

DESCRIPTION**Invention Title: METHOD AND DEVICE FOR CONTROLLING
LOGISTICS ROBOT****Technical Field**

- [1] The present invention relates to a method and device for controlling a logistics robot that enables the logistics robot to move efficiently within an operation boundary.

Background Art

- [2] Logistics robots are being introduced for flexible and efficient supply and transfer of parts and the like in general logistics warehouses and factories, as well as in smart factories that manufacture products of different specifications using various parts.
- [3] A logistics robot is a collective term for an autonomous mobile robot (AMR: Autonomous Mobile Robot) and an automated guided vehicle (AGV: Automated Guided Vehicle), and such a logistics robot may perform movement and tasks according to control by a control device.
- [4] In a smart factory, a logistics robot may move along an optimal movement route based on path planning to perform a mission assigned from a control device.
- [5] Meanwhile, in a process where the logistics robot moves along the movement route as described above, when a direction change of a large angle is required, such as entering an intersection, the logistics robot decelerates, rotates, and accelerates for the direction change, and in this process, movement of the logistics robot may be delayed.

[6] Therefore, there is a need to present a method for reducing the time delayed due to the direction change of the logistics robot so that the logistics robot may move efficiently.

[7]

[8] 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 acknowledgment that they correspond to prior art already known to those of ordinary skill in the art.

Disclosure

Technical Problem

[9] An object of the present invention is to provide a method and device for controlling a logistics robot that may improve movement efficiency of the logistics robot by enabling the logistics robot to move while reducing the time required for direction change based on an area rule set at a waypoint.

[10]

[11] The problem of the present invention is not limited to the problems mentioned above, and other problems not mentioned may be clearly understood by those skilled in the art from the description below.

[12]

Technical Solution

[13] A method for controlling a logistics robot according to an embodiment of the present invention for realizing the above problem includes: designating a plurality of waypoints in a movable area for the logistics robot within a predetermined operation boundary, and setting an area rule for a waypoint where a predetermined turning condition is satisfied based on a relative positional relationship among the plurality of waypoints, among the plurality of waypoints; and transmitting

the plurality of waypoints and the area rule to the logistics robot such that the logistics robot moves according to the plurality of waypoints and the area rule within the operation boundary, wherein the area rule is set such that the logistics robot passes through a turning area set to include the waypoint where the turning condition is satisfied, while spaced apart from the waypoint where the turning condition is satisfied.

- [14] For example, the turning area may be defined as an area within a certain radius from the waypoint satisfying the turning condition.
- [15] For example, the method may further include designating a non-movable area for the logistics robot within the operation boundary, and the area rule may be set such that the logistics robot passes through the turning area while curved driving, spaced apart at least a predetermined turning distance from an outer edge of the non-movable area.
- [16] For example, the area rule may be set such that the logistics robot performs curved driving while moving a predetermined exit distance from the waypoint satisfying the turning condition, and the exit distance may be set to be equal to or less than a distance from the waypoint where the turning condition is satisfied to a next waypoint.
- [17] For example, the area rule may be set to be applied when the logistics robot enters within a predetermined entry distance from the waypoint where the turning condition is satisfied.
- [18] For example, the area rule may be set such that the logistics robot passes through while occupying the turning area equal to or less than a predetermined degree.
- [19] For example, the area rule may be set such that the logistics robot moves while in contact with a boundary of the turning area.

- [20] For example, the turning condition may be satisfied for a waypoint positioned in the middle in arrangement among the three waypoints, when a minimum angle formed by three consecutively arranged waypoints among the plurality of waypoints is equal to or less than a predetermined value.
- [21] For example, the area rule may be variable according to logistics robot information including at least one of whether a load is loaded on the logistics robot, a type, a task to be performed, and a speed.
- [22] For example, the area rule may be variable according to load information including at least one of a shape, a weight, a volume, and a type of a load loaded on the logistics robot.
- [23]
- [24] A control device for a logistics robot according to an embodiment of the present invention for realizing the above problem includes: a map management unit configured to designate a plurality of waypoints in a movable area for the logistics robot within a predetermined operation boundary, and to set an area rule for a waypoint where a predetermined turning condition is satisfied based on a relative positional relationship among the plurality of waypoints, among the plurality of waypoints; and a communication unit configured to transmit the plurality of waypoints and the area rule to the logistics robot such that the logistics robot moves according to the plurality of waypoints and the area rule within the operation boundary, wherein the area rule is set such that the logistics robot passes through a turning area set to include the waypoint where the turning condition is satisfied, while spaced apart from the waypoint where the turning condition is satisfied.
- [25] For example, the turning area may be defined as an area within a certain radius from the waypoint satisfying the turning condition.

