

DESCRIPTION

Invention Title: METHOD FOR CONTROLLING LOGISTICS ROBOT,
AND CONTROL DEVICE

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Technical Field

[1] The present disclosure relates to a method for controlling a logistics robot configured to perform path planning on the basis of a movement area having directionality, and a control device thereof.

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Background Art

[2] For the flexible and efficient supply and transport of parts, components, etc., logistics robots are being introduced not only in general logistics warehouses and factories, but also in smart factories and the like that manufacture products of specifications different from each other by using various parts and components.

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[3] A logistics robot refers to a general conceptual term for an autonomous mobile robot (AMR), an automated guided vehicle (AGV), and the like. Such a logistics robot may move and perform tasks under the control of a control device.

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[4] In a smart factory, a logistics robot may move along an optimal movement path based on path planning in order to perform missions assigned by a control device.

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[5] Multiple logistics robots may be provided in the smart factory, and in a case where movement paths of a plurality of logistics robots overlap, the logistics robots may become deadlocked. For example, in a case where one logistics robot is moving down while another is moving up in a narrow passage in the smart factory, these two logistics robots may become deadlocked. Therefore, path planning that takes into account the movement directions of logistics robots in the smart factory is required in practice.

[6] The foregoing is intended merely to aid in the understanding of the background of the present disclosure, and is not intended to mean that the present disclosure falls within the purview of the related art that is already known to those skilled in the art.

Disclosure

Technical Problem

[7] Accordingly, an objective of the present disclosure for solving the technical problem is to provide a solution for preventing deadlock of logistics robots by performing path planning for the logistics robots on the basis of movement areas having directionality.

[8] In addition, another objective of the present disclosure for solving the technical problem is to provide a solution for improving the accuracy and flexibility of a movement path

according to path planning by specifying waypoints to be passed through by a logistics robot through global path planning and performing local path planning between the specified waypoints.

[9] In addition, a yet another objective of the present disclosure for solving the technical problem is to provide a solution for preventing collisions of logistics robots by applying an offset to a driving reference line of each of a plurality of movement areas and performing path planning according to the driving reference line to which the offset is applied.

[10] The technical problems to be achieved in the present disclosure are not limited to the technical problems mentioned above, and other technical problems that are not mentioned will be clearly understood by those skilled in the art to which the present disclosure belongs from the following description.

Technical Solution

[11] According to one exemplary embodiment of the present disclosure, as a means for solving the technical problems, there is provided a method for controlling a logistics robot operating within a preset operational boundary, the method including: setting area rules comprising a movable direction for at least one movement area variably settable within the operational boundary; and setting a movement path of the logistics robot

between a departure point and a destination point of the logistics robot on the basis of the area rules.

[12] In addition, according to one exemplary embodiment of the present disclosure, as a means for solving the technical problems, there is provided a control device for controlling a logistics robot operating within a preset operational boundary, the control device including: a map management unit for setting area rules comprising a movable direction for at least one movement area variably settable within the operational boundary; and a movement path setting unit for setting a movement path of the logistics robot between a departure point and a destination point of the logistics robot on the basis of the area rules.

Advantageous Effects

[13] According to the present disclosure, path planning for logistics robots is performed on the basis of movement areas having directionality, whereby deadlock of the logistics robots may be prevented.

[14] In addition, according to the present disclosure, waypoints to be passed through by a logistics robot is specified through global path planning and local path planning is performed between the specified waypoints, whereby the accuracy and flexibility of a movement path according to the path planning may be improved.

[15] In addition, according to the present disclosure, an offset is applied to a driving reference line of each of a plurality of movement areas and path planning is performed according to the driving reference lines to which the offset is applied, whereby collisions of logistics robots may be prevented.

[16] The effects of the present disclosure are not limited to the above-mentioned effects, and other effects that are not mentioned herein will be clearly understood by those skilled in the art from the following description.

Description of Drawings

[17] FIG. 1 is a block diagram illustrating an example of a configuration of an operational boundary applicable to exemplary embodiments of the present disclosure.

[18] FIG. 2 is a block diagram illustrating an example of a configuration of a control device applicable to the exemplary embodiments of the present disclosure.

[19] FIG. 3 is a block diagram illustrating an example of a configuration of a work schedule management unit included in the control device applicable to the exemplary embodiments of the present disclosure.

[20] FIG. 4 is a block diagram illustrating an example of a configuration of a logistics robot applicable to the exemplary embodiments of the present disclosure.

[21] FIG. 5 is a perspective view illustrating an example of the exterior of the logistics robot applicable to the exemplary embodiments of the present disclosure.

[22] FIG. 6 is a flowchart illustrating an example of a driving process of the logistics robot applicable to the exemplary
5 embodiments of the present disclosure.

[23] FIG. 7 is a sequence diagram illustrating a process of setting a movement path of a logistics robot in a logistics system according to one exemplary embodiment of the present
10 disclosure.

[24] FIG. 8 is a view illustrating a process in which the control device performs global path planning according to one exemplary embodiment of the present disclosure.

[25] FIG. 9 is a view illustrating a process in which a logistics robot performs local path planning according to one exemplary
15 embodiment of the present disclosure.

[26] FIG. 10 is a view illustrating a process in which a control device applies offsets to driving reference lines of movement areas according to one exemplary embodiment of the present
20 disclosure.

