

DESCRIPTION

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

Technical Field

- [1] The present invention relates to a method of controlling a logistics robot and a control device configured to change a property of a movement area for a logistics robot according to state information within an operation boundary.

Background Art

- [2] In general logistics warehouses or factories, as well as smart factories configured to manufacture products of different specifications using various components, logistics robots are being introduced for flexible and efficient supply and transfer of components and so on.
- [3] A logistics robot is a concept generally referring to an Autonomous Mobile Robot (AMR) and an Automated Guided Vehicle (AGV), and such a logistics robot can perform movement and work according to control of a control device.
- [4] In a smart factory, a logistics robot can move along an optimal movement path based on path planning to perform a mission assigned from a control device.
- [5] The matters described as the background art above are only for enhancing understanding of the background of the present invention, and should not be taken as an admission that they correspond to prior art already known to a person having ordinary skill in the art.

Disclosure

Technical Problem

- [6] Accordingly, the present invention has a technical problem to be solved by generating a detour movement path of a logistics robot by changing a property of a movement area for the logistics robot according to state information within an operation boundary.
- [7] The technical problems to be achieved in the present invention are not limited to the technical problems mentioned above, and other technical problems not mentioned will be clearly understood by a person having ordinary skill in the art to which the present invention belongs from the description below.

Technical Solution

- [8] A method of controlling a logistics robot operating within a preset operation boundary according to an embodiment comprises: a step of setting an area rule including a movable direction for at least one movement area variably settable within the operation boundary; a step of determining whether to change the area rule of the movement area associated with the predetermined area, based on state information including at least one of information associated with an occupancy number of the logistics robot in a predetermined area within the operation boundary, information associated with a process state within the operation boundary, and mission information for the logistics robot; and a step of setting a path of the logistics robot between a starting point and a destination according to the mission information of the logistics robot, based on the area rule in which the determination is considered.
- [9] For example, the predetermined area may correspond to the movement area or a predetermined zone including at least a part of the movement area.

- [10] For example, the area rule may include at least one of an activation status of the movement area or the movable direction of the movement area.
- [11] For example, the area rule may further include at least one of a center offset of a virtual lane, waiting before entry, position, size, and deceleration of the logistics robot within the virtual lane.
- [12] For example, the determining may comprise a step of changing the area rule of the movement area associated with the predetermined area based on a determination that the occupancy number of the logistics robot reaches the occupancy limit number.
- [13] For example, based on determining generation of a detour movement path according to reaching of the occupancy limit number, the method may further comprise a step of generating the detour movement path according to the changed area rule.
- [14] For example, the step of setting the occupancy limit number comprises a step of setting multiple occupancy limit numbers by state according to a state of each of the logistics robots, and the step of changing may be performed based on a determination that any one of the multiple occupancy limit numbers by state is satisfied.
- [15] For example, the state of each of the logistics robots may include at least one of a normal state, an error state, a loading status, a type of load during loading, and a mission execution state associated with a predetermined mission.
- [16] For example, the information associated with the occupancy number of the logistics robot may be determined by considering at least one of a movement direction of each logistics robot existing within the movement area, a position on the movement area, and a velocity.

- [17] Also, a control device configured to control a logistics robot operating within a preset operation boundary according to an embodiment comprises: a map management unit configured to set an area rule including a movable direction for at least one movement area variably settable within the operation boundary; and a work schedule management unit configured to determine whether to change the area rule of the movement area associated with the predetermined area based on state information including at least one of information associated with an occupancy number of the logistics robot in a predetermined area within the operation boundary, mission information for the logistics robot, and information associated with the process state, and to set a path of the logistics robot between a starting point and a destination according to the mission information of the logistics robot, based on the area rule in which the determination is considered.
- [18] For example, the predetermined area may correspond to the movement area or a predetermined zone including at least a part of the movement area.
- [19] For example, the area rule may include at least one of an activation status of the movement area or the movable direction of the movement area.
- [20] For example, the area rule may further include at least one of a center offset of a virtual lane, waiting before entry, position, size, and deceleration of the logistics robot within the virtual lane.
- [21] For example, the map management unit sets an occupancy limit number of the logistics robot for the predetermined area, and the work schedule management unit may change the area rule of the movement area associated with the predetermined area based on a determination that the occupancy number of the logistics robot reaches the occupancy limit number.

- [22] For example, the work schedule management unit may generate the detour movement path according to the changed area rule based on determining generation of a detour movement path according to reaching of the occupancy limit number.
- [23] For example, the map management unit sets multiple occupancy limit numbers by state according to a state of each of the logistics robots, and the work schedule management unit may change the area rule of the movement area associated with the predetermined area based on a determination that any one of the multiple occupancy limit numbers by state is satisfied.
- [24] For example, the state of each of the logistics robots may include at least one of a normal state, an error state, a loading status, a type of load during loading, and a mission execution state associated with a predetermined mission.
- [25] For example, the information associated with the occupancy number of the logistics robot may be determined by considering at least one of a movement direction of each logistics robot existing within the movement area, a position on the movement area, and a velocity.

Advantageous Effects

- [26] According to the present invention, movement of a logistics robot can be smoothly facilitated by changing a property of a movement area for the logistics robot according to state information within an operation boundary to generate a detour movement path of the logistics robot.
- [27] The effects obtainable from the present invention are not limited to the effects mentioned above, and other effects not mentioned will be clearly understood by a person having ordinary skill in the art to which the present invention belongs from the description below.