- [26] For example, the map management unit may designate a non-movable area for the logistics robot within the operation boundary, and the area rule may be set such that the logistics robot passes through the turning area while curved driving, spaced apart at least a predetermined turning distance from an outer edge of the non-movable area.
- [27] For example, the area rule may be set such that the logistics robot performs curved driving while moving a predetermined exit distance from the waypoint satisfying the turning condition, and the exit distance may be set to be equal to or less than a distance from the waypoint where the turning condition is satisfied to a next waypoint.
- [28] For example, the area rule may be set to be applied when the logistics robot enters within a predetermined entry distance from the waypoint where the turning condition is satisfied.
- [29] For example, the area rule may be set such that the logistics robot passes through while occupying the turning area equal to or less than a predetermined degree.
- [30] For example, the area rule may be set such that the logistics robot moves while in contact with a boundary of the turning area.
- [31] For example, the turning condition may be satisfied for a waypoint positioned in the middle in arrangement among the three waypoints, when a minimum angle formed by three consecutively arranged waypoints among the plurality of waypoints is equal to or less than a predetermined value.
- [32] For example, the area rule may be variable according to logistics robot information including at least one of whether a load is loaded on the logistics robot, a type, a task to be performed, and a speed.

- [33] For example, the area rule may be variable according to load information including at least one of a shape, a weight, a volume, and a type of a load loaded on the logistics robot.

Advantageous Effects

- [34] According to various embodiments of the present invention as described above, it becomes possible to reduce the time required for deceleration, rotation, and acceleration in a process where the logistics robot performs a direction change to pass through a section that is not a straight section.
- [35] Through this, it becomes possible to improve movement efficiency of a single logistics robot, and furthermore, it becomes possible to alleviate traffic congestion due to movement among a plurality of logistics robots within the operation boundary through improvement of movement efficiency of each single logistics robot.
- [36] In addition, it becomes possible to reduce the cycle time of a transportation process through the logistics robot through improvement of movement efficiency of the logistics robot and alleviation of traffic congestion.

[37]

- [38] The effects obtainable from the present invention are not limited to the effects mentioned above, and other effects not mentioned may be clearly understood by those of ordinary skill in the art to which the present invention pertains from the description below.

Description of Drawings

- [39] FIG. 1 is a block diagram illustrating an example of an operation boundary configuration of a logistics system applicable to embodiments of the present invention.
- [40] FIG. 2 is a block diagram illustrating an example of a control device configuration applicable to embodiments of the present invention.

[41] FIG. 3 is a block diagram illustrating an example of a logistics robot configuration applicable to embodiments of the present invention.

[42] FIG. 4 is a diagram for explaining an area rule according to an embodiment of the present invention.

[43] FIG. 5 is a sequence diagram of logistics robot control according to an embodiment of the present invention.

Mode for Disclosure

[44] Specific structural or functional descriptions for the embodiments of the present invention disclosed in this specification or application are merely exemplified for the purpose of describing the embodiments according to the present invention, and the embodiments according to the present invention may be implemented in various forms and should not be construed as being limited to the embodiments described in this specification or application.

[45] Since the embodiments according to the present invention may be subjected to various modifications and may have various forms, specific embodiments are illustrated in the drawings and described in detail in this specification or application. However, this is not intended to limit the embodiments according to the concept of the present invention to specific disclosed forms, and should be understood to include all modifications, equivalents, or substitutes included in the spirit and technical scope of the present invention.

[46] In the description of the following embodiments, the term "predetermined" means that a numerical value of a parameter is determined in advance when the parameter is used in a process or algorithm. The numerical value of the parameter may be set when the process or algorithm starts or may be set during a period in which the process or algorithm is performed, depending on the embodiment.

- [47] Unless otherwise defined, all terms used herein, including technical or scientific terms, have the same meaning as commonly understood by those of ordinary skill in the art to which the present invention pertains. Terms such as those defined in commonly used dictionaries should be interpreted as having a meaning consistent with the meaning in the context of the related art, and should not be interpreted in an ideal or excessively formal sense unless explicitly defined in this specification.
- [48] Hereinafter, embodiments disclosed in this specification will be described in detail with reference to the accompanying drawings, and the same or similar components will be assigned the same reference numerals regardless of the drawing reference numerals, and redundant description thereof will be omitted.
- [49] The suffixes "module" and "unit" for components used in the following description are given or used interchangeably only for ease of writing the specification, and do not have meanings or roles that are distinct from each other by themselves.
- [50] In describing the embodiments disclosed in this specification, when it is determined that a detailed description of related known technologies may obscure the gist of the embodiments disclosed in this specification, the detailed description thereof will be omitted. In addition, the accompanying drawings are only for easy understanding of the embodiments disclosed in this specification, and the technical idea disclosed in this specification is not limited by the accompanying drawings, and should be understood to include all modifications, equivalents, or substitutes included in the spirit and technical scope of the present invention.
- [51] Terms including ordinal numbers such as first, second, and the like 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.