[27] FIGS. 11 and 12 are views illustrating a process in which logistics robots move along respective driving reference lines of movement areas to which offsets are applied according to one exemplary embodiment of the present disclosure.

Mode for Invention

[28] Hereinafter, exemplary embodiments disclosed in the present specification will be described in detail with reference to the accompanying drawings, but regardless of the reference numerals, the same or similar components are given the same reference numbers, and the overlapping description thereof will be omitted. The words "module" and "part/unit" used as compound words for the components used in the following descriptions are given or mixed in consideration of only the ease of writing the specification, and the words do not have distinct meanings or roles by themselves. In describing the exemplary embodiments disclosed in the present specification, when it is determined that a detailed description of a related known technology may obscure the subject matter of the exemplary embodiments disclosed in the present specification, the detailed description thereof will be omitted. In addition, the accompanying drawings are only for easy understanding of the exemplary embodiments disclosed in the present specification, the technical idea disclosed in the present specification is not limited by the accompanying drawings, and it should be understood that the accompanying drawings include all changes, equivalents, or substitutes, which are included in the spirit and technical scope of the present disclosure.

[29] Although the terms including ordinal numbers, such as first, second, etc. may be used herein to describe various components,

these components should not be limited by these terms. These terms are only used for the purpose of distinguishing one component from another component.

[30] It will be understood that when a component is referred to as being "coupled", "connected", or "linked" to another component, it may be directly coupled or connected to the other component or intervening components may be present. In contrast, when a component is described as being "directly connected", "directly coupled", or "directly linked" to another component, it should be understood that there are no intervening component present therebetween.

[31] As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[32] It will be further understood that the terms "comprise", "include", "have", etc. when used in the present specification, specify the presence of stated features, integers, steps, operations, components, parts, and/or combinations of them but do not preclude the presence or addition of one or more other features, integers, steps, operations, components, parts, and/or combinations thereof.

[33] In addition, "unit" or "control unit" included in internal component names of a logistics robot or a control device is just a term widely used for naming of a controller that controls specific functions, and does not mean a generic function unit.

For example, in order to control a function in charge, each control device may include: a modem/transceiver for communicating with other control devices or sensors; a memory for storing an operating system or logic instructions and input/output information; and one or more processors for performing determination, calculations, decisions, etc., which are required for controlling the function in charge. Depending on the implementation, a single processor may also be responsible for operations for a plurality of control devices.

[34] First, according to one exemplary embodiment, a configuration of an operational boundary in which a logistics robot is arranged and operated is described with reference to FIG. 1.

[35] FIG. 1 is a block diagram illustrating an example of a configuration of an operational boundary applicable to exemplary embodiments of the present disclosure.

[36] Referring to FIG. 1, the operational boundary 100 may include a logistics robot 110, a production device 120, a monitoring device 130, and a control device 140.

[37] Depending on a production process and target production speed of a product, the operational boundary 100 may be provided with a plurality of logistics robots 110, a plurality of production devices 120, and a plurality of detection devices 130. The operational boundary 100 may be implemented as a smart

factory, but is not necessarily limited thereto. Below, each component is described.

[38] First, the logistics robot 110 may include an autonomous mobile robot (hereinafter, referred to as an "AMR" for convenience) and an automated guided vehicle (hereinafter, referred to as an "AGV" for convenience). Depending on an operation policy of the logistics robot 110 in the operational boundary 100, only one type of AGV or AMR may be operated, or AGV and AMR may also be operated together within the operational boundary 100.

[39] An AGV generally performs operations (i.e., movement, steering, stopping, etc.) required within the operational boundary 100 by recognizing and following guidance equipment arranged on a floor for guidance of AGV. Here, the guidance equipment may refer to, but are not limited to, optically recognizable markers (i.e., spots, 2D codes, etc.), tags recognizable in a contactless way at close range (e.g., NFC tags, RFID tags, etc.), magnetic strips, wires, etc. The guide equipment may be arranged continuously on the floor or may also be arranged discontinuously and spaced apart from each other. Since the AGV fundamentally perform operations by recognizing and following the guidance equipment, it is required that the guidance equipment be installed in advance before operation. In a case of moving the AGV to a new path or modifying an existing path, the guidance equipment should be physically installed or

modified. In addition, the AGV is designed not to deviate from a path that is set by the guidance equipment, so in a case where an obstacle is detected on a path or in the vicinity, it is common that the AGV stops until the detected obstacle is removed or until separate control is given to the AGV. In the operation of the AGV, the control device 140 should control the AGV on the basis of the guidance equipment, so that in individual command units or mission units including a plurality of commands (e.g., recovery, supply, charging, patrol, etc.), the control device 140 may transmit, to the AGV, commands such as "drive until a third marker is recognized" or "change a heading direction by 90 degrees when the third marker is recognized" from a current position.

[40] The most distinguishing feature from an AGV is that an AMR is able to not only determine a current position thereof (i.e., positioning) through surrounding detection but also set its own path (i.e., path planning) by using the positioning and a map. Accordingly, in a case where the map with compatible coordinates is shared between the AMR and the control device 140, the control device 140 may control the AMR by instructing the AMR on a path on the basis of the coordinates. In addition, in a case where an obstacle is detected while driving, the AMR is able to avoid the obstacle by setting an avoidance path autonomously and then return to the original path. A function for the control device 140 to set a path of the AMR with one or more transit coordinates

may be referred to as global path planning, and a function for the AMR to set a movement path or an avoidance path between the transit coordinates according to the global path planning may be referred to as local path planning.