Description of Drawings

- [28] FIG. 1 is a block diagram showing an example of an operation boundary configuration applicable to embodiments of the present invention.
- [29] FIG. 2 is a block diagram showing an example of a control device configuration applicable to embodiments of the present invention.
- [30] FIG. 3 is a block diagram showing an example of a work schedule management unit configuration included in a control device applicable to embodiments of the present invention.
- [31] FIG. 4 is a block diagram showing an example of a logistics robot configuration applicable to embodiments of the present invention.
- [32] FIG. 5 is a perspective view showing an example of a logistics robot exterior applicable to embodiments of the present invention.
- [33] FIG. 6 is a flowchart showing an example of a driving process of a logistics robot applicable to embodiments of the present invention.
- [34] FIG. 7 is a sequence diagram configured to explain a method of generating a detour movement path of a logistics robot according to an embodiment of the present invention.
- [35] FIGS. 8a, 8b, 9, 10a, 10b, 10c, and 10d are drawings configured to explain a process in which a logistics robot performs detour movement or waiting according to an embodiment of the present invention.
- [36] FIG. 11 is a drawing configured to explain a process in which an activation status of a movement path for a logistics robot is controlled according to an embodiment of the present invention.

Mode for Disclosure

- [37] Hereinafter, embodiments disclosed in the present specification will be described in detail with reference to the accompanying drawings, and the same or similar components are assigned the same reference numerals regardless of drawing symbols, and redundant descriptions thereof will be omitted. The suffixes "module" and "unit" for components used in the following description are given or mixed only by considering ease of specification writing, and do not have meanings or roles that are distinguished from each other by themselves. Also, in describing the embodiments disclosed in the present specification, when it is determined that a detailed description of related known technology may obscure the gist of the embodiments disclosed in the present specification, the detailed description thereof is omitted. Also, the accompanying drawings are only for easily understanding the embodiments disclosed in the present specification, and the technical ideas disclosed in the present specification are not limited by the accompanying drawings, and it should be understood to include all changes, equivalents, and substitutes included in the spirit and technical scope of the present invention.
- [38] Terms including ordinal numbers such as first, second, and so on may be used to describe various components, but the components are not limited by the terms. The terms are used only for the purpose of distinguishing one component from another component.
- [39] When a component is mentioned as being "connected to" or "accessing" another component, it should be understood that it may be directly connected to or directly accessing the another component, but another component may exist in the middle. On the other hand, when a component is mentioned as being "directly connected to" or "directly accessing" another component, it should be understood that no other component exists in the middle.

- [40] Singular expressions include plural expressions unless the context clearly indicates otherwise.
- [41] In the present specification, terms such as "comprising" or "having" are intended to designate that a feature, number, step, operation, component, part, or combination thereof described in the specification exists, and it should be understood that they do not preclude the existence or addition of one or more other features, numbers, steps, operations, components, parts, or combinations thereof.
- [42] Also, the unit or control unit included in the internal configuration names of the logistics robot or control device is only a term widely used for naming a controller configured to control a specific function, and does not mean a generic function unit. For example, each controller may include a modem/transceiver configured to communicate with another controller or sensor for controlling a function in charge, a memory configured to store an operating system, logic commands, input/output information, and so on, and one or more processors configured to perform determinations, calculations, decisions, and so on necessary for controlling the function in charge. According to an implementation, one processor may be in charge of calculations for multiple controllers.
- [43] First, the configuration of an operation boundary in which a logistics robot according to an embodiment is disposed and operated is described with reference to FIG. 1.
- [44]
- [45] FIG. 1 is a block diagram showing an example of an operation boundary configuration applicable to embodiments.
- [46] Referring to FIG. 1, operation boundary 100 may include logistics robot 110, production device 120, monitoring device 130, and control device 140.

- [47] Operation boundary 100 may be equipped with multiple logistics robots 110, multiple production devices 120, and multiple detection devices 130 according to a production process of a product and a target production speed. Operation boundary 100 may be implemented as a smart factory, but is not necessarily limited thereto. Hereinafter, each component is described.
- [48] First, logistics robot 110 may include an Autonomous Mobile Robot (hereinafter, referred to as 'AMR' for convenience) and an Automated Guided Vehicle (hereinafter, referred to as 'AGV' for convenience). In operation boundary 100, only one type of AGV or AMR may be operated according to an operation policy of logistics robot 110, or AGV and AMR may be operated together within operation boundary 100.
- [49] An AGV generally performs operations required within operation boundary 100 (movement, direction change, stop, and so on) by recognizing and following guidance facilities disposed at a floor for guiding the AGV. Here, the guidance facilities may mean optically recognizable markers (spots, 2D codes, and so on), tags recognizable in a non-contact manner at a short distance (for example, NFC tags, RFID tags, and so on), magnetic strips, wires, and so on, but this is exemplary and not necessarily limited thereto. The guidance facilities may be disposed continuously at the floor, or may be disposed discontinuously and spaced apart from each other. Since the AGV basically performs operations through recognition and following of guidance facilities, it requires that guidance facilities are installed in advance before operation, so when moving the AGV to a new path or modifying an existing path, it is necessary that new installation or modification of guidance facilities is physically performed. Also, since the AGV does not deviate from a path set through guidance facilities, when an obstacle is detected on a path or periphery, the AGV generally stops until the detected obstacle disappears or receives separate control. In

operating the AGV, control device 140 must control the AGV based on guidance facilities, so control device 140 may transmit a command meaning 'driving until a 3rd marker is recognized at a current position', 'converting a heading direction by 90 degrees when the 3rd marker is recognized', and so on to the AGV in units of individual commands or in units of missions including multiple commands (for example, collection, supply, charging, patrol, and so on).