- [52] When a component is referred to as being "connected" or "coupled" to another component, it should be understood that the component may be directly connected or coupled to the other component, but other components may exist in between. On the other hand, when a component is referred to as being "directly connected" or "directly coupled" to another component, it should be understood that no other component exists in between.
- [53] Singular expressions include plural expressions unless the context clearly dictates otherwise.
- [54] In this specification, terms such as "comprises" or "has" should be understood to designate the presence of features, numbers, steps, operations, components, parts, or combinations thereof described in the specification, and do not preclude the possibility of the presence or addition of one or more other features, numbers, steps, operations, components, parts, or combinations thereof.
- [55] A controller may include a communication device that communicates with other controllers or sensors to control functions in charge, a memory that stores an operating system, logic instructions, and input/output information, and one or more processors that perform judgment, calculation, and determination necessary for control of the functions in charge.
- [56]
- [57] First, a configuration of an operation boundary in which a logistics robot according to an embodiment is disposed and operated will be described with reference to FIG. 1.

- [58] Referring to FIG. 1, the operation boundary 100 may include a logistics robot 110, a facility 120, a monitoring device 130, and a control device 140.
- [59] The operation boundary 100 may be provided with a plurality of logistics robots 110, a plurality of facilities 120, and a plurality of monitoring devices 130 according to a production process and a target production speed of a product. The operation boundary 100 may be implemented as a smart factory, and the plurality of facilities may be implemented as production devices, but is not necessarily limited thereto. Hereinafter, each component will be described.
- [60] First, the 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). Only one type of AGV or AMR may be operated according to an operation policy of the logistics robot 110 in the operation boundary 100, or AGV and AMR may be operated together within the operation boundary 100.
- [61] The AGV generally performs operations (movement, direction change, stop, etc.) required within the operation boundary 100 by recognizing and following a guide facility disposed on a floor for guiding the AGV. Here, the guide facility may mean an optically recognizable marker (spot, 2D code, etc.), a tag that may be recognized in a non-contact manner at a short distance (for example, NFC tag, RFID tag, etc.), a magnetic strip, a wire, or the like, but this is exemplary and is not necessarily limited thereto. The guide facility may be disposed continuously on the floor or may be disposed discontinuously spaced apart from each other. Because the AGV basically performs operations through recognition and following of the guide facility, a guide facility is required to be installed in advance before operation, and when the AGV needs to be moved to a new route or an existing route needs

to be modified, physical installation or modification of the guide facility is required. In addition, because the AGV does not deviate from a route set through the guide facility, when an obstacle is detected on or around the route, it is general that the AGV stops until the detected obstacle disappears or receives separate control. In the operation of the AGV, because the control device 140 needs to control the AGV based on the guide facility, the control device 140 may transmit commands having meanings such as 'drive until the 3rd marker is recognized from the current position', 'change heading direction by 90 degrees when the 3rd marker is recognized', and the like to the AGV in individual command units or mission units including a plurality of commands (for example, recovery, supply, charging, patrol, etc.).

[62] The AMR may determine a current position (i.e., localization) through surrounding detection, and a point that is most distinguished from the AGV is that self-path setting (path planning) is possible using localization and a map. Therefore, when a map having compatible coordinates is shared between the AMR and the control device 140, the control device 140 may control the AMR in a manner of instructing a route to the AMR based on coordinates. In addition, when an obstacle is detected during driving, the AMR may set an avoidance route by itself to avoid the obstacle and then return to the original route. A function in which the control device 140 sets a route of the AMR to one or more waypoint coordinates may be referred to as global path planning, and a function in which the AMR sets a movement route or sets an avoidance route between waypoint coordinates according to global path planning may be referred to as local path planning.

[63]

[64] Next, the facility 120 may mean a device (robot arm, conveyor belt, etc.) that performs a production process of a product within the operation boundary 100, for example, and in a

broader sense, may mean a device disposed to assist mission performance such as entry and exit of the logistics robot 110 when the production process is performed by a person. The device disposed to assist mission performance may be a device that detects a state of a designated position where a pallet carried by the logistics robot 110 may be put down or collected within an area where a specific production process is performed, a device that determines a process progress, an entry/exit blocking means within the area, and the like, but is not necessarily limited thereto.

- [65] For example, the facility 120 is controlled through a PLC (Programmable Logic Controller), and may perform communication with the control device 140 in relation to process progress.
- [66] The monitoring device 130 may perform a function of acquiring information for determining a situation within the operation boundary 100 and transmitting the information to the control device 140. For example, the monitoring device 130 may include a camera, a proximity sensor, and the like, but is not necessarily limited thereto.
- [67] The control device 140 may communicate with the aforementioned components 110, 120, and 130 to acquire information necessary for operation of the operation boundary 100 or control each component. For example, the control device 140 may perform dispatching of the logistics robot 110, route setting, mission allocation, process management for each product, material management, and the like.
- [68] In implementation, the control device 140 may include a local control device (ACS: AMR/AGV Control System) that controls peripheral process facilities based on the position of AGV/AMR and performs mission-based control of AGV/AMR, and an integrated control device (MoRIMS: Mobile Robot Integrated Monitoring System) that integrates and controls two or more local control devices. The integrated control device may

perform a state and route of all logistics robots 110 within the operation boundary 100, logistics flow setting, and traffic control from each of the plurality of local control devices. For example, when the local control device (ACS) is provided for each logistics robot unit of the same manufacturer or the same model, the integrated control device may perform integrated control for collision prevention, such as bottleneck level analysis of intersection/overlapping areas, driving acceleration/deceleration control, and avoidance route regeneration through heterogeneous traffic distribution control based on information acquired through the plurality of local control devices (ACS).

