

DESCRIPTION

Invention Title: METHOD OF CONTROLLING LOGISTICS ROBOTS, AND CONTROL DEVICE

Technical Field

- [1] The present invention relates to a method and a control device for controlling logistics robots that perform automatic logistics optimization through organic grouping 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] Logistics robots are a concept collectively referring to autonomous mobile robots (AMR: Autonomous Mobile Robot) and automated guided vehicles (AGV: Automated Guided Vehicle), and such logistics robots may perform movement and work according to control of a control device.
- [4] In a smart factory, logistics robots may move along an optimal movement path based on path planning to perform missions assigned from the control device.
- [5] Meanwhile, due to the characteristics of logistics robots moving in smart factories, the work efficiency of smart factories may increase as work continues uninterrupted and when the number of logistics robots assigned to each work is evenly distributed. Accordingly, there is a need for a method of grouping the number of logistics robots assigned

to corresponding work in order to increase the work efficiency of the entire factory.

- [6] 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 those of ordinary skill in this technical field.

Disclosure

Technical Problem

- [7] Accordingly, the present invention has as a technical objective to be achieved implementing automatic logistics optimization through organic grouping within an operation boundary.
- [8] The technical objectives to be achieved in the present invention are not limited to the technical objectives mentioned above, and other technical objectives not mentioned may be clearly understood by those of ordinary skill in the technical field to which the present invention belongs from the description below.

Technical Solution

- [9] A method of controlling a plurality of logistics robots operating within a preset operation boundary according to an embodiment may comprise: a step of grouping the plurality of logistics robots to set a plurality of work groups; and a step of performing a mission defined for each of the set plurality of work groups by a plurality of logistics robots grouped in a corresponding work group.
- [10] For example, the method may further comprise a step of adjusting a group setting of the plurality of logistics robots grouped in each of the plurality of work groups

based on a result of mission execution performed by each of the plurality of work groups.

- [11] For example, the setting step may comprise a step of setting the number of logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups.
- [12] For example, the method may further comprise a step of generating a work command for the plurality of logistics robots according to a priority set for each of the plurality of work groups.
- [13] For example, the plurality of work groups may be defined according to a plurality of group classifications, and the group classification may be configured as a tree structure including a top-level group classification and at least one or more lower group classifications.
- [14] For example, the adjusting step may comprise a step of determining a mission execution result for each of the plurality of work groups according to an operation state or an operation indicator of the plurality of logistics robots.
- [15] For example, the operation state may correspond to one of an idle state or an operation state.
- [16] For example, the operation indicator may be determined by a part supply required time relative to a part supply request time in a predetermined process.
- [17] For example, the setting step may comprise a step of assigning logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups, and the adjusting step may comprise a step of reassigning logistics robots for each of the plurality of work groups by adjusting the operation

limit number or the distribution ratio limit of logistics robots set for each of the plurality of work groups.

- [18] For example, in the setting step, at least one individual logistics robot among the logistics robots may be concurrently grouped in a plurality of work groups.
- [19] A control device for controlling a plurality of logistics robots operating within a preset operation boundary according to an embodiment may comprise: a group management unit configured to group the plurality of logistics robots to set a plurality of work groups; and a work schedule management unit configured to determine a result of performing a mission defined for each of the set plurality of work groups by a plurality of logistics robots grouped in a corresponding work group.
- [20] For example, the control device may further comprise a group adjustment unit configured to adjust a group setting of the plurality of logistics robots grouped in each of the plurality of work groups based on the result.
- [21] For example, the group management unit may set the number of logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups.
- [22] For example, the group management unit may generate a work command for the plurality of logistics robots according to a priority set for each of the plurality of work groups.
- [23] For example, the plurality of work groups may be defined according to a plurality of group classifications, and the group classification may be configured as a tree structure including a top-level group classification and at least one or more lower group classifications.

- [24] For example, the work schedule management unit may determine the result for each of the plurality of work groups according to an operation state or an operation indicator of the plurality of logistics robots.
- [25] For example, the operation state may correspond to one of an idle state or an operation state.
- [26] For example, the operation indicator may be determined by a part supply required time relative to a part supply request time in a predetermined process.
- [27] For example, the group management unit may assign logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups, and the group adjustment unit may reassign logistics robots for each of the plurality of work groups by adjusting the operation limit number or the distribution ratio limit of logistics robots set for each of the plurality of work groups.
- [28] For example, the group management unit may assign at least one individual logistics robot among the logistics robots to a plurality of work groups concurrently.