5 **[41]** A more detailed configuration of the logistics robot 110 will be described below with reference to FIGS. 4 and 5, and a driving control process of an AMR will be described below with reference to FIG. 6.

10 **[42]** Next, the production device 120 may mean a device (e.g., a robot arm, a conveyor belt, etc.) for performing a production process of a product in the operational boundary 100, and in a broader sense, may also mean a device arranged to assist in performing missions such as entry and exit of the logistics robot 110 when the production process is performed by a person.

15 The device arranged to assist in the performing of the missions may include: a device for detecting a state of a specified position at which a pallet carried by the logistics robot 110 may be dropped off or be collected within an area where a specific production process is performed; a device for
20 determining process progress; and a means for blocking entry and exit within the area, but this is not necessarily limited thereto.

[43] For example, the production device 120 is controlled through a Programmable Logic Controller (PLC) and may perform

communication with the control device 140 in relation to process progress.

[44] The monitoring device 130 may perform a function of obtaining information for assessing a situation within the operational boundary 100 and transmitting the information to the control device 140. For example, the monitoring device 130 may include a camera, a proximity sensor, etc., but this is not necessarily limited thereto.

[45] The control device 140 may communicate with the aforementioned components 110, 120, and 130, so as to obtain information required for the operation of the operational boundary 100 or to control each component. For example, the control device 140 may perform dispatching, path setting, mission assignment, process management for each product, material management, and the like of the logistics robot 110.

[46] In the implementation, the control device 140 may include: a local control device (i.e., ACS: AMR/AGV Control System) for controlling surrounding process equipment on the basis of positions of AGV/AMR and performing mission-based control of the AGV/AMR; and an integrated control device (i.e., MoRIMS: Mobile Robot Integrated Monitoring System) for integrating and controlling two or more local control devices. The integrated control device may obtain status and paths of all logistics robots 110 within the operational boundary 100 from each of a plurality of local control devices and perform logistics flow

setting and traffic control. For example, in a case where local control devices (ACSSs) are provided in units of logistics robots of the same manufacturer or model, the integrated control device may perform integrated control for collision prevention, such as bottleneck level analysis in intersection/overlapping areas, driving acceleration or deceleration control, and avoidance path regeneration, through heterogeneous traffic distribution control on the basis of information obtained through the plurality of local control devices (ACSSs).

[47] In addition, the integrated control device may also have a Manufacturing Execution System (MES) as an upper control subject thereof, and the Manufacturing Execution System (MES) may be linked with an automated scheduler (i.e., APS: Advanced Planning and Scheduling).

[48] Naturally, in addition to the components 110, 120, 130, and 140 of the operational boundary 100 described above, other objects may be appropriately arranged within the operational boundary 100, the objects including: a device for intercommunication between each component such as a beacon, a repeater, an Access Point (AP); a charger for charging a logistics robot 110; a loading space for storing or loading parts; a space for storing finished products or intermediate products; a traffic light; a circuit breaker; a waiting space for an idle logistics robot 110; and so on.

[49] Below, the configuration of the control device 140 applicable to the exemplary embodiments of the present disclosure is described with reference to FIG. 2.

[50] FIG. 2 is a block diagram illustrating an example of a configuration of a control device applicable to the exemplary embodiments of the present disclosure. Each component illustrated in FIG. 2 mainly represents the components related to the exemplary embodiments of the present disclosure, and in the implementation of an actual control device 140, more or fewer components than such components may also be included.

[51] Referring to FIG. 2, the control device 140 may include a firmware management unit 141, a traffic control unit 142, a process management unit 143, a production/logistics management unit 144, an inventory management unit 145, a communication unit 146, a vehicle monitoring unit 147, a map management unit 148, and a work schedule management unit 149.

[52] The firmware management unit 141 obtains the latest firmware of a logistics robot 110 through the communication unit 146 and transmits this firmware to the logistics robot 110 so as to perform a firmware update, thereby maintaining the firmware of the logistics robot 110 up to date.

[53] The traffic control unit 142 controls a traffic light and a crossing gate on the basis of a path of a logistics robot 110, and may also re-calculate the path of the logistics robot 110 according to traffic.

[54] The process management department 143 may define a process for each product and manage missions related to process progress, proceeding positions, etc.

[55] The production/logistics management department 144 may dispatch a logistics robot 110 on the basis of missions.

[56] The inventory management unit 145 manages a position and quantity of each material. Information related to such management may be useful for more efficient process operations such as sending a logistics robot 110 to a destination point (i.e., a destination) for pallet pickup or retrieval earlier than a time point at which actual assembly/consumption of materials is detected.

[57] The communication unit 146 may perform communication not only with internal components such as the logistics robot 110, the production device 120, and the monitoring device 130 of the operational boundary 100, but also with external entities such as a firmware update server.