[69] In addition, the integrated control device may also have a manufacturing execution system (MES: Manufacturing Execution System) as its upper control entity, and the manufacturing execution system (MES) may be linked with an automated scheduler (APS: Advanced Planning & Scheduling).

[70] In addition to the configuration 110, 120, 130, and 140 of the operation boundary 100 described above, it goes without saying that devices for mutual communication between each component such as a beacon, a repeater, an AP (Access Point), a charger for charging the logistics robot 110, a loading space for storing or loading parts, a space for storing finished products or intermediate products, a traffic light, a gate, a waiting space for idle logistics robots 110, and the like may be appropriately disposed within the operation boundary 100.

[71] Hereinafter, a configuration of a control device 140 applicable to embodiments of the present invention will be described with reference to FIG. 2.

[72]

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

invention. Each component illustrated in FIG. 2 mainly illustrates components related to embodiments of the present invention, and in actual implementation of the control device 140, more or fewer components may be included.

- [74]** 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 monitoring unit 147, a map management unit 148, a task generation unit 140a, and an optimal route calculation unit 140b.
- [75]** The firmware management unit 141 may acquire the latest firmware of the logistics robot 110 through the communication unit 146, and transmit the firmware to the logistics robot 110 to perform a firmware update, thereby maintaining the firmware of the logistics robot 110 in the latest state.
- [76]** The traffic control unit 142 controls traffic lights and gates based on a route of the logistics robot 110, and may recalculate a route of the logistics robot 110 according to traffic.
- [77]** The process management unit 143 may define a process for each product and manage missions such as process progress and progress position.
- [78]** The production/logistics management unit 144 may dispatch the logistics robot 110 based on a mission.
- [79]** The inventory management unit 145 manages a position and quantity for each material, and such information may be useful for more efficient process operation, such as dispatching the logistics robot 110 to a destination earlier than a time point at which actual assembly/consumption of material is detected for pallet pickup or recovery.

- [80] The communication unit 146 may perform communication with not only internal components of the operation boundary 100 such as the logistics robot 110, the facility 120, and the monitoring device 130, but also external entities such as a firmware update server.
- [81] The monitoring unit 147 may monitor a position, a route, a battery state, a communication state, a power train state, and the like of each individual logistics robot 110. Here, the route is a concept including a waypoint-based global route and a real-time local route. In addition, the battery state may include voltage, current, temperature, peak values of voltage and current, state of charge (SOC: State Of Charge), state of health (SOH: State Of Health), and the like. The communication state may include information on a currently activated communication protocol (Wi-Fi, etc.), a connected AP, a distance to the AP, a channel in use, and the like. In addition, the power train state may include load, temperature, RPM, and the like of a drive system.
- [82] In addition, the monitoring unit 147 may also check a mission currently assigned to each individual logistics robot 110, an operation mode, a firmware version, and the like.
- [83] The map management unit 148 acquires map information in a grid map form acquired while the AMR among the logistics robots 110 drives inside the operation boundary 100, and may provide a tool that a factory manager may edit based on the acquired map information. Through editing of the map information, a zone in which one or more predetermined operations are performed when the logistics robot 110 enters, a virtual lane, an intersection, an entry prohibition area, and the like may be set, but this is exemplary and is not necessarily limited thereto. In addition, the map management unit 148 may also distribute the map to the remaining logistics robots 110 other than the logistics robot 110 that

acquired the initial grid map through actual driving, through the communication unit 146.

[84] The task generation unit 140a may generate a task to be performed by the logistics robot 110 based on a process state progressed through the facility 120, a supply state of logistics, monitoring information within the operation boundary 100 acquired through the monitoring device 130, and the like.

[85]

[86] Meanwhile, an embodiment of the present invention proposes to enable the logistics robot 110 to move while reducing the time required for direction change based on an area rule set at a waypoint, thereby improving movement efficiency of the logistics robot 110.

[87] To this end, the map management unit 148 according to an embodiment of the present invention may designate a plurality of waypoints in a movable area for the logistics robot 110 within the operation boundary 100. Here, the waypoint may be defined as coordinates on the map, and a movement route of the logistics robot 110 may be formed through a combination of waypoints.

[88] In addition, the map management unit 148 may set an area rule for a waypoint satisfying a predetermined turning condition among the designated plurality of waypoints.

[89] In this case, whether the turning condition is satisfied may be determined based on a relative positional relationship among the plurality of waypoints, and for example, when a minimum angle formed by three consecutively arranged waypoints among the plurality of waypoints is equal to or less than a predetermined value, the turning condition may be satisfied for a waypoint positioned in the middle in arrangement among the three waypoints.