Advantageous Effects

- [29] According to the present invention, work efficiency of the entire process may be increased by implementing automatic logistics optimization through organic grouping within an operation boundary.
- [30] The effects that may be obtained 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 technical field to which the present invention belongs from the description below.

Description of Drawings

- [31] FIG. 1 is a block diagram illustrating an example of an operation boundary configuration applicable to the embodiments of the present invention.
- [32] FIG. 2 is a block diagram illustrating an example of a control device configuration applicable to the embodiments of the present invention.
- [33] FIG. 3 is a block diagram illustrating an example of a logistics robot configuration applicable to the embodiments of the present invention.
- [34] FIG. 4 is a perspective view illustrating an example of an exterior of a logistics robot applicable to the embodiments of the present invention.
- [35] FIG. 5 is a flowchart illustrating an example of a driving process of a logistics robot applicable to the embodiments of the present invention.
- [36] FIG. 6 is a flowchart for explaining basic setting and operation of a method of controlling logistics robots according to an embodiment of the present invention.
- [37] FIG. 7 is a flowchart for explaining operation change according to mission execution progress of a method of controlling logistics robots according to an embodiment of the present invention.
- [38] FIG. 8 and FIG. 9 are diagrams for explaining operation of a group management unit according to an embodiment of the present invention.

Mode for Disclosure

- [39] Hereinafter, embodiments disclosed in this specification will be described in detail with reference to the accompanying drawings, wherein the same or similar

components will be assigned the same reference numerals regardless of drawing numerals, and redundant descriptions thereof will be omitted. 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 distinguish them from each other by themselves. In addition, when a detailed description of related known technologies is determined to obscure the gist of the embodiments disclosed in this specification in describing the embodiments disclosed in this specification, the detailed description thereof will be omitted. In addition, the accompanying drawings are only for easily understanding 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, and substitutes included in the spirit and technical scope of the present invention.

[40] Terms including ordinal numbers such as first and second 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.

[41] When a component is referred to as being "connected" or "coupled" to another component, it should be understood that it 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 components exist in between.

- [42] Singular expressions include plural expressions unless the context clearly indicates otherwise.
- [43] In this specification, terms such as "comprise" or "have" should be understood as specifying the existence of features, numbers, steps, operations, components, parts, or combinations thereof described in the specification, and do not preclude the possibility of the existence or addition of one or more other features, numbers, steps, operations, components, parts, or combinations thereof.
- [44] In addition, unit or control unit included in the names of internal configurations of logistics robots or control devices is only a term widely used in naming controllers that control specific functions, and does not mean a generic function unit. For example, each controller may include a modem/transceiver that communicates with other controllers or sensors for control of a function 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 required for control of the function in charge. Depending on implementation, one processor may be in charge of operations for a plurality of controllers.
- [45] First, the configuration of the operation boundary in which logistics robots according to the embodiments are deployed and operated will be described with reference to FIG. 1.
- [46] FIG. 1 is a block diagram illustrating an example of an operation boundary configuration applicable to the embodiments.
- [47] Referring to FIG. 1, the operation boundary 100 may include logistics robots 110, production devices 120, monitoring devices 130, and a control device 140.