[58] The vehicle monitoring unit 147 may monitor the positions, paths, battery status, communication status, power train status, and the like of individual logistics robots 110. Here, a path is a conceptual term including a waypoint-based global path and a real-time local path. In addition, the battery status may include voltage, current, temperature, peak voltage and peak current, state of charge (SOC), state of health (SOH), and the like. The communication status may include information on a

currently activated communication protocol (such as Wi-Fi), a connected AP, a distance to the AP, a channel in use, etc. In addition, power train status may include drivetrain load, temperature, RPM, etc.

5 **[59]** In addition, the vehicle monitoring unit 147 may also check missions, operation modes, firmware versions, and the like, which are currently assigned to the individual logistics robots 110.

10 **[60]** The map management unit 148 obtains map data in the form of a grid map obtained while an AMR among logistics robots 110 drives within the operational boundary 100, and may provide a tool for allowing a factory manager to edit the obtained map data. Through the editing of the map data, a zone, a virtual lane, an intersection, a no-entry zone, and the like, in which
15 a logistics robot 110 performs one or more preset operations upon entry, may be set, but this is an example and is not necessarily limited thereto. In addition, the map management unit 148 may also distribute a corresponding map, which is obtained from an initial grid map through the actual driving,
20 to the remaining logistics robots 110 other than the logistics robot 110 through the communication unit 146.

25 **[61]** The work schedule management unit 149 may manage and monitor the missions of a logistics robot 110 on the basis of process information, which is of the operational boundary 100 and received from the production device 120 and the monitoring

device 130 through the communication unit 146. In addition, the work schedule management unit 149 may select a specific logistics robot 110 to assign a mission, and set a global path of the logistics robot 110 according to the assigned mission.

5 **[62]** A more specific configuration and an operation method of the work schedule management unit 149 are described with reference to FIG. 3.

10 **[63]** FIG. 3 is a block diagram illustrating an example of a configuration of a work schedule management unit included in the control device applicable to the exemplary embodiments of the present disclosure.

15 **[64]** Referring to FIG. 3, the work schedule management unit 149 may include a mission group management unit 149a, an operation mission management unit 149b, a priority calculation unit 149c, a control operation status management unit 149d, and a movement path setting unit 149e.

20 **[65]** The mission group management unit 149a may group missions of logistics robots 110 on the basis of process information and manage the grouped missions.

25 **[66]** The operation mission management unit 149b may generate a list of missions of a logistics robot 110 currently in progress and monitor the generated list.

30 **[67]** The priority calculation unit 149c may set priorities for the missions of the logistics robot 110 and change and monitor the set priorities.

[68] The control operation status management unit 149d may monitor and compare the operation status of a logistics robot 110 and the control status of production equipment of a PLC on the basis of data provided from the mission group management unit 149a, the operation mission management unit 149b, and the priority calculation unit 149c.

[69] The movement path setting unit 149e may set an optimal global path for a logistics robot 110 according to the missions that are set in the mission group management unit 149a on the basis of at least one of a virtual lane or a zone.

[70] Next, a logistics robot will be described with reference to FIGS. 4 and 5.

[71] FIG. 4 is a block diagram illustrating an example of a configuration of a logistics robot applicable to the exemplary embodiments of the present disclosure.

[72] Referring to FIG. 4, the logistics robot 110 may include a driving unit 111, a sensing unit 112, a loading unit 113, a communication unit 114, and a control unit 115. Below, each component is described.

[73] The driving unit 111 may include a driving source, wheels, suspensions, etc., involved in the movement, steering, and stopping of a logistics robot 110. An electric motor supplied with power from a built-in battery (not shown) may be used as the driving source. The wheels may include: one or more driving wheels supplied with driving power from the driving source; and

non-driving wheels that rotate by movement of a vehicle body without receiving the driving power. Depending on the implementation, in a case where a plurality of driving wheels is provided, a driving source may be matched for each driving wheel so that the rotation of each driving wheel may be controlled independently. In such a case, the rotation directions of driving wheels different from each other may be made different from each other, so as to rotate the vehicle body without a separate steering means, whereby steering becomes realizable. At least some of the non-driving wheels may be composed of caster type wheels, but this is an example and is not necessarily limited thereto.

[74] The sensing unit 112 is for detecting the surrounding environment or self-operating status of a logistics robot 110, and may include at least one of a 2D laser scanner (e.g., a LiDAR), a 3D vision (i.e., stereo) camera, a multi-axis gyro sensor, an acceleration sensor, a wheel encoder, and a proximity sensor.

[75] An encoder may output information with which how much a wheel has rotated can be determined by using light emitted from a light-emitting element (e.g., a photodiode). For example, the encoder may count the number of slits, which are arranged along the circumference directions of a wheel or a disk rotating together with the wheel, per unit time. The control unit 115 may perform odometry for estimating displacement by analyzing

positional variations over time with data obtained through the encoder and gyro sensor. However, a displacement estimated on the basis of encoder data may have errors compared to an actual displacement due to the slip or wear of the wheel (i.e., wheel radial change). Accordingly, when performing the odometry, the control unit 115 may output a result that tends to be close to an actual value by performing correction for noise and errors on the information, which is collected from the wheel and gyro sensor, with a predetermined algorithm (e.g., EKF: Extended Kalman Filter). Such odometry may be particularly useful in a case where current position determination (i.e., localization) using a 2D laser scanner, which will be described later, is not executable.