- [90] The area rule may be set such that the logistics robot 110 passes through a turning area set to include the waypoint where the turning condition is satisfied, while spaced apart from the waypoint where the turning condition is satisfied. In other words, it may mean an area that includes the waypoint on the map and is expanded based on the waypoint.
- [91] More specifically, such a turning area may be implemented in various forms, and for example, the turning area may be implemented as an area within a certain radius from the waypoint satisfying the predetermined condition.
- [92] In addition, the map management unit 148 may designate a non-movable area for the logistics robot 110 within the operation boundary 100, and in this case, the area rule may be set such that the logistics robot 110 passes through the turning area while curved driving, spaced apart at least a predetermined turning distance from an outer edge of the non-movable area.
- [93] Furthermore, the area rule may be set such that the logistics robot 110 performs curved driving while moving a predetermined exit distance from the waypoint satisfying the turning condition, and in this case, the exit distance may be set to be equal to or less than a distance from the waypoint where the turning condition is satisfied to a next waypoint. That is, in this case, the logistics robot 110 maintains curved driving not only within the turning area, but also until a certain point before reaching the next waypoint, thereby enabling the logistics robot 110 to turn gently without an abrupt direction change.
- [94] In addition, the area rule may be set to be applied when the logistics robot 110 enters within a predetermined entry distance from the waypoint satisfying the turning condition. In this case, the entry distance may be greater than or equal to a radius of the turning area.

- [95] In particular, the map management unit 148 may set the area rule such that the logistics robot 110 moves while occupying the turning area equal to or less than a predetermined degree in a process of passing through the turning area while spaced apart from the waypoint where the turning condition is satisfied. In this case, the predetermined degree for occupation of the turning area may include occupation time or a degree of overlap between a movement route of the logistics robot 110 and the turning area. Furthermore, the map management unit 148 may also set the area rule such that the logistics robot 110 moves while in contact with a boundary of the turning area, and in this case, the logistics robot 110 may move while occupying the turning area to a minimum, thereby moving the shortest distance to the next waypoint.
- [96] Meanwhile, the area rule may be variable according to a driving state of the logistics robot 110. In particular, the area rule may be variable according to logistics robot information for the logistics robot 110 and load information loaded on the logistics robot 110.
- [97] In this case, the logistics robot information may include at least one of whether a load is loaded on the logistics robot 110, a type, a task to be performed, and a speed, and the load information may include at least one of whether a load is loaded, a weight, a volume, and a type of the load.
- [98] The reason for making the area rule variable in this way is that the degree to which the logistics robot 110 may safely change direction may vary according to a driving state of the logistics robot 110. Therefore, a shape of the turning area of the area rule, the entry distance, the exit distance, the turning distance, and the like may be variable according to the logistics robot information and the load information.
- [99] For example, when a load is loaded on the logistics robot 110, a greater centripetal force is applied compared to when there is no load, so the area rule may be set such that the logistics

robot 110 moves while occupying the turning area a little more even if some deceleration is involved, rather than turning while maintaining speed as much as possible.

[100] Meanwhile, such waypoints and area rules may be transmitted to the logistics robot 110 through the communication unit 146, and for example, the waypoints and area rules may be transmitted in the form of route information in which each is reflected.

[101] In this case, the optimal route calculation unit 140b may calculate an optimal route according to the waypoints and the area rule, and reflect the optimal route in the route information, and the optimal route may be calculated in consideration of a task to be performed by the logistics robot 110 and a position of the facility 120 to be passed accordingly, in addition to the waypoints and the area rule.

[102] The logistics robot 110 that has received the optimal route in this way may move according to the area rule set at each waypoint in a process of moving along a global route according to the waypoints.

[103] Hereinafter, a logistics robot applicable to embodiments of the present invention will be described.

[104]

[105] FIG. 3 is a block diagram illustrating an example of a logistics robot configuration applicable to embodiments of the present invention.

[106] Referring to FIG. 3, 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, and in particular, the logistics robot 110 applied to embodiments of the present invention may be an AMR. Hereinafter, each component will be described.

- [107] The driving unit 111 may include a driving source, a wheel, a suspension, and the like related to movement, steering, and stopping of the logistics robot 110. An electric motor that receives power from a built-in battery (not shown) may be used as the driving source. The wheel may include one or more driving wheels that receive driving force from the driving source, and non-driving wheels that rotate by movement of the vehicle body without receiving driving force. Depending on the implementation, when a plurality of driving wheels are provided, a driving source may be matched for each driving wheel so that rotation of each driving wheel may be independently controlled. In such a case, by making rotation directions of different driving wheels different, steering may be achieved by rotating the vehicle body without a separate steering means. At least some of the non-driving wheels may be configured as caster-type wheels, but this is exemplary and is not necessarily limited thereto.
- [108] The sensing unit 112 is for detecting a surrounding environment of the logistics robot 110 or its own operation state, 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.
- [109] The encoder may output information that may determine how much the wheel has rotated using light emitted from a light emitting element (for example, a photodiode). For example, the encoder may count the number of slits disposed along a circumferential direction on the wheel or a disk rotating together with the wheel during a unit time. The control unit 115 may perform odometry that estimates displacement by analyzing the amount of position change over time with data acquired through the encoder and the gyro sensor. However, there may be an error between the displacement estimated based on the encoder data and the actual displacement due to slip or wear of the wheel (change

in wheel rolling radius). Therefore, when performing odometry, the control unit 115 may perform correction for noise and error with a predetermined algorithm (for example, EKF: Extended Kalman Filter) on information collected from the wheel and the gyro sensor, and output a result having a tendency close to the actual value. Such odometry may be particularly useful when current position determination (Localization) using the 2D laser scanner described later is impossible.