- [48] The operation boundary 100 may be provided with a plurality of logistics robots 110, a plurality of production devices 120, and a plurality of monitoring devices 130 according to the production process and target production speed of products. The operation boundary 100 may be implemented as a smart factory, but is not necessarily limited thereto. Hereinafter, each component will be described.
- [49] First, the logistics robot 110 may include an autonomous mobile robot (Autonomous Mobile Robot, hereinafter referred to as 'AMR' for convenience) and an automated guided vehicle (Automated Guided Vehicle, hereinafter referred to as 'AGV' for convenience). Depending on the operation policy of the logistics robot 110 in the operation boundary 100, only one type of AGV or AMR may be operated, or AGV and AMR may be operated together in the operation boundary 100.
- [50] The AGV generally performs operations required in the operation boundary 100 (movement, turning, stopping, etc.) by recognizing and following guide facilities arranged on the floor for guiding the AGV. Here, guide facilities may mean optically recognizable markers (spots, 2D codes, etc.), tags recognizable in a non-contact manner at close range (e.g., NFC tags, RFID tags, etc.), magnetic strips, wires, etc., but this is exemplary and is not necessarily limited thereto. Guide facilities may be continuously arranged on the floor or may be discontinuously spaced apart from each other. Since the AGV basically performs operations through recognition and following of guide facilities, it requires guide facilities to be installed in advance before operation, and when it is necessary to move the AGV to a new path or modify an existing path, new installation or modification of guide facilities needs to be physically performed. In addition, since the AGV does not deviate from the path set through the guide facilities, when an obstacle

is detected on or around the path, the AGV generally stops until the detected obstacle disappears or receives separate control. In the operation of the AGV, since the control device 140 must control the AGV based on the guide facilities, commands meaning 'drive until the 3rd marker is recognized from the current position', 'when the 3rd marker is recognized, turn the heading direction by 90 degrees', etc. may be transmitted to the AGV in individual command units or mission units (e.g., retrieval, supply, charging, patrol, etc.) including a plurality of commands.

- [51] The AMR may determine the current position (i.e., localization) through peripheral sensing, and the most distinguishing point from the AGV is that the AMR is capable of self-path planning using localization and a map. Therefore, when a map with 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 the path to the AMR based on coordinates. In addition, when an obstacle is detected during driving, the AMR may autonomously set an avoidance path to avoid the obstacle and then return to the original path. The function of the control device 140 setting the path of the AMR with one or more waypoint coordinates may be referred to as global path planning, and the function of the AMR setting a movement path or an avoidance path between waypoint coordinates according to global path planning may be referred to as local path planning.
- [52] A more detailed configuration of the logistics robot 110 will be described later with reference to FIGS. 4 and 5, and the driving control process of the AMR will be described later with reference to FIG. 6.
- [53] Next, the production device 120 may mean a device (e.g., a robot arm, a conveyor belt, etc.) that performs the

production process of products in the operation boundary 100, and in a broader sense, may mean a device arranged to assist in performing missions such as entry and exit of the logistics robot 110 when the production process is performed by a person. A device arranged to assist in performing missions may be a device that detects the state of a designated position where the logistics robot 110 may put down or collect a pallet carried within an area where a specific production process is performed, a device that determines process progress, an access blocking means within the area, etc., but is not necessarily limited thereto.

- [54] For example, the production device 120 is controlled through a PLC (Programmable Logic Controller) and may perform communication with the control device 140 regarding process progress.
- [55] The monitoring device 130 may perform a function of obtaining information for determining the situation within the operation boundary 100 and transmitting it to the control device 140. For example, the monitoring device 130 may include a camera, a proximity sensor, etc., but is not necessarily limited thereto.
- [56] The control device 140 may communicate with the aforementioned components 110, 120, and 130 to obtain information necessary for operation of the operation boundary 100 or control each component. For example, the control device 140 may perform dispatching, path setting, mission assignment, process management by product, material management, etc. of the logistics robot 110.
- [57] In implementation, the control device 140 may include a local control device (ACS: AMR/AGV Control System) that controls surrounding process equipment 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 the state and path of all logistics robots 110 within the operation boundary 100, logistics flow setting, and traffic control from each of a plurality of local control devices. For example, when the local control device (ACS) is provided in units of logistics robots 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 cross/overlap zones, driving acceleration/deceleration control, and avoidance path regeneration through traffic distribution control between different types based on information obtained through a plurality of local control devices (ACS).

- [58] 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 in turn be linked with an automated scheduler (APS: Advanced Planning & Scheduling).
- [59] In addition to the configuration 110, 120, 130, and 140 of the operation boundary 100 described above, devices for mutual communication between components such as beacons, repeaters, and APs (Access Points), chargers for charging the logistics robot 110, loading spaces for storing or loading parts, spaces for storing finished products or intermediate products, traffic lights, barriers, and waiting spaces for idle logistics robots 110 may of course be appropriately arranged within the operation boundary 100.

