target using the partially invalidated data.
9. The autonomous vehicle according to claim 8, wherein the one or more programs, when executed, cause the one or more processors to: in a case in which a part of the conveyance target is in a measurement range of the one or more sensors, invalidate the data corresponding to the part of the conveyance target.
10. The autonomous vehicle according to claim 1, wherein the one or more programs, when executed, cause the one or more processors to: collate identification information based on the recognition result with registered identification information of the conveyance target.
11. The autonomous vehicle according to claim 1, wherein the one or more markings include a first marking and a second marking, and the one or more programs, when executed, cause the one or more processors to: verify validity of identification information based on the recognition result based on at least one of: a relationship between information obtained by recognizing the first marking and information obtained by recognizing the second marking; or a distance between the first marking and the second marking.
12. The autonomous vehicle according to claim 1, wherein the autonomous vehicle docks with the conveyance target and conveys the conveyance target.
13. A conveyance object, which is configured to be conveyed by the autonomous vehicle of claim 12, the conveyance object comprising: one or more markings, wherein the one or more markings include identification information of the conveyance object, and the identification information is used for control of conveyance of the conveyance object by the autonomous vehicle.
14. The conveyance object according to claim 13, wherein the one or more markings include one or more markings disposed frontward and one or more markings disposed rearward in a traveling direction of the autonomous vehicle in which the autonomous vehicle brings the conveyance object into a conveyable state.
15. The conveyance object according to claim 14, wherein a quantity of information obtained by the autonomous vehicle that recognizes the one or more markings disposed rearward is greater than a quantity of information obtained by the autonomous vehicle that recognizes the one or more markings disposed frontward.
16. The conveyance object according to claim 14, wherein the one or more markings disposed

frontward include a first marking and a second marking, the one or more markings disposed rearward include a third marking and a fourth marking the first marking and the third marking are arranged along the traveling direction, the second marking and the fourth marking are arranged along the traveling direction, the first marking and the second marking are arranged along a direction intersecting the traveling direction, and the third marking and the fourth marking are arranged along the direction intersecting the traveling direction.

17. The conveyance object according to claim 14, wherein the one or more markings include one or more markings disposed frontward and one or more markings disposed rearward in a second traveling direction that is opposite to the traveling direction and in which the autonomous vehicle brings the conveyance object into the conveyable state.

18. A control method for an autonomous vehicle, the control method comprising: obtaining, by one or more sensors included in the autonomous vehicle, one or more images of a conveyance target that includes one or more markings; identifying, by one or more processors, the conveyance target based on a recognition result of the one or more markings included in the one or more images; and controlling, by the one or more processors, conveyance of the conveyance target by the autonomous vehicle based on an identification result of the conveyance target.

19. The control method for the autonomous vehicle according to claim 18, wherein the one or more markings are disposed at one or more positions at which the one or more images are capturable by the one or more sensors in a traveling direction of the autonomous vehicle in which the autonomous vehicle brings the conveyance target into a conveyable state, and the one or more markings include one or more markings disposed frontward in the traveling direction, and one or more markings disposed rearward in the traveling direction.

20. The control method for the autonomous vehicle according to claim 18, wherein the one or more processors partially invalidate data obtained by the one or more sensors included in the autonomous vehicle based on the recognition result of the one or more markings, and control the conveyance of the conveyance target by the autonomous vehicle using the partially invalidated data.