[110] The 2D laser scanner may scan the surrounding environment by irradiating a laser to the surroundings through a rotating reflector and detecting a signal reflected back. At this time, a detection result in a point cloud shape may be output by analyzing the intensity of the reflected signal and the time difference between irradiation and reception.

[111] The 3D vision camera may 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 that projects infrared light of a predetermined pattern may be provided so that detection is possible even for a flat object of the same color (for example, a white wall).

[112] In general, the 2D laser scanner is used for mapping, navigation, object recognition, and the like, and the 3D camera may be utilized for obstacle avoidance particularly during navigation, but this is exemplary and is not necessarily limited thereto.

[113] The loading unit 113 is a means for loading an object to be transported, and may be a top plate itself on the upper portion of the vehicle body or a table, a lift, a turntable rotating along a vertical axis, a forklift, a conveyor, or a combination thereof disposed on the top plate. In the case of

the forklift, telescopic and tilting functions may be supported similarly to a forklift truck.

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

[115] The control unit 115 is an entity that performs overall control of the aforementioned components 111, 112, 113, and 114, and may perform a current mission, current position, destination determination, route planning, loading unit control, and the like based on information acquired from the control device 140 through the communication unit 114.

[116] In particular, in the logistics robot 110 applicable to embodiments of the present invention, the control unit 115 may acquire waypoints and area rules set thereon from the control device 140, and control the driving unit 111 so that the logistics robot 110 moves along a route according to the waypoints while satisfying the area rules set at the waypoints.

[117] Hereinafter, the area rule according to an embodiment of the present invention will be described in more detail with reference to FIG. 4.

[118]

[119] FIG. 4 is a diagram for explaining an area rule according to an embodiment of the present invention.

[120] Referring to FIG. 4, a process in which the logistics robot 110 moves along a plurality of waypoints #1 to #3 is shown.

[121] First, because a section in which the logistics robot 110 moves from waypoint #1 to waypoint #2 is a straight

section, the optimal route calculation unit 149 may not set a separate area rule for waypoints #1 and #2.

[122] In contrast, because a section in which the logistics robot 110 moves from waypoint #2 to waypoint #3 is not a straight section, a direction change is required for the logistics robot 110 to pass through the section. In this case, when the logistics robot 110 passes waypoint #2 and moves to waypoint #3, a direction change of about 90 degrees is required, and the logistics robot 110 may decelerate in the process of reaching waypoint #2 for the direction change, rotate at waypoint #2, and then accelerate again while moving toward waypoint #3.

[123] When the logistics robot 110 moves in this way, overturning due to abrupt direction change may be prevented, but movement may be delayed in the process of deceleration, rotation, and then acceleration.

[124] Therefore, the map management unit 148 may set an area rule for a waypoint positioned in the middle in arrangement among the three waypoints #1 to #3, when a minimum angle formed by three consecutively arranged waypoints #1 to #3 among the plurality of waypoints is equal to or less than a predetermined value. In this case, the predetermined value for the minimum angle may be, for example, 90 degrees, and according to FIG. 4, waypoint #2 satisfying the predetermined condition becomes the waypoint satisfying the predetermined condition.

[125] The area rule may be set such that the logistics robot 110 passes through the turning area Z1 while spaced apart from waypoint #2 to minimize movement delay due to direction change of the logistics robot 110. Here, the turning area Z1 is set as an area including waypoint #2 satisfying the predetermined condition.

[126] In this case, the turning area Z1 may be set as an area within a certain radius r1 from waypoint #2, and the radius r1 of the turning area Z1 may be variable according to load information for the logistics robot 110. For example, the radius r1 of the turning area Z1 may become smaller as the weight or volume of the load loaded on the logistics robot 110 is larger, thereby reducing the risk of overturning even if the logistics robot 110 moves relatively slowly. However, the radius r1 of the turning area Z1 may be limited according to positions of other facilities 120 or other logistics robots 110 within the operation boundary 100.

[127] Meanwhile, the area rule may be set such that the logistics robot 110 passes through within the turning area Z1 while also spaced apart at least a predetermined turning distance r2 from an outer edge of the non-movable area Z2, as well as from waypoint #2. Through this, while enabling the logistics robot 110 to efficiently move to the next waypoint #3 without directly passing through waypoint #2, it becomes possible to prevent the logistics robot 110 from deviating from an operable range or colliding with other objects such as the facility 120.