- [50] The AMR can determine a current position (that is, localization) through peripheral detection, and the most distinguishable point from the AGV is that path planning is possible by itself using localization and a map. Therefore, when a map in which coordinates are compatible is shared with the AMR and control device 140, control device 140 can control the AMR in a manner of instructing a path to the AMR based on coordinates. Also, when an obstacle is detected during driving, the AMR can set an avoidance path by itself, avoid the obstacle, and then return to an existing path. A function in which control device 140 sets a path of the AMR with one or more waypoint coordinates may be referred to as global path planning, and a function in which the AMR sets a movement path or sets an avoidance path between waypoint coordinates according to global path planning may be referred to as local path planning.
- [51] A more detailed configuration of logistics robot 110 will be described later with reference to FIGS. 4 and 5, and a driving control process of the AMR will be described later with reference to FIG. 6, respectively.
- [52] Next, production device 120 may mean a device (for example, a robot arm, a conveyor belt, and so on) configured to perform a production process of a product in operation boundary 100, and in a broader sense, may mean a device disposed to assist mission execution such as entry and exit of logistics robot 110 when a production process is performed by a person. A

device disposed to assist mission execution may be a device configured to detect a state of a designated position where logistics robot 110 can put down or collect a pallet carried in an area where a specific production process is performed, a device configured to determine process progress, an entry blocking means within an area, and so on, but is not necessarily limited thereto.

- [53] For example, production device 120 is controlled through a Programmable Logic Controller (PLC), and may perform communication with control device 140 in relation to process progress.
- [54] Monitoring device 130 may perform a function of acquiring information for determining a situation within operation boundary 100 and transmitting it to control device 140. For example, monitoring device 130 may include a camera, a proximity sensor, and so on, but is not necessarily limited thereto.
- [55] Control device 140 may perform communication with the above-described components 110, 120, 130 to acquire information necessary for operation of operation boundary 100 or control each component. For example, control device 140 may perform dispatching of logistics robot 110, path setting, mission assignment, process management by product, material management, and so on.
- [56] In an implementation, control device 140 may include an AMR/AGV Control System (ACS) configured to control peripheral process facilities based on positions of AGVs/AMRs and perform mission-based control of AGVs/AMRs, and a Mobile Robot Integrated Monitoring System (MoRIMS) configured to integrate and control two or more ACSs. The MoRIMS may perform states and paths of all logistics robots 110 within operation boundary 100, logistics flow setting, and traffic control from each of multiple ACSs. For example, when an ACS is provided in units of logistics robots of the same manufacturer

or the same model, the MoRIMS may perform integrated control for collision prevention such as analysis of a bottleneck level of a crossing/overlapping area, driving acceleration/deceleration control, avoidance path regeneration, and so on through traffic distribution control between different types based on information acquired through multiple ACSs.

- [57] In addition, the MoRIMS may also have a Manufacturing Execution System (MES) as its upper control subject, and the MES may be interlocked with an Advanced Planning & Scheduling (APS) again.
- [58] Of course, in addition to the configuration 110, 120, 130, 140 of operation boundary 100 described above, devices for mutual communication between each component such as beacons, repeaters, APs (Access Points), and so on, chargers for charging logistics robot 110, loading spaces for storing or loading components, spaces where finished products or intermediate products are stored, traffic lights, barriers, standby spaces for idle logistics robots 110, and so on may be appropriately disposed within operation boundary 100.
- [59] Hereinafter, the configuration of control device 140 applicable to embodiments of the present invention is described with reference to FIG. 2.
- [60] FIG. 2 is a block diagram showing an example of a control device configuration applicable to embodiments of the present invention. Each component shown in FIG. 2 is mainly shown as a component related to embodiments of the present invention, and more or fewer components may be included in actual implementation of control device 140.
- [61] Referring to FIG. 2, control device 140 may include firmware management unit 141, traffic control unit 142, process management unit 143, production/logistics management unit 144, inventory management unit 145, communication unit 146, job

generation unit 147, map management unit 148, and work schedule management unit 149.

- [62] Firmware management unit 141 acquires latest firmware of logistics robot 110 through communication unit 146, and may transmit it to logistics robot 110 so that firmware update is performed to maintain firmware of logistics robot 110 in a latest state.
- [63] Traffic control unit 142 controls traffic lights and barriers based on a path of logistics robot 110, and may recalculate a path of logistics robot 110 according to traffic.
- [64] Process management unit 143 may define processes by product, and manage missions such as process progress and progress position.
- [65] Production/logistics management unit 144 may dispatch logistics robot 110 based on missions.
- [66] Inventory management unit 145 manages positions and quantities by material, and such information may be useful for more efficient process operation, such as sending logistics robot 110 to a destination in advance before a time point when actual assembly/consumption of material is detected for pallet pickup or collection.
- [67] Communication unit 146 may perform communication with internal components of operation boundary 100 such as logistics robot 110, production device 120, and monitoring device 130, as well as external entities such as firmware update servers and so on.
- [68] The job generation unit receives logistics sequence information from a Manufacturing Execution System (MES, not shown), process state information and component supply information from production device 120, and process peripheral monitoring information from monitoring device 130 through communication unit 146, and may generate mission (Job)

information for logistics robot 110 based on the received information and transmit it to work schedule management unit 149 to be described later. The mission information may include starting point and destination information for each logistics robot 110.