- [60] Hereinafter, the configuration of the control device 140 applicable to the embodiments of the present invention will be described with reference to FIG. 2.
- [61] FIG. 2 is a block diagram illustrating an example of a control device configuration applicable to the embodiments of the present invention. Each component illustrated in FIG. 2 mainly shows components related to the embodiments of the present invention, and more or fewer components may be included in the actual implementation of the control device 140.
- [62] 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, an optimal path calculation unit 146, a group control unit 147, a map management unit 148, and a work schedule management unit 149. Although not explicitly illustrated in FIG. 2, the control device 140 may further include a communication unit for exchanging signals with the remaining components 110, 120, and 130 of FIG. 1.
- [63] The firmware management unit 141 may obtain the latest firmware of the logistics robot 110 through the communication unit, transmit it to the logistics robot 110 so that a firmware update is performed, and maintain the firmware of the logistics robot 110 in the latest state.
- [64] The traffic control unit 142 controls traffic lights and barriers based on the path of the logistics robot 110 and may also recalculate the path of the logistics robot 110 according to traffic.
- [65] The process management unit 143 may define processes by product and manage missions such as process progress and progress position.

- [66] The production/logistics management unit 144 may dispatch the logistics robot 110 based on missions.
- [67] The inventory management unit 145 manages the position and quantity by material, and such information may be useful for more efficient process operation, such as dispatching the logistics robot 110 to the destination earlier than the time when actual material assembly/consumption is detected for pallet pickup or retrieval.
- [68] The optimal path calculation unit 146 may generate a global path so that each of the logistics robots 110 constituting the corresponding work group may move along an optimal path within the work boundary according to the mission within the work group assigned by the group management unit 147b.
- [69] The group control unit 147 manages work groups for the plurality of logistics robots 110 and may operate and manage the logistics robots 110 within the work group. To this end, as illustrated in FIGS. 6 and 7 to be described later, the group control unit 147 may include a group adjustment unit 147a that performs group adjustment according to operation results, and a group management unit 147b that performs work group management and control of logistics robots accordingly. A more specific operation of the group control unit 147 will be described later with reference to FIGS. 6 to 9.
- [70] The map management unit 148 obtains map data in the form of a grid map obtained while the AMR among the logistics robots 110 drives inside the operation boundary 100 and may provide a tool for a factory manager to edit the obtained map data. Through editing of map data, zones in which the logistics robot 110 performs one or more preset operations upon entry, virtual lanes, intersections, no-entry zones, etc. may be set, but this is exemplary and is not necessarily limited thereto. In addition, the map

management unit 148 may distribute the map to the remaining logistics robots 110 other than the logistics robot 110 that initially obtained the grid map through actual driving through the communication unit 146.

- [71] The work schedule management unit 149 may manage and monitor missions of the logistics robot 110 based on process information of the operation boundary 100 received from the production device 120 and the monitoring device 130 through the communication unit. In addition, the work schedule management unit 149 may select a specific logistics robot 110 and assign a mission thereto.
- [72] 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. Hereinafter, each component will be described.
- [73] The driving unit 111 may include a driving source, wheels, and suspension, etc. involved in movement, steering, and stopping of the logistics robot 110. The driving source may use an electric motor that receives power from a built-in battery (not shown). The wheels 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 implementation, when a plurality of driving wheels are provided, a driving source may be matched to each driving wheel so that the rotation of each driving wheel may be independently controlled. In such a case, steering may be achieved by rotating the vehicle body without a separate steering means by making the 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 is not necessarily limited thereto.

- [74] The sensing unit 112 is for sensing the surrounding environment of the logistics robot 110 or its own operation state, and may include at least one of a 2D laser scanner (e.g., LiDAR), a 3D vision (stereo) camera, a multi-axis gyro sensor, an acceleration sensor, a wheel encoder, and a proximity sensor.
- [75] The encoder may output information capable of determining how much the wheel has rotated using light emitted from a light emitting element (e.g., a photodiode). For example, the encoder may count the number of slits arranged along the circumferential direction on the wheel or a disk rotating together with the wheel during a unit time. The control unit 115 is capable of performing odometry that estimates displacement by analyzing the amount of position change over time with data obtained through the encoder and the gyro sensor. However, displacement estimated based on encoder data may have an error from actual displacement due to slip or wear (change in effective radius of the wheel) of the wheel. Therefore, when performing odometry, the control unit 115 may correct noise and error with a predetermined algorithm (e.g., EKF: Extended Kalman Filter) on information collected from the wheel and the gyro sensor to 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 to be described later is not possible.
- [76] The 2D laser scanner may scan the surrounding environment by irradiating a laser around through a rotating reflector and sensing a signal reflected back. At this time, a sensing result in the form of a point cloud may be output by analyzing the intensity of the reflected signal and the time difference between irradiation/reception.