[128] Furthermore, the area rule may also be set such that the logistics robot 110 performs curved driving while moving a predetermined exit distance from the waypoint satisfying the turning condition. In this case, the exit distance may be set to be shorter than a distance to the next waypoint #3. According to such an area rule, the logistics robot 110 may maintain turning driving to some extent and then switch to straight driving instead of immediately straight driving after leaving the turning area Z1, and through curved driving, the logistics robot 110 may minimize repetition of straight driving followed by direction change.

[129] Meanwhile, the area rule may be set such that the logistics robot 110 moves while occupying the turning area Z1

equal to or less than a predetermined degree. The predetermined degree for occupation of the turning area may include occupation time or a degree of overlap between a movement route of the logistics robot 110 and the turning area Z1, and the higher the predetermined degree, the more abrupt direction change of the logistics robot 110 may be reduced. The predetermined degree for occupation of the turning area may also be varied based on load information for the logistics robot 110. For example, the predetermined degree may become larger as the weight or volume of the load loaded on the logistics robot 110 is larger, thereby reducing the risk of overturning even if the logistics robot 110 moves relatively slowly. However, the predetermined degree for occupation of the turning area Z1 may be limited according to positions of other facilities 120 or other logistics robots 110 within the operation boundary 100.

[130] Meanwhile, the area rule may be set to be applied when the logistics robot 110 enters within a predetermined entry distance d1 from waypoint #2. In this case, the logistics robot 110 may drive straight before entering within the predetermined entry distance d1, and may turn through direction change after entering the entry distance d1. Through this, the logistics robot 110 may start turning at a position away from waypoint #2 that requires a large direction change to pass through, thereby enabling the logistics robot 110 to move without an abrupt direction change.

[131] Such entry distance d1 may be variable according to logistics robot information and load information. For example, the entry distance d1 may become larger as the weight or volume of the load loaded on the logistics robot 110 is larger, thereby enabling the logistics robot 110 to start direction change at an earlier time so that direction change may be performed gently for a longer time. However, the entry distance d1 may be limited according to positions of other

facilities 120 or other logistics robots 110 within the operation boundary 100.

[132] Meanwhile, although not shown in FIG. 4, more waypoints may be designated in the operation boundary 100 or the map, and the area rule may be applied again depending on whether the condition is satisfied after passing through waypoint #3.

[133] Hereinafter, an entire control process including the operation of the control device 140 described above will be described with reference to FIG. 5.

[134]

[135] FIG. 5 is a sequence diagram of logistics robot control according to an embodiment of the present invention.

[136] Referring to FIG. 5, first, the map management unit 148 may set a map by designating a plurality of waypoints in a movable area for the logistics robot within the operation boundary 100, and setting an area rule for a waypoint where the turning condition is satisfied among the plurality of waypoints in step S501.

[137] The map set in this way may be transmitted to the optimal route calculation unit 140b in the form of map information in step S502, and may be utilized for the optimal route calculation unit 140b to calculate an optimal route.

[138] Meanwhile, because a movement route of the logistics robot 110 needs to be determined in consideration of what task the logistics robot 110 performs, a task to be performed by the logistics robot 110 is also reflected in the calculation of the optimal route, in addition to the map information as described above.

[139] More specifically, the task generation unit 140a may collect information for assigning a task to the logistics robot 110, such as process state information, process surroundings monitoring information, and parts supply

information from the facility 120 and the monitoring device 130 in steps S503 to S504, and may generate a task to be performed by the logistics robot 110 based thereon.

[140] The task generation unit 140a may transmit departure point and destination information of the logistics robot 110 to the optimal route calculation unit 140b based on the generated task, and may additionally transmit waypoint information.

[141] The optimal route calculation unit 140b may select an entire route for the logistics robot 110 to move based on the map information including waypoints and area rules transmitted from the map management unit 148, and the departure point, destination information, and the like according to a task to be performed by the logistics robot 110 transmitted from the task generation unit 140a in step S508.

[142] The selected entire route information is transmitted to the logistics robot 110 through the communication unit 146 in step S509, and the logistics robot 110 that has received this drives while following the entire route in step S510.

[143] Meanwhile, the logistics robot 110 transmits driving situation information to the optimal route calculation unit 140b through the communication unit 146 in step S511 in a process of driving while following the entire route, and the optimal route calculation unit 140b may confirm a current position of the logistics robot 110 through the transmitted driving situation information.

[144] When the logistics robot 110 is scheduled to move to a waypoint where the turning condition is satisfied, the optimal route calculation unit 140b may determine the area rule based on the logistics robot information and load information in the current state in step S512, and transmit the determined area rule to the logistics robot 110 again

through the communication unit 146 so that the logistics robot 110 may perform turning driving according to the determined area rule.

[145]

[146] According to various embodiments of the present invention as described above, it becomes possible to reduce the time required for deceleration, rotation, and acceleration in a process where the logistics robot performs a direction change to pass through a section that is not a straight section.

[147] Through this, it becomes possible to improve movement efficiency of a single logistics robot, and furthermore, it becomes possible to alleviate traffic congestion due to movement among a plurality of logistics robots within the operation boundary through improvement of movement efficiency of each single logistics robot.