[76] The 2D laser scanner may scan the surrounding environment by emitting lasers onto the surroundings through a rotating reflector and then detecting reflected signals. At this time, a detection result in a point cloud shape may be output by analyzing an intensity of the reflected signals and a time difference between the light emission and signal reception.

[77] The 3D vision camera may calculate a distance to an object on the basis of a parallax between two cameras spaced a predetermined distance apart, i.e., a pixel distance between images captured by the respective cameras. In this case, a texture projector for projecting infrared light in a predetermined pattern may also be provided, so as to enable

detection even on an object (e.g., a white wall) having a flat surface of the same color.

[78] Generally, 2D laser scanners are used for mapping, navigation, object recognition, etc., and 3D cameras may be used for navigation, especially for obstacle avoidance, but these are examples and are not necessarily limited thereto.

[79] The loading unit 113 is a means for loading a transport target item, and may be a lift, a turntable for rotating along a vertical axis, a forklift, a conveyor, a top plate itself on an upper part of a vehicle body, a table arranged on the top plate, or a combination thereof. Similar to a forklift truck, the forklift may also support a telescopic and tilting function.

[80] The communication unit 114 may perform communication with other components, such as the production device 120, and the control device 140, within the operational boundary 100, may support communication between logistics robots 110, and may also communicate with a charger when a charging mission is performed.

[81] The control unit 115 is a subject that performs overall control of each of the aforementioned components 111, 112, 113, and 114, and may perform functions regarding a current mission, a current position, destination-point determination, path planning, loading-unit control, and the like on the basis of information obtained from the control device 140 through the communication unit 114.

[82] FIG. 5 is a perspective view illustrating an example of the exterior of the logistics robot applicable to the exemplary embodiments of the present disclosure.

[83] Referring to FIG. 5, an example of an AMR is illustrated as a logistics robot 110, and a vehicle body thereof may have a track-type planar shape having a longitudinal axis extending along a first axis direction as a whole. One driving wheel 111-1 is arranged in a center part of the vehicle body in the first axis direction, and may be arranged on one side in a second axis direction. The other driving wheel (not shown) may be arranged on the other side so as to face the driving wheel 111-1 in the second axis direction. Such driving-wheel arrangement may be called a "differential drive (DD)". Although not illustrated in FIG. 4, two or more non-driving wheels may be arranged on the lower part of the vehicle body. In this case, when rotating in the same direction at the same speed, two driving wheels are enabled to move forward or backward along the first axis direction, and when rotating in opposite directions at the same speed, two driving wheels are able to rotate around a rotation axis extending along a third axis direction and passing through a plane center C of the vehicle body. In addition, the sensor unit 112 may be arranged on a front part of the vehicle body, and the loading unit 113 may be arranged on an upper part of the vehicle body. The loading unit 113 may be configured to be raised and lowered along the third axis direction, and a rack

or tray may be fixed to the upper part thereof through a guide 113-1.

[84] However, the AMR shape illustrated in FIG. 5 described above is exemplary, and naturally, an AGV may also have a similar shape to the AMR shape or an AMR may have a shape different from that illustrated in FIG. 5.

[85] Next, a driving process of a logistics robot 110 will be described with reference to FIG. 6.

[86] FIG. 6 is a flowchart illustrating an example of a driving process of the logistics robot 110 applicable to the exemplary embodiments of the present disclosure. In FIG. 6, for convenience, it is assumed that the logistics robot 110 is an AMR capable of positioning and local path planning.

[87] Referring to FIG. 6, first, in step S601, while driving within an operational boundary 100, an AMR may obtain an actual measured grid map through a LiDAR, etc.

[88] In step S602, when the AMR has transmitted the obtained grid map to a control device 140, the processes of grid map editing and matching may be performed in a map management unit 148 of the control device 140. Here, the editing process may include a process of setting various zones described on the aforementioned grid map, a process of assigning a cost for each grid, etc. Here, the assigning of the cost may be performed in a way that the closer the AMR is to an obstacle or a no-entry zone, the higher the cost is assigned, so as to prevent the AMR

from moving around the obstacle or entering the no-entry zone. This is because when the AMR sets a local path, the AMR selects a set of cells having the lowest cost among waypoints as the path.

5 **[89]** In addition, the map matching process may mean a process of matching coordinates between a CAD map used in the design of the operational boundary 100, the actual measured grid map (i.e., a LiDAR map), and a topology map having undergone the editing process.

10 **[90]** Thereafter, in step S603, the control device 140 may share the topology map with all AMRs within a factory through a communication unit 146.

[91] The next Steps thereafter may be processes applicable to individual AMRs.

15 **[92]** In step S604, the AMR may perform localization for determining a current position on the map through sensor data of a sensing unit 112 and the obtained map. For example, the AMR may determine the current position thereof by comparing the map and the surrounding terrain obtained through a LiDAR on the
20 basis of feature points.

[93] The control device 140 may select a particular AMR and assign a mission, and the mission may generally be assigned with one or more waypoints determined through global path planning. Each waypoint may be defined by its coordinates on a map, and
25 may be accompanied by information on a direction (i.e. a heading

direction) that the AMR should face from the corresponding coordinates. Based on such mission assignment, a destination point may be set to the AMR (i.e., "Yes" in S605), and in step S606, the AMR may perform local path planning between waypoints
5 on the basis of the costs of the topology map.