- [77] The 3D vision camera may calculate the distance to an object based on the disparity between two cameras spaced apart by a certain distance, that is, the 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 sensing is possible even for a plane object of the same color (e.g., a white wall).
- [78] Generally, 2D laser scanners are used for mapping, navigation, and object recognition, and 3D cameras may be utilized for obstacle avoidance, especially among navigation, but this is exemplary and is not necessarily limited thereto.
- [79] The loading unit 113 is a means for loading objects to be transferred, and may be the top plate itself on the upper part of the vehicle body or a table, lift, turntable rotating along a vertical axis, fork lift, conveyor arranged on the top plate, or a combination thereof. In the case of the fork lift, similar to a forklift truck, telescopic and tilting functions may be supported.
- [80] The communication unit 114 may perform communication with other components within the operation boundary 100 such as the production device 120 and the control device 140, may also support communication between logistics robots 110, and may also communicate with a charger when performing a charging mission.
- [81] The control unit 115 is an entity that performs overall control of each of the aforementioned components 111, 112, 113, and 114, and may perform current mission, current position, destination determination, path planning, loading unit control, etc. based on information obtained from the control device 140 through the communication unit 114.

- [82] FIG. 4 is a perspective view illustrating an example of an exterior of a logistics robot applicable to the embodiments of the present invention.
- [83] Referring to FIG. 4, an example of an AMR is illustrated as the logistics robot 110. The vehicle body may have a track-type planar shape having a long axis extending along a first axis direction as a whole. One driving wheel 111-1 may be disposed at a central portion of the vehicle body in the first axis direction and may be disposed at one side in the second axis direction, and another driving wheel (not shown) may be disposed at the other side in the second axis direction to face the one driving wheel 111-1. Such a driving wheel arrangement may be referred to as a 'differential drive (DD)'. Although not illustrated in FIG. 4, two or more non-driving wheels may be disposed at the lower part of the vehicle body. In such a case, when two driving wheels rotate in the same direction at the same speed, forward or backward movement along the first axis direction is possible, and when they rotate in opposite directions at the same speed, the vehicle body may rotate about a rotation axis extending along the third axis direction and passing through the planar center C of the vehicle body. In addition, the sensor unit 112 may be disposed at the front portion of the vehicle body, and the loading unit 113 may be disposed at the upper surface portion. The loading unit 113 may be configured to be able to ascend and descend along the third axis direction, and a rack or a tray may be fixed through a guide 113-1 on the upper surface.
- [84] However, the AMR form of FIG. 5 described above is exemplary, and it is of course possible that the AGV has a similar form or the AMR has a different form.

- [85] Next, the driving process of the logistics robot 110 will be described with reference to FIG. 5.
- [86] FIG. 5 is a flowchart illustrating an example of a driving process of the logistics robot 110 applicable to the embodiments of the present invention. In FIG. 5, for convenience, it is assumed that the logistics robot 110 is an AMR capable of localization and local path planning.
- [87] Referring to FIG. 5, first, the AMR may obtain an actual measurement grid map through LiDAR, etc. while driving inside the operation boundary 100 in step S501.
- [88] When the AMR transmits the obtained grid map to the control device 140, a grid map editing and matching process may be performed at the map management unit 148 of the control device 140 in step S502. Here, the editing process may include a process of setting the aforementioned various zones on the grid map, a process of assigning costs to each grid, etc. Here, the assignment of costs may be performed in a direction in which costs are assigned higher as they are closer to obstacles or no-entry zones so that the AMR does not move to the vicinity of obstacles or into zones that should not be entered. This is because the AMR selects a set of cells with the lowest cost between waypoints as a path in setting a local path.
- [89] In addition, the map matching process may mean a process of matching coordinates between a CAD map used in the design of the operation boundary 100, an actual measurement grid map (LiDAR map), and a topology map that has undergone the editing process.
- [90] Thereafter, the control device 140 may share the topology map with all AMRs within the factory through the communication unit in step S503.