[148] In addition, it becomes possible to reduce the cycle time of a transportation process through the logistics robot through improvement of movement efficiency of the logistics robot and alleviation of traffic congestion.

[149] Description of Reference Numerals

[150] 100: operation boundary

[151] 110: logistics robot

[152] 120: facility

[153] 130: monitoring device

[154] 140: control device

CLAIMS

[Claim 1]

A method for controlling a logistics robot, the method comprising:

designating a plurality of waypoints in a movable area of the logistics robot within a predetermined operation boundary, and setting an area rule of a waypoint where a predetermined turning condition is satisfied based on a relative positional relationship among the plurality of waypoints, among the plurality of waypoints; and

transmitting the plurality of waypoints and the area rule to the logistics robot such that the logistics robot moves according to the plurality of waypoints and the area rule within the operation boundary,

wherein the area rule is set such that the logistics robot passes through a turning area set to include the waypoint where the turning condition is satisfied, while spaced apart from the waypoint where the turning condition is satisfied.

[Claim 2]

The method of claim 1, wherein the turning area is defined as an area within a certain radius from the waypoint satisfying the turning condition.

[Claim 3]

The method of claim 1, further comprising:

designating a non-movable area for the logistics robot within the operation boundary,

wherein the area rule is set such that the logistics robot passes through the turning area while curved driving, spaced apart at least a predetermined turning distance from an outer edge of the non-movable area.

[Claim 4]

The method of claim 3, wherein the area rule is set such that the logistics robot performs curved driving while moving a predetermined exit distance from the waypoint satisfying the turning condition, and

the exit distance is set to be equal to or less than a distance from the waypoint where the turning condition is satisfied to a next waypoint.

[Claim 5]

The method of claim 1, wherein the area rule is set to be applied when the logistics robot enters within a predetermined entry distance from the waypoint where the turning condition is satisfied.

[Claim 6]

The method of claim 1, wherein the area rule is set such that the logistics robot passes through while occupying the turning area equal to or less than a predetermined degree.

[Claim 7]

The method of claim 1, wherein the area rule is set such that the logistics robot moves while in contact with a boundary of the turning area.

[Claim 8]

The method of claim 1, wherein the turning condition is satisfied for a waypoint positioned in the middle in arrangement among the three waypoints, when a minimum angle formed by three consecutively arranged waypoints among the plurality of waypoints is equal to or less than a predetermined value.

[Claim 9]

The method of claim 1, wherein the area rule is variable according to logistics robot information including at least one of

whether a load is loaded on the logistics robot, a type, a task to be performed, and a speed.

[Claim 10]

The method of claim 1, wherein the area rule is variable according to load information including at least one of a shape, a weight, a volume, and a type of a load loaded on the logistics robot.

[Claim 11]

A control device for a logistics robot, the device comprising:

a map management unit configured to designate a plurality of waypoints in a movable area of the logistics robot within a predetermined operation boundary, and to set an area rule of a waypoint where a predetermined turning condition is satisfied based on a relative positional relationship among the plurality of waypoints, among the plurality of waypoints; and

a communication unit configured to transmit the plurality of waypoints and the area rule to the logistics robot such that the logistics robot moves according to the plurality of waypoints and the area rule within the operation boundary,

wherein the area rule is set such that the logistics robot passes through a turning area set to include the waypoint where the turning condition is satisfied, while spaced apart from the waypoint where the turning condition is satisfied.

[Claim 12]

The device of claim 11, wherein the turning area is defined as an area within a certain radius from the waypoint satisfying the turning condition.

[Claim 13]

The device of claim 11, wherein the map management unit designates a non-movable area for the logistics robot within the operation boundary, and

the area rule is set such that the logistics robot passes through the turning area while curved driving, spaced apart at least a predetermined turning distance from an outer edge of the non-movable area.

[Claim 14]

The device of claim 13, wherein the area rule is set such that the logistics robot performs curved driving while moving a predetermined exit distance from the waypoint satisfying the turning condition, and

the exit distance is set to be equal to or less than a distance from the waypoint where the turning condition is satisfied to a next waypoint.

[Claim 15]

The device of claim 11, wherein the area rule is set to be applied when the logistics robot enters within a predetermined entry distance from the waypoint where the turning condition is satisfied.

[Claim 16]

The device of claim 11, wherein the area rule is set such that the logistics robot passes through while occupying the turning area equal to or less than a predetermined degree.

[Claim 17]

The device of claim 11, wherein the area rule is set such that the logistics robot moves while in contact with a boundary of the turning area.

[Claim 18]

The device of claim 11, wherein the turning condition is satisfied for a waypoint positioned in the middle in arrangement among the three waypoints, when a minimum angle formed by three consecutively arranged waypoints among the plurality of waypoints is equal to or less than a predetermined value.

[Claim 19]

The device of claim 11, wherein the area rule is variable according to logistics robot information including at least one of whether a load is loaded on the logistics robot, a type, a task to be performed, and a speed.

[Claim 20]

The device of claim 11, wherein the area rule is variable according to load information including at least one of a shape, a weight, a volume, and a type of a load loaded on the logistics robot.