- [69]** Map management unit 148 acquires map data in a grid map form acquired by an AMR among logistics robots 110 while driving through interior of operation boundary 100, and may provide a tool through which a factory manager can edit the acquired map data. Through editing of map data, an area (zone) where logistics robot 110 performs one or more operations set in advance upon entry, a virtual lane, an intersection, a no-entry area, and so on may be set, but this is exemplary and not necessarily limited thereto.
- [70]** Here, a zone may include one or more virtual lanes, and a virtual lane may be referred to as a movement area. For example, in a case of an intersection zone in which an intersection where multiple virtual lanes meet is designated as one zone, it may be viewed as being configured with multiple movement areas.
- [71]** Map management unit 148 may set an area rule (or property) for each such movement area (lane) and each zone. The area rule may include at least one of an activation status of a movement area (lane) or zone (non-movable during deactivation), a driving direction, a center offset of a virtual lane that becomes a driving reference line when logistics robot 110 drives, waiting before entry, position and size, and speed adjustment of logistics robot 110 within the virtual lane, but this is exemplary and not necessarily limited thereto. Here, when speed adjustment of logistics robot 110 within the virtual lane is implemented in a form of deceleration, when a specific area is excessively congested, collision risk can be improved by entering and driving at a low speed in the area.

- [72] Also, map management unit 148 may distribute the map through communication unit 146 to remaining logistics robots 110 other than logistics robot 110 that acquired an initial grid map through actual driving.
- [73] Work schedule management unit 149 may determine whether to change an area rule based on at least one of process information of operation boundary 100 received through communication unit 146 from production device 120 and monitoring device 130, mission information of logistics robot acquired from job generation unit 147, and an area rule change condition, and may generate or adjust a global path of logistics robot 110 based on an area rule in which the determination result is reflected.
- [74] Exemplary area rule change conditions are as follows, and two or more exemplary conditions may be combined.
- [75] - Occupancy number of logistics robots within a specific LANE/ZONE
- [76] - State information of logistics robots occupying a specific LANE/ZONE (logistics robot type, loading status, type of load during loading, error status, position path, position within area, and so on)
- [77] - Number of logistics robots having specific state information within a specific LANE/ZONE
- [78] - In case of a position within a specific LANE/ZONE, can be included as a count target when at a beginning of a path according to the area, and can be excluded when at a later part
- [79] - Path direction and position of a logistics robot trying to enter a specific LANE/ZONE and path direction and position of an occupying logistics robot can be considered
- [80] - Mission/JOB information, for example, a mission/JOB defined by comprehensively considering logistics sequence received

from MES, component supply information, process state information, and monitoring information

- [81] - Component supply information (supply component type, form, size, and so on)
- [82] - Process state information (information received from facility PLC)
- [83] - Monitoring information (information received from sensors around facility)
- [84] A more specific configuration and operation method of work schedule management unit 149 is described with reference to FIG. 3.
- [85] FIG. 3 is a block diagram showing an example of a work schedule management unit configuration included in a control device applicable to embodiments of the present invention.
- [86] Referring to FIG. 3, work schedule management unit 149 may include mission group management unit 149a, operation mission management unit 149b, priority calculation unit 149c, control operation state management unit 149d, and movement path setting unit 149e.
- [87] Mission group management unit 149a may group missions of logistics robot 110 based on process information, and manage grouped missions.
- [88] Operation mission management unit 149b may create a list for missions of logistics robot 110 currently in progress, and monitor the created list.
- [89] Priority calculation unit 149c may determine priorities for missions of logistics robot 110, and change and monitor the determined priorities.
- [90] Control operation state management unit 149d may monitor and compare operation states of logistics robot 110 and production facility control states of PLC based on data of

mission group management unit 149a, operation mission management unit 149b, and priority calculation unit 149c. Also, control operation state management unit 149d may determine whether to change an area rule based on at least one of process information of operation boundary 100 received through communication unit 146 from production device 120 and monitoring device 130, mission information of logistics robot acquired from job generation unit 147, and an area rule change condition.

- [91] Movement path setting unit 149e may set an optimal global path for logistics robot 110 according to a mission set in mission group management unit 149a, based on an area rule currently applied to at least one of a virtual lane or a zone.
- [92] Next, a logistics robot is described with reference to FIGS. 4 and 5.
- [93] FIG. 4 is a block diagram showing an example of a logistics robot configuration applicable to embodiments of the present invention.
- [94] Referring to FIG. 4, logistics robot 110 may include driving unit 111, sensing unit 112, loading unit 113, communication unit 114, and controller 115. Hereinafter, each component is described.
- [95] Driving unit 111 may include a drive source, wheels, suspension, and so on related to movement, steering, and stopping of logistics robot 110. An electric motor configured to receive power from a built-in battery (not shown) may be used as the drive source. The wheels may include one or more driving wheels configured to receive driving force from the drive source, and non-driving wheels configured to rotate by movement of a vehicle body without receiving driving force. According to an implementation, when multiple driving wheels are provided, a drive source may be matched for each driving wheel so that rotation of each driving wheel can be controlled

independently. In such a case, steering can be performed by rotating the vehicle body without a separate steering means by making rotation directions of different driving wheels different. At least some of the non-driving wheels may be configured as caster-type wheels, but this is exemplary and not necessarily limited thereto.

- [96] Sensing unit 112 is configured to detect a peripheral environment of logistics robot 110, its own operation state, and so on, and may include at least one of a 2D laser scanner (for example, LiDAR), a 3D vision (stereo) camera, a multi-axis gyro sensor, an acceleration sensor, a wheel encoder, and a proximity sensor.
- [97] The encoder may output information capable of determining how much a wheel has rotated using light emitted from a light emitting element (for example, a photodiode). For example, the encoder may count a number of slits disposed along a circumferential direction on a wheel or a disc rotating with the wheel per unit time. Controller 115 can perform odometry configured to estimate displacement by analyzing a position change amount versus time with data acquired through the encoder and gyro sensor. However, there may be an error between displacement estimated based on encoder data and actual displacement because slip or wear of the wheel (change of wheel companion radius). Therefore, when performing odometry, controller 115 may output a result having a tendency close to an actual value by performing correction for noise and error with information collected from an overgyro sensor by a predetermined algorithm (for example, Extended Kalman Filter (EKF)). Such odometry can be particularly useful when current position determination (Localization) using a 2D laser scanner to be described later is impossible.
- [98] The 2D laser scanner can scan a peripheral environment by irradiating a laser to periphery through a rotating reflector and detecting a signal reflected and returned. At this time,

a detection result in a point cloud form can be output by analyzing intensity of the reflected signal and a time difference between irradiation/reception.