[94] In step S607, when a path is determined, the AMR starts driving. In step S609, when an obstacle is detected through the sensing unit 112 during the driving (i.e., "Yes" in S608), the AMR may perform an evasive maneuver by performing a local
10 path search for bypassing the detected obstacle. Depending on a case, depending on the evasive maneuver, or depending on the failure of the evasive maneuver, the control device 140 may also update the mission of the corresponding AMR.

[95] In addition, in step S610, the AMR may also correct
15 positioning errors while moving by using the aforementioned odometry technique while driving until the AMR reaches the destination point.

[96] After reaching the destination point in step S611, the AMR may perform mission-based maneuvers in step S612. For example,
20 the AMR may determine whether a condition for entering a particular process zone is clear or not, and retrieve an empty pallet or drop a load loaded on the loading unit 113 at the destination point.

[97] In the above, the components and operation method of the
25 logistics robot 110, production device 120, monitoring device

130, and control device 140, which are included in the operational boundary 100 and applicable to the exemplary embodiments of the present disclosure, have been described.

[98] Hereinafter, a description is provided on an operation method of a logistics system, wherein in controlling a logistics robot operating within a preset operational boundary, a control device sets area rules for a variably settable movement area (e.g., a virtual lane) within the operational boundary and performs path planning between a departure point and a destination point of the logistics robot on the basis of the set area rules.

[99] FIG. 7 is a sequence diagram illustrating a process of setting a movement path of a logistics robot operating within a preset operational boundary according to one exemplary embodiment of the present disclosure. In FIG. 7, for convenience, it is assumed that the logistics robot 110 is an AMR capable of positioning and local path planning.

[100] Referring to FIG. 7, in step S701, a map management unit 148 of a control device 140 may variably set at least one of the size or position of at least one movement area on a map of a preset operational boundary, and may set area rules including a movable direction and an offset of a driving reference line for each variably settable movement area. In this case, the movement area may be specified on a CAD map used in the design of the operational boundary, but is not necessarily limited

thereto. The movable direction of the movement area may be set to any one of a first longitudinal direction, a second longitudinal direction opposite to the first longitudinal direction, and both directions including the first and second longitudinal directions in the movement area.

[101] The driving reference line of a movement area may be adjusted according to a value of an offset based on the center line of each of a plurality of movement areas. More specifically, the driving reference line may be shifted to one side of the center line or to the other side of the center line depending on the value of the offset. For example, the driving reference line may be set to the center line of the movement area in a case where the value of the offset value is "0", may be shifted to one side (e.g., a left side) of the center line of the movement area in a case where the value of the offset is a positive number, and may be shifted to the other side (e.g., a right side) of the center line of the movement area in a case where the value of the offset is a negative number.

[102] In step S702, a map management unit 148 of a control device 140 may generate movement area information including information on the position, size, movable direction, and offset of driving reference line of each of the plurality of movement areas specified on a map. In this case, the map management unit 148 may transmit the movement area information to a movement path

setting unit 149e of a work schedule management unit 149 of the control device 140.

[103] A production device 120 and a monitoring device 130 may transmit process information of the operational boundary to a communication unit 146 of the control device 140. More specifically, in step S703, the production device 120 may transmit operation information of a production robot and logistics delivery information of production equipment to the control device 140. In step S704, the monitoring device 130 may transmit peripheral sensor information of the production equipment to the control device 140.

[104] In step S705, the work schedule management unit 149 of the control device 140 may select a specific logistics robot 110 within the operational boundary and assign a mission on the basis of the process information that is of the operational boundary and received through the communication unit 146 in steps S703 and S704.

[105] In step S706, a movement path setting unit 149e of the control device 140 may determine a destination point of the logistics robot 110 according to the mission assigned to the logistics robot 110, and may set a global path between a departure point (i.e., a current position) and the destination point of the logistics robot 110 on the basis of the movement area information received in step S702.

[106] More specifically, the movement path setting unit 149e may select at least one movement area along a movable direction among a plurality of movement areas through a preset algorithm (e.g., A* algorithm) between the departure point and the destination point of the logistics robot 110 according to the set area rules on the basis of the movement area information, and may set a global path within the at least one movement area selected. In this case, the movement path setting unit 149e may set the global path by considering the number of logistics robots for each movement area.

[107] In addition, the movement path setting unit 149e may set the global path according to the driving reference line of the at least one movement area selected according to the movable direction among the plurality of movement areas on the basis of the movement area information on the offsets of the driving reference lines. At this time, the driving reference line of each of the plurality of movement areas may be in a state where an offset is applied.

[108] Meanwhile, a global path according to the present exemplary embodiments may be specified by the coordinates of at least one waypoint. More specifically, the movement path setting unit 149e may specify waypoints along a driving reference line of a movement area. Here, a waypoint is defined as a point to be passed through by a logistics robot 110, and may include an

intersection between driving reference lines of the movement area.

[109] Thereafter, in step S707, the communication unit 146 of the control device 140 may transmit the global path specified by the coordinates of the at least one waypoint to the communication unit 114 of the logistics robot 110.