- [91] The subsequent steps may be processes applied to individual AMRs.
- [92] The AMR may determine the current position on the map (localization) through sensor data of the sensing unit 112 and the obtained map in step S504. For example, the AMR may determine the current position by comparing the surrounding terrain obtained through LiDAR with the map based on feature points.
- [93] The control device 140 may select a specific AMR and assign a mission thereto, and the mission may generally be assigned one or more waypoints determined through global path planning. The waypoint may be defined as coordinates on the map, and information about the direction (i.e., heading) that the AMR should face at the corresponding coordinates may be accompanied. According to such mission assignment, a destination may be set in the AMR (Yes in step S505), and the AMR may perform local path planning between waypoints based on the cost of the topology map in step S506.
- [94] When the path is determined, the AMR starts driving in step S507, and when an obstacle is detected through the sensing unit 112 during driving (Yes in step S508), the AMR may perform an avoidance maneuver by performing a local path search to bypass the detected obstacle in step S509. In some cases, the control device 140 may update the mission of the corresponding AMR according to the avoidance maneuver or according to the failure of the avoidance maneuver.
- [95] In addition, the AMR may correct the position error during movement through the aforementioned odometry technique until reaching the destination in step S510.
- [96] Thereafter, when the destination is reached in step S511, the AMR may perform a mission-based maneuver in step S512.

For example, the AMR may determine whether conditions for entering a specific process zone are cleared, retrieve an empty pallet at the destination, or drop the loaded material loaded on the loading unit 113.

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

[98] Hereinafter, in controlling the plurality of logistics robots 110 operating within the preset operation boundary by the control device 140, an operation method of a logistics system that increases the work efficiency of the entire process by performing missions through organic grouping within the operation boundary and changing the setting of groups according to mission execution results will be described.

[99] FIG. 6 is a flowchart for explaining basic setting and operation of a method of controlling logistics robots according to an embodiment of the present invention. As illustrated in FIG. 6, the group control unit 147 may include a group adjustment unit 147a and a group management unit 147b. In the following drawings including FIG. 6, for convenience, it is assumed that the logistics robot 110 is an AMR capable of localization and local path planning.

[100] Referring to FIG. 6, first, information necessary for initial setting of a work group may be transmitted to the group management unit 147b in steps S610, S620, and S630. In more detail, production sequence information of a production management system (MES: Manufacturing Execution System) 210 may be transmitted to the group management unit 147b via a logistics management system 220 in step S610. In addition, process setting information from the production

device 120 and monitoring device setting information from the monitoring device 130 may each be transmitted to the group management unit 147b in step S620. In addition, logistics robot information including identification information and current position information from each logistics robot 110 may be transmitted to the group management unit 147b in step S630.

[101] The group management unit 147b may perform initial setting for work groups based on the information obtained through the aforementioned processes in steps S610, S620, and S630 in step S640. For example, the group management unit 147b may set group definition according to missions, initial assignment of logistics robots by group, and logistics robot organization through designation of distribution ratio (or quantity) by group. The group definition according to missions may be in a tree form including one top-level group and at least one lower group thereunder, but this is exemplary and is not necessarily limited thereto.

[102] In addition, the group management unit 147b may set a plurality of work groups by grouping the plurality of logistics robots 110 based on the current positions of the plurality of logistics robots 110. For example, the group management unit 147b may set a group of logistics robots whose current position is a first process area (e.g., a trim process) as a first work group, and may set a group of logistics robots whose current position is a second process area (e.g., a final process) as a second work group. At this time, the group management unit 147b may set the number of logistics robots 110 for each of the plurality of work groups to satisfy the distribution ratio or quantity of the logistics robots 110 set for each of the plurality of work groups.