[99] A 3D vision camera can calculate a distance to an object based on parallax between two cameras spaced apart by a certain distance, that is, a pixel distance between images captured through each camera. At this time, a texture projector configured to project infrared light of a predetermined pattern may be provided so that detection is possible even for a flat body of the same color (for example, a white wall).

[100] In general, a 2D laser scanner is used for mapping, navigation, object recognition, and so on, and a 3D camera can be utilized for navigation and particularly obstacle avoidance, but this is exemplary and not necessarily limited thereto.

[101] Loading unit 113 is a means for loading goods to be transferred, and may be a top plate itself of an upper part of a vehicle body or a table disposed on the top plate, a lift, a turntable rotating along a vertical axis, a fork lift, a conveyor, or a combination form thereof. In a case of a fork lift, it may support telescopic and tilting functions similarly to a forklift.

[102] Communication unit 114 may perform communication with other components within operation boundary 100 such as production device 120, control device 140, and so on, may also support communication between logistics robots 110, and can also communicate with a charger when performing a charging mission.

[103] Controller 115 is a subject configured to perform overall control of each component 111, 112, 113, 114 described above, and may perform a current mission, current position, destination determination, path planning, loading unit

control, and so on based on information acquired from control device 140 through communication unit 114.

[104] FIG. 5 is a perspective view showing an example of a logistics robot exterior applicable to embodiments of the present invention.

[105] Referring to FIG. 5, an example of an AMR is shown as logistics robot 110. The vehicle body may have a track-type planar shape having a long axis extending along a 1-axis direction as a whole. One driving wheel 111-1 is disposed at a center part of the vehicle body in the 1-axis direction, and may be disposed at one side in the 2-axis direction, and another driving wheel (not shown) may be disposed at another side so as to face one driving wheel 111-1 in the 2-axis direction. Such a driving wheel arrangement may be referred to as a 'differential drive (DD)'. Although not shown in FIG. 4, two or more non-driving wheels may be disposed at a lower part of the vehicle body. In such a case, when two driving wheels rotate at the same speed in the same direction, forward movement or backward movement is possible along the 1-axis direction, and when they rotate at the same speed in opposite directions to each other, rotation is possible around a rotation axis extending along the 3-axis direction and passing through a planar center © of the vehicle body. Also, sensor unit 112 may be disposed at a front part of the vehicle body, and loading unit 113 may be disposed at a top surface part. Loading unit 113 may be configured to be capable of lifting along the 3-axis direction, and a rack or a tray and so on may be fixed through guide 113-1 at an upper surface.

[106] However, the AMR form of FIG. 5 described above is exemplary, and of course, an AGV may have a similar form to this, or an AMR may have a different form from this.

[107] Next, a driving process of logistics robot 110 is described with reference to FIG. 6.

- [108] FIG. 6 is a flowchart showing an example of a driving process of logistics robot 110 applicable to embodiments of the present invention. In FIG. 6, it is assumed for convenience that logistics robot 110 is an AMR capable of localization and local path planning.
- [109] Referring to FIG. 6, first, the AMR may acquire an actual measurement grid map through LiDAR and so on while driving through interior of operation boundary 100 (S601).
- [110] When the AMR transmits the acquired grid map to control device 140, a grid map editing and matching process may be performed in map management unit 148 of control device 140 (S602). Here, the editing process may include a process of setting various zones described above in the grid map described above, a process of assigning cost for each grid, and so on. Here, assignment of cost may be performed in a direction in which cost is assigned higher as closer to an obstacle or no-entry area so that the AMR does not move to periphery of an obstacle or an area where entry should not be made. This is because the AMR selects a set of cells having lowest cost as a path in setting a local path between waypoints.
- [111] Also, the map matching process may mean a process of matching coordinates between a CAD map used in design of operation boundary 100, an actual measurement grid map (LiDAR map), and a topology map that has gone through an editing process.
- [112] Thereafter, control device 140 may share the topology map to all AMRs in the factory through communication unit 146 (S603).
- [113] Subsequent steps may be a process applied to individual AMRs.
- [114] The AMR may determine a current position on the map through sensor data of sensing unit 112 and the acquired map

(localization) (S604). For example, the AMR may determine a current position by comparing peripheral terrain acquired through LiDAR and a map based on feature points.

[115] Control device 140 may select a specific AMR and assign a mission, and the mission may generally be assigned one or more waypoints determined through global path planning. A waypoint may be defined as a coordinate on a map, and information about a direction (that is, heading) toward which the AMR should face at the coordinate may be accompanied. According to such mission assignment, a destination may be set in the AMR (Yes of S605), and the AMR may perform local path planning between waypoints based on cost of the topology map (S606).

[116] When a path is determined, the AMR initiates driving (S507), and when an obstacle is detected through sensing unit 112 during driving (Yes of S608), local path search may be performed to avoid the detected obstacle and avoidance maneuver may be performed (S609). In some cases, according to avoidance maneuver or failure of avoidance maneuver, control device 140 may update a mission of the AMR.