[110] The communication unit 114 of the logistics robot 110 receives the global path specified by the coordinates of each waypoint, and a control unit 115 of the logistics robot 110 may control its own vehicle to move along the global path by causing its own vehicle to pass through the coordinates of each waypoint.

[111] In addition, in step S708, the control unit 115 of the logistics robot 110 may set a local path so as to avoid a nearby obstacle detected through a sensing unit 112 between waypoints, and control its own vehicle so as to move along the set local path.

[112] In step S709, the communication unit 114 of the logistics robot 110 may transmit the local path including the current position of the logistics robot 110, i.e., an actual driving path, to the communication unit 146 of the control device 140.

[113] In step S710, the work schedule management unit 149 of the control device 140 may monitor the logistics robot 110 performing the mission on the basis of the local path including the current position of the logistics robot 110. For example, in a case of monitoring the logistics robot 110 that has failed

to perform an evasive maneuver, the work schedule management unit 149 may update the mission of the logistics robot 110.

[114] FIG. 8 is a view illustrating a process in which the control device performs global path planning according to one exemplary embodiment of the present disclosure.

[115] Referring to FIG. 8, an example of a map of the operational boundary in which a plurality of movement areas 801 to 806 is specified is illustrated. Each of the movement areas 801 and 802 may be set to have a bidirectional movable direction, and each of the movement areas 803, 804, 805, and 806 may be set to have a unidirectional movable direction. More specifically, the movable direction of the movement areas 803 and 805 may be set to a first longitudinal direction (i.e., a downward direction), and the movable direction of the movement areas 804 and 806 may be set to a second longitudinal direction (i.e., an upward direction). A logistics robot A corresponds to a target for which a control device 140 sets a global path. Logistics robots B and C correspond to targets occupying their respective movement areas 805 and 804.

[116] The control device 140 may set the global path by considering the movable direction of each of the plurality of movement areas 801 to 806 between a departure point S and a destination point E of the logistics robot A. For example, the control device 140 may set a global path by using the movement area 801, the movement area 803, and the movement area 802, or

may set a global path by using the movement area 801, the movement area 805, and the movement area 802.

[117] In this case, in a case of checking that the different logistics robot B in the vicinity has occupied the movement area 805 on the basis of a result of collecting the current positions of the logistics robots A, B, and C within an operational boundary, the control device 140 may set an optimal global path for the logistics robot A by using the movement area 801, the movement area 803, and the movement area 802.

[118] Thereafter, the control device 140 may specify waypoints at preset distance intervals (e.g., 25 meters) along a driving reference line of each movement area. The control device 140 may transmit the coordinates of the specified waypoints to the logistics robot A.

[119] As seen in FIG. 8, the control device 140 may efficiently secure the movement paths of the logistics robots within the operational boundary by setting the global path of logistics robots on the basis of the movement areas having directionality. For example, the control device 140 may prevent a collision or deadlock between the logistics robots within the operational boundary by dividing the paths, through which the logistics robots A and C move, into the movement area 803 and the movement area 804 having the movable directions different from each other.

[120] FIG. 9 is a view illustrating a process in which a logistics robot performs local path planning according to one exemplary embodiment of the present disclosure.

[121] Referring to FIG. 9, a logistics robot A may receive the coordinates of the waypoints illustrated in FIG. 8 from the control device 140. The logistics robot A may set a local path so as to pass through the coordinates of the waypoints and avoid a nearby obstacle between the coordinates of the waypoints. Accordingly, the logistics robot A may comply with a global path according to the global path planning of the control device 140 and prevent a collision with a nearby obstacle through the local path setting in accordance with the local path planning. Accordingly, the accuracy and flexibility of pass planning may be improved.

[122] FIG. 10 is a view illustrating a process in which a control device applies offsets to driving reference lines of movement areas according to one exemplary embodiment of the present disclosure.

[123] Referring to FIG. 10, an example of a map of an operational boundary in which movement areas 1001 and 1002 are specified is illustrated. A movable direction of the movement area 1001 may be set to a first longitudinal direction (i.e., a downward direction), and a movable direction of the movement area 1002 may be set to a second longitudinal direction (i.e., an upward direction).

[124] The control device 140 may adjust a driving reference line of the movement area 1001 on the basis of a center line of the movement area 1001 according to a value of a first offset Offset 1. For example, the driving reference line of the movement area 1001 shifts to the leftward direction of the center line of the movement area 1001 in a case where the value of the first offset Offset 1 is a positive number, and may move further away from the center line as the value of the first offset Offset 1 increases.

[125] The control device 140 may adjust a driving reference line of the movement area 1002 on the basis of a center line of the movement area 1002 according to a value of a second offset Offset 2. For example, the driving reference line of the movement area 1002 shifts to the rightward direction of the center line of the movement area 1002 in a case where the value of the second offset Offset 2 is a negative number, and may move further away from the center line as the value of the second offset Offset 2 decreases.

[126] The control device 140 may specify waypoints along the driving reference line of each of the movement areas 1001 and 1002 to which the offsets are applied.

[127] FIGS. 11 and 12 are views illustrating a process in which logistics robots move along respective driving reference lines of movement areas to which offsets are applied according to one exemplary embodiment of the present disclosure.