- [103] A specific form of work group setting will be described later with reference to FIG. 8 and FIG. 9.
- [104] When the work group setting is completed, the group management unit 149b may transmit the work group setting information to the group adjustment unit 147a for subsequent group adjustment in step S650.
- [105] When the above-described setting procedure is completed, logistics robot control for process progress may be performed. To this end, first, current status information of the operation boundary may be collected at the work schedule management unit 149. Specifically, production sequence information from the production management system 210 may be transmitted to the work schedule management unit 149 via the logistics management system in step S660. In addition, the logistics management system 220 may provide part supply information, the production device 120 may provide process state information, and the monitoring device 130 may provide surrounding monitoring information to the work schedule management unit 149, respectively, in step S671.
- [106] The work schedule management unit 149 may determine missions required within the operation boundary based on each obtained information and transmit mission information (e.g., supply, retrieval, charging, etc.) including departure point and destination information to the group management unit 147b in step S672.
- [107] The group management unit 147b may determine a work group to perform each mission in step S673 and assign missions to individual logistics robots within the responsible group based on the determined mission work group information in step S674.
- [108] The mission information assigned to each logistics robot is transmitted to the optimal path calculation unit

146, and the optimal path calculation unit 146 may determine an optimal path for each logistics robot based on the mission. Logistics robot control may be performed in a manner in which the determined optimal path information is transmitted to each logistics robot in step S675.

[109] Here, the logistics robot control process in step S670 through mission determination by the work schedule management unit 149 according to real-time updated process information, group management and mission assignment by the group management unit 147b, and optimal path determination by the optimal path calculation unit 146 therethrough may be repeatedly and continuously performed along with the process progress.

[110] When the mission progresses through control of the logistics robot through group setting according to the process described above with reference to FIG. 6, operation change according to the degree of mission execution is possible. This will be described with reference to FIG. 7.

[111] FIG. 7 is a flowchart for explaining operation change according to mission execution progress of a method of controlling logistics robots according to an embodiment of the present invention. FIG. 7 may be a process that follows after the control of the logistics robot progresses through the process of FIG. 6.

[112] Referring to FIG. 7, the work schedule management unit 149 may obtain process state information from the production device 120 in step S710, surrounding monitoring information from the monitoring device 130 in step S720, and logistics robot information (identification information, path information, position information, etc.) from the logistics robot 110 in step S730. The work schedule management unit 149 may determine a logistics robot mission execution result based on the obtained information and

provide it to the group adjustment unit 147a in step S740. The logistics robot mission execution result may include whether the mission required execution time is satisfied, the execution time deviation by mission, the ratio of movement required time during mission of the logistics robot, the mission execution ratio by logistics robot, whether mission delay due to congestion, unnecessary waiting, work delay due to shortage of logistics robots, etc. occurs, the degree of occurrence, or a score or index calculated through a combination thereof, but this is exemplary and is not limited thereto as long as it may indicate whether a problem has occurred in mission execution, and is not limited to any form.

[113] As an example, the mission execution result may include an operation state and an operation indicator. At this time, the operation state of the logistics robot 110 may correspond to one of an idle state or a run state depending on whether a task is assigned. Here, the idle state corresponds to a state in which a task is not assigned to the logistics robot 110, and the run state may correspond to a state in which a task is assigned to the logistics robot 110. In addition, the operation indicator of the logistics robot 110 may be determined by the part supply required time relative to the part supply request time in a predetermined process. At this time, the part supply request time may be set differently for each process, and the part supply required time may correspond to a time period from the time when the logistics robot 110 receives a supply task request to the time when the loaded material is dropped in the corresponding process area, but is not necessarily limited thereto. The operation indicator of the logistics robot 110 may be set to 100 (%) when the part supply required time is less than or equal to the part supply request time.