[117] Also, the AMR may correct a position error during movement through the odometry technique described above during driving until reaching a destination (S610).

[118] Thereafter, when reaching the destination (S611), the AMR may perform mission-based maneuver (S612). For example, the AMR may determine whether conditions for entering a specific process area are cleared, collect an empty pallet at a destination, or drop a load loaded on loading unit 113.

[119] Above, the configuration and operation method of logistics robot 110, production device 120, monitoring device 130, and control device 140 included in operation boundary 100 applicable to embodiments of the present invention have been described.

[120]

[121] Hereinafter, an operation method of a logistics system configured to generate a detour movement path of a logistics robot by changing a property of a movement area for the logistics robot according to state information within an operation boundary in controlling logistics robot operating within a preset operation boundary by a control device is described.

[122] FIG. 7 is a sequence diagram configured to explain a process in which a logistics system according to an embodiment of the present invention sets a movement path of a logistics robot operating within a preset operation boundary. In FIG. 7, it is assumed for convenience that logistics robot 110 is an AMR capable of localization and local path planning.

[123] Referring to FIG. 7, map management unit 148 of control device 140 may variably set at least one of a size or a position of at least one movement area on a map of a preset operation boundary, and set an area rule including a movable direction, an offset of a driving reference line, and so on in each movement area variably settable (S710). At this time, the movement area may be designated on a CAD map used in design of operation boundary, but is not necessarily limited thereto. An area rule related to a movement area may be activated or deactivated according to facility information of operation boundary. For example, a movable direction of a movement area may be set to any one of a first longitudinal direction of the movement area, a second longitudinal direction facing the first longitudinal direction, and a bidirectional direction including the first and second longitudinal directions. Also, a driving reference line of a movement area may be adjusted according to a value of offset based on a center line of each of multiple movement areas. More specifically, the driving reference line may be shifted to one side of the center line or shifted to another side of

the center line according to a value of offset. For example, the driving reference line is set to a center line of the movement area when a value of offset corresponds to '0', is shifted to one side (for example, left) of the center line of the movement area when a value of offset corresponds to a positive number, and may be shifted to another side (for example, right) of the center line of the movement area when a value of offset corresponds to a negative number.

[124] Also, map management unit 148 of control device 140 may set an occupancy limit number of logistics robot 110 for a predetermined area (S701). Here, the predetermined area corresponds to the movement area or a predetermined zone including at least a part of the movement area, and the predetermined zone may correspond to a traffic zone corresponding to a crossroad or an interlock zone.

[125] Map management unit 148 may transmit configuration information including an area rule for the predetermined area and movement area to work schedule management unit 149 (S720).

[126] Thereafter, optimal path control (S730) for logistics robot 110 in which whether to change an area rule according to an embodiment is reflected may be performed. The optimal path control (S730) process may be repeatedly performed according to satisfaction of a preset condition. For example, a repetitive execution condition of the process (S730) may be arrival of a specific point such as a waypoint by individual logistics robot 110, but is not necessarily limited thereto.

[127] Hereinafter, a specific process in which optimal path control (S730) is performed is described.

[128] Production device 120 and monitoring device 130 may transmit process information of operation boundary to job generation unit 147 (S731, S732, S733). More specifically, production device 120 may transmit process state information and component supply information to job generation unit 147

(S731, S733), and monitoring device 130 may transmit process peripheral monitoring information to job generation unit 147 (S732). Although not shown, each information transmitted from production device 120 and monitoring device 130 to job generation unit 147 (that is, process information of operation boundary) may be shared to other components within control device 140 such as work schedule management unit 149 and so on.

- [129]** Job generation unit 147 may generate Job (mission) information including starting point and destination information of logistics robot 110 based on the acquired information and transmit it to work schedule management unit 149.
- [130]** Meanwhile, logistics robot 110 may transmit state information such as path, position, error status, and so on to work schedule management unit 149.
- [131]** Schedule management unit 149 may determine whether to change an area rule based on at least one of process information of operation boundary 100 received through communication unit 146 from production device 120 and monitoring device 130, mission information of logistics robot acquired from job generation unit 147, logistics robot state information, and a preset area rule change condition (for example, occupancy number of logistics robot in predetermined area reaches occupancy limit number), and through this, may determine an area rule (that is, property of Lane/Zone) (S736).
- [132]** Work schedule management unit 149 may generate or adjust a global path of logistics robot 110 based on an area rule in which a determination result is reflected. More specifically, work schedule management unit 149 may instruct logistics robot 110 to decelerate or wait for a specific time when necessary (S737), or may select an optimal path based on an area rule in which a determination result of whether to change is reflected (S738). Here, the selected optimal path may mean

a global path including one or more waypoints, and may be the same as an existing path or may be in a form of a detour path or a shortened path in which at least a part is modified.

[133] Also, a target of change of an area rule may be associated with a predetermined zone in which an area rule change condition is satisfied. In other words, a target of change of an area rule may be the predetermined zone itself in which an area rule change condition is satisfied, or may further include a movement area (Lane) for providing a detour path around it together with it. For example, when an occupancy number of logistics robots 110 occupying a predetermined zone reaches a preset limit number, the zone is assigned a non-movable property, and accordingly, an area rule may be changed so that a driving direction of a movement area (Lane) around the zone is reversed or added so that detour is possible for another logistics robot 110 that cannot pass through the zone. At this time, an occupancy number of logistics robots 110 occupying an area may be determined by considering a movement direction, a movement speed, a position on the area, and so on of each logistics robot 110 existing within the area. For example, considering a position, movement direction, and speed of a specific logistics robot, when it is expected to deviate from an area within a preset time (for example, 3 seconds and so on), the specific logistics robot may be excluded in calculating an occupancy number of logistics robots occupying the area. This is because even if another robot requiring optimal path calculation passes through the area, since there is a high possibility that the specific logistics robot has already deviated from that area at a time point when the another robot arrives, it may not substantially affect occurrence of congestion in that area.