[128] Referring to FIGS. 11 and 12, a logistics robot D may receive the coordinates of the waypoints for the movement area 1001 in FIG. 10 from the control device 140, and a logistics robot E may receive the coordinates of the waypoints for the movement area 1002 in FIG. 10 from the control device 140.

[129] Referring to FIG. 11, the logistics robots D and E may be in a state where respective loads 1101 and 1102 are loaded. The logistics robot D may move along the driving reference line positioned to the left of the center line of the movement area 1001 in FIG. 10, and the logistics robot E may move along the driving reference line positioned to the right of the center line of the movement area 1002 in FIG. 10. That is, in the present exemplary embodiments, by applying respective offsets to the driving reference lines of the movement areas, it is possible to prevent the loads 1101 and 1102 from colliding with each other when the logistics robots D and E cross-drive.

[130] Referring to FIG. 12, the logistics robots D and E may be in a state where respective loads 1201 and 1202 are loaded thereon. The logistics robot E may set a local path for avoiding an obstacle located ahead. In this case, in the present exemplary embodiments, by applying respective offsets to the driving reference lines of the movement areas, it is possible to prevent the loads 1201 and 1202 from colliding with each other even when an avoidance maneuver is performed due to the obstacle in the vicinity of the logistics robot E.

[131] Meanwhile, the above-described present disclosure may be implemented as computer-readable code in a medium on which a program is recorded. The computer-readable medium includes all types of recording devices in which data readable by a computer system is stored. Examples of the computer-readable medium include a Hard Disk Drive (HDD), a Solid State Disk (SSD), a Silicon Disk Drive (SDD), a ROM, a RAM, a CD-ROM, a magnetic tape, a floppy disk, an optical data storage device, etc. Accordingly, the above detailed description should not be construed as restrictive in all respects but as exemplary. The scope of the present disclosure should be determined by a reasonable interpretation of the appended claims, and all modifications within the equivalent scope of the present disclosure are included in the scope of the present disclosure.

[132] <Description of the Reference Numerals in the Drawings>

[133] 100: operational boundary 110: logistics robot

[134] 120: production device 130: monitoring device

[135] 140: control device

CLAIMS

[Claim 1] A method for controlling a logistics robot operating within a preset operational boundary, the method comprising:

setting area rules comprising a movable direction for at least one movement area variably settable within the operational boundary; and

setting a movement path of the logistics robot between a departure point and a destination point of the logistics robot based on the area rules.

[Claim 2] The method of claim 1, further comprising:

variably setting at least one of a size or position of the at least one movement area within the operational boundary.

[Claim 3] The method of claim 1, wherein the movable direction is set to any one of a first direction, a second direction opposite to the first direction, and a bidirectional direction comprising the first and second directions.

[Claim 4] The method of claim 1, wherein the area rules comprise a driving reference line of the at least one movement area, and

the driving reference line is adjusted according to a value

of an offset relative to a center line of each of the at least one movement area.

[Claim 5] The method of claim 4, wherein the driving reference line is shifted to one side of the center line or to the other side of the center line depending on the value of the offset.

[Claim 6] The method of claim 1, wherein the setting of the movement path comprises:

setting the movement path by coordinates of waypoints to be passed through by the logistics robot.

[Claim 7] The method of claim 6, further comprising:

transmitting the coordinates of the waypoints from a control device to the logistics robot.

[Claim 8] The method of claim 7, further comprising:

setting, by the logistics robot, a local movement path for avoiding an obstacle between the waypoints.

[Claim 9] The method of claim 6, wherein the waypoints are specified along a driving reference line of the at least one movement area, and comprise an intersection between driving reference lines.

[Claim 10] The method of claim 1, wherein the setting of the movement path comprises:

setting the movement paths by considering the number of logistics robots per the at least one movement area.

[Claim 11] A control device for controlling a logistics robot operating within a preset operational boundary, the control device comprising:

a map management unit configured to set area rules comprising a movable direction for at least one movement area variably settable within the operational boundary; and

a movement path setting unit configured to set a movement path of the logistics robot between a departure point and a destination point of the logistics robot based on the area rules.

[Claim 12] The control device of claim 11, wherein the map management unit variably sets at least one of a size or position of the at least one movement area within the operational boundary.

[Claim 13] The control device of claim 11, wherein the movable direction is set to any one of a first direction, a second direction opposite to the first direction, and a bidirectional direction comprising the first and second directions.

[Claim 14] The control device of claim 11, wherein the area rules comprise a driving reference line of the at least one movement area, and

the driving reference line is adjusted according to a value of an offset relative to a center line of each of the at least one movement area.

[Claim 15] The control device of claim 14, wherein the driving reference line is shifted to one side of the center line or to the other side of the center line depending on the value of the offset.

[Claim 16] The control device of claim 11, wherein the movement path setting unit sets the movement path by coordinates of waypoints to be passed through by the logistics robot.

[Claim 17] The control device of claim 16, further comprising:

a communication unit configured to transmit the coordinates of the waypoints from the control device to the logistics robot.

[Claim 18] The control device of claim 16, wherein the waypoints are specified along a driving reference line of the at least one movement area, and comprise an intersection between driving reference lines.

[Claim 19] The control device of claim 11, wherein the movement path setting unit configured to set the movement paths by considering the number of logistics robots per the at least one movement area.

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