- [114] The group adjustment unit 147a may update the distribution ratio of logistics robots by work group based on the mission execution result in step S750 and may reallocate logistics robots by group according to the updated distribution ratio in step S760.
- [115] This process in steps S750 and S760 may not be performed when there is no problem with the mission execution result (e.g., a preset evaluation factor condition is satisfied), and may be performed when it is determined that there is a problem with the mission execution result.
- [116] If the work group setting is updated/adjusted through steps S750 to S760, the updated/adjusted group setting information may be transmitted to the group management unit 147b in step S770.
- [117] Each detailed step (S781, S782, S783, S784, S785) of the logistics robot control process in step S780 performed based on the updated setting information thereafter corresponds to each detailed step (S671, S672, S673, S674, S675) of step S670 described above with reference to FIG. 6, and redundant descriptions will be omitted.
- [118] FIG. 8 and FIG. 9 are diagrams for explaining the operation of a group management unit according to an embodiment of the present invention. In FIGS. 8 and 9, it is assumed that the operation boundary is a smart factory for vehicle production.
- [119] As described above, the functions of the group management unit 147b may include group definition, logistics robot assignment by group, etc.
- [120] For example, through the information collected through steps S610, S620, and S630 of FIG. 6, as illustrated in FIG. 8, the group management unit 147b may define three upper

groups as trim, chassis, and final C. Group definition may be made according to various criteria, and in the case of FIG. 8 and FIG. 9, it may be made according to the type of process in the production factory.

[121] In addition, lower groups may be defined according to group items corresponding to different missions for each upper group. For example, in the case of the trim group, three lower groups may be defined according to supply/retrieval missions for each of parts A, B, and C.

[122] In the case of the distribution ratio of logistics robots (AMRs here), the upper group may be set as a ratio to the total logistics robots within the work boundary, and the lower group may be set as a ratio within the distribution ratio of its upper group, respectively. The assignment of individual logistics robots may be automatically performed according to the position and quantity of logistics robots, or manual setting by an operator may be allowed.

[123] In addition, as illustrated in FIG. 9, a specific logistics robot (No. 1) may be redundantly assigned to a plurality of lower groups. That is, assuming that the total number of logistics robots is 16, the trim group is assigned 50% of the total, so 8 logistics robots belong to the trim group. The trim group is again assigned in a ratio of 4:4:2 for each of parts A, B, and C, and through the redundant assignment of the No. 1 logistics robot, the corresponding ratio may be satisfied even with 8 logistics robots.

[124] In FIG. 8 and FIG. 9, for ease of understanding, a form in which lower group classification is divided according to supply/retrieval missions by parts is illustrated, but this is exemplary, and various user definitions such as waiting at a specific position within

the boundary, rearranging logistics objects, speed synchronization, and platoon driving are of course possible. In addition, the group classification is illustrated as a tree structure of upper groups and lower groups, but this is also exemplary, and the tree structure may be set in various stages and forms according to the content of items and missions at each stage.

[125] As described above, the present invention may increase the work efficiency of a smart factory by adjusting the settings of groups and agents according to mission execution results of logistics robots in the smart factory, and may implement automatic logistics optimization through organic grouping within the operation boundary.

[126] Meanwhile, the present invention described above may be implemented as computer-readable code on a medium on which a program is recorded. The computer-readable medium includes all types of recording devices in which data readable by a computer system is stored. Examples of 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, etc. Therefore, the above detailed description should not be construed as limiting in all respects and should be considered as exemplary. The scope of the present invention should be determined by reasonable interpretation of the appended claims, and all modifications within the equivalent scope of the present invention are included in the scope of the present invention.

CLAIMS

[Claim 1]

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

grouping the plurality of logistics robots to set a plurality of work groups; and

performing a mission defined for each of the set plurality of work groups by a plurality of logistics robots grouped in a corresponding work group.

[Claim 2]

The method of claim 1, further comprising:

adjusting a group setting of the plurality of logistics robots grouped in each of the plurality of work groups based on a result of mission execution performed by each of the plurality of work groups.

[Claim 3]

The method of claim 1, wherein the setting comprises:

setting a number of logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups.

[Claim 4]

The method of claim 1, further comprising:

generating a work command for the plurality of logistics robots according to a priority set for each of the plurality of work groups.

[Claim 5]

The method of claim 1, wherein the plurality of work groups are defined according to a plurality of group classifications, and the group classification is configured as a tree structure including a top-level group classification and at least one or more lower group classifications.

[Claim 6]

The method of claim 1, wherein the adjusting comprises:

determining a mission execution result for each of the plurality of work groups according to an operation state or an operation indicator of the plurality of logistics robots.

[Claim 7]

The method of claim 6, wherein the operation state corresponds to one of an idle state or an operation state.

[Claim 8]

The method of claim 6, wherein the operation