[134] Waypoint information corresponding to the selected optimal path may be transmitted to logistics robot 110 (S739).

- [135] For example, work schedule management unit 149 may determine whether to set a state of logistics robot 110 to a standby state or whether to generate a detour movement path for logistics robot 110 by considering at least one of an occupancy rate of a movement area or an offset of a driving reference line of a movement area. Here, work schedule management unit 149 may determine generation of the detour movement path when a state of logistics robot 110 located in a movement area where an occupancy limit number of logistics robot 110 has been reached is an error state.
- [136] Work schedule management unit 149 of control device 140 may delete a movement path assigned to logistics robot 110 according to a job regeneration request received from logistics robot 110 when determining generation of a detour movement path, and set a detour movement path of logistics robot 110 according to a property of a movement area.
- [137] FIGS. 8a, 8b, 9, 10a, 10b, 10c, and 10d are drawings configured to explain a process in which a logistics robot performs detour movement or waiting according to an embodiment of the present invention.
- [138] Referring to FIG. 8a, in an operation boundary in which movement areas 801 and 802 having different movable directions from each other are disposed side by side, logistics robot A enters movement area 801 in which an area rule is set in a downward direction.
- [139] Accordingly, work schedule management unit 149 performs optimal path control (S730) described above with reference to FIG. 7. For example, when an occupancy limit number for predetermined area 810 on movement area 801 is set to '1', the occupancy limit number is satisfied by logistics robot B. In such a case, work schedule management unit 149 may change predetermined area 810 to a non-movable property, and determine a change of an area rule so that a movement direction of movement area 802 on an opposite side of area

810 is reversed as shown in FIG. 8b. Also, work schedule management unit 149 may transmit a waypoint so that logistics robot A moves down through movement area 802 according to the changed area rule. Therefore, logistics robot A can ultimately avoid or overtake logistics robot B by using lane 802 near existing lane 801.

[140] Referring to FIG. 9, a detour movement path in which logistics robot A performs overtaking driving for logistics robots B and C that have entered first in a traffic zone TZ set in one movement area among two-lane movement areas having the same movable direction is shown. For example, when an occupancy limit number for traffic zone TZ is set to '2', work schedule management unit 149 may change an area rule of the zone TZ to 'non-movable' and provide detour path information to logistics robot A.

[141] In FIG. 10a, a situation is assumed in which, to arrive at a destination of logistics robot A, it is necessary to enter movement area 1030 having a downward movement direction through one movement area 1010 among two-lane movement areas having opposite movable directions from each other.

[142] According to approach of logistics robot A to movement area 1010, work schedule management unit 149 performs optimal path control (S730) described above with reference to FIG. 7.

[143] For example, when an occupancy limit number for traffic zone TZ set in one movement area 1010 is set to '2', the occupancy limit number is satisfied by logistics robots B and C that have entered first in the zone TZ, and work schedule management unit 149 changes an area rule of the zone TZ to 'non-movable'. Also, work schedule management unit 149 may change a movement direction property of movement area 1020 near traffic zone TZ to bidirectional to provide a path for entering movement area 1030 that logistics robot A must pass through, as shown in FIG. 10b. Thereafter, work schedule management unit 149 may provide an optimal movement path

entering movement area 1030 having a downward movement direction through movement area 1020 near traffic zone TZ to logistics robot A according to the changed area rule. At this time, a state of late-entering logistics robot D may be in a standby state. Of course, since an area rule of movement area 1020 near traffic zone TZ has a bidirectional movement property, after logistics robot A passes through the area 1020, late-entering logistics robot D can use the area 1020 in a direction in which it was originally proceeding.

[144] Unlike FIG. 10b in which an area rule of movement area 1020 near traffic zone TZ is changed, as shown in FIG. 10c, work schedule management unit 149 may activate slave lane 1010' of movement area 1010 entered by logistics robot A and provide a detour path to go back a way it came.

[145] In FIG. 10d, an assumption similar to FIG. 10a is applied, and it is assumed that an occupancy limit number for traffic zone TZ is set to '3'. In such a case, the occupancy limit number is satisfied by logistics robots B, C, D that have entered first in the zone TZ, and work schedule management unit 149 changes an area rule of the zone TZ to 'non-movable'. However, since work schedule management unit 149 is in a situation where use of a detour path as in FIG. 10a is impossible (that is, zone TZ detour impossible even by changing a movement direction of an arbitrary movement area), it may transmit a waiting or deceleration command to logistics robot A (that is, S737 of FIG. 7). Thereafter, when at least one of logistics robots B, C, D that have entered first deviates from the zone TZ, work schedule management unit 149 may change an area rule of zone TZ to 'movable' again, and provide an optimal path to the logistics robot A by reflecting this. Of course, as described above, when considering a direction, movement speed, and position, and so on of each of logistics robots B, C, D that have entered first, when at least one is expected to deviate from zone TZ within a predetermined time, a logistics robot expected to deviate is

excluded from occupancy count, so an area rule of zone TZ is maintained and logistics robot A may immediately enter the zone TZ.

[146] FIG. 11 is a drawing configured to explain a process in which an activation status of a movement path for a logistics robot is controlled according to an embodiment of the present invention. Referring to FIG. 11, movement area 1103 disposed between first process area 1101 and second process area 1102 is shown. At this time, a process direction may correspond to a direction from first process area 1101 to second process area 1102. For example, assuming operation boundary is an automobile factory, when an AGV carrying a vehicle chassis loaded moves from first process area 1101 to second process area 1102 across movement area 1103, a PLC of production device 120 may notify this to control device 140 and request deactivation of movement area 1103. At this time, when a condition that an occupancy limit count of movement area 1103 is satisfied by movement of the AGV is set as an area rule change condition together with a PLC signal, an interlock function can be substantially implemented.

[147] In contrast, control device 140 may activate deactivated movement area 1103 so that logistics robot A enters movement area 1103 when it is determined that processes of first process area 1101 and second process area 1102 are not proceeding based on information about process state. Meanwhile, the present invention described above can be implemented as a computer-readable code on a medium in which a program is recorded. A computer-readable medium includes all types of recording devices in which data readable by a computer system is stored. Examples of computer-readable media include HDD (Hard Disk Drive), SSD (Solid State Disk), SDD (Silicon Disk Drive), ROM, RAM, CD-ROM, magnetic tape, floppy disk, optical data storage device, and so on. Therefore, the detailed description above should not be interpreted restrictively in all aspects and should be considered as

exemplary. The scope of the present invention should be determined by reasonable interpretation of the appended claims, and all changes within an equivalent range of the present invention are included in the scope of the present invention.

CLAIMS

[Claim 1]

A method of controlling a logistics robot operating within a preset operation boundary, the method comprising:

setting an area rule including a movable direction for at least one movement area variably settable within the operation boundary;

determining whether to change the area rule of the movement area associated with the predetermined area, based on state information including at least one of information associated with an occupancy number of the logistics robot in a predetermined area within the operation boundary, information associated with a process state within the operation boundary, and mission information for the logistics robot; and

setting a path of the logistics robot between a starting point and a destination according to the mission information of the logistics robot, based on the area rule in which the determination is considered.

[Claim 2]

The method of claim 1, wherein the predetermined area corresponds to the movement area or a predetermined zone including at least a part of the movement area.

[Claim 3]

The method of claim 1, wherein the area rule includes at least one of an activation status of the movement area or the movable direction of the movement area.

[Claim 4]

The method of claim 3, wherein the area rule further includes at least one of a center offset of a virtual lane, waiting before entry, position, size, and deceleration of the logistics robot within the virtual lane.

[Claim 5]

The method of claim 1, further comprising:

setting an occupancy limit number of the logistics robot for the predetermined area,

wherein the determining comprises:

changing the area rule of the movement area associated with the predetermined area based on a determination that the occupancy number of the logistics robot reaches the occupancy limit number.

[Claim 6]

The method of claim 5, further comprising:

generating the detour movement path according to the changed area rule based on determining generation of a detour movement path according to reaching of the occupancy limit number.

[Claim 7]

The method of claim 5, wherein the setting of the occupancy limit number comprises:

setting multiple occupancy limit numbers by state according to a state of each of the logistics robots, and

wherein the changing is performed based on a determination that any one of the multiple occupancy limit numbers by state is satisfied.

[Claim 8]

The method of claim 7, wherein the state of each of the logistics robots includes at least one of a normal state, an error state, a loading status, a type of load during loading, and a mission execution state associated with a predetermined mission.

[Claim 9]

The method of claim 1, wherein the information associated with the occupancy number of the logistics robot is determined by considering at least one of a movement direction of each logistics robot existing within the movement area, a position on the movement area, and a velocity.

[Claim 10]

A control device configured to control a logistics robot operating within a preset operation boundary, the control device comprising:

a map management unit configured to set an area rule including a movable direction for at least one movement area variably settable within the operation boundary; and

a work schedule management unit configured to determine whether to change the area rule of the movement area associated with the predetermined area based on state information including at least one of information associated with an occupancy number of the logistics robot in a predetermined area within the operation boundary, mission information for the logistics robot, and information associated with the process state, and to set a path

of the logistics robot between a starting point and a destination according to the mission information of the logistics robot, based on the area rule in which the determination is considered.

[Claim 11]

The control device of claim 10, wherein the predetermined area corresponds to the movement area or a predetermined zone including at least a part of the movement area.

[Claim 12]

The control device of claim 10, wherein the area rule includes at least one of an activation status of the movement area or the movable direction of the movement area.

[Claim 13]

The control device of claim 12, wherein the area rule further includes at least one of a center offset of a virtual lane, waiting before entry, position, size, and deceleration of the logistics robot within the virtual lane.

[Claim 14]

The control device of claim 11, wherein the map management unit sets an occupancy limit number of the logistics robot for the predetermined area, and

wherein the work schedule management unit changes the area rule of the movement area associated with the predetermined area based on a determination that the occupancy number of the logistics robot reaches the occupancy limit number.

[Claim 15]

The control device of claim 14, wherein the work schedule management unit generates the detour movement path according to the changed area rule based on determining generation of a detour movement path according to reaching of the occupancy limit number.

[Claim 16]

The control device of claim 14, wherein the map management unit sets multiple occupancy limit numbers by state according to a state of each of the logistics robots, and

wherein the work schedule management unit changes the area rule of the movement area associated with the predetermined area based on a determination that any one of the multiple occupancy limit numbers by state is satisfied.

[Claim 17]

The control device of claim 16, wherein the state of each of the logistics robots includes at least one of a normal state, an error state, a loading status, a type of load during loading, and a mission execution state associated with a predetermined mission.

[Claim 18]

The control device of claim 10, wherein the information associated with the occupancy number of the logistics robot is determined by considering at least one of a movement direction of each logistics robot existing within the movement area, a position on the movement area, and a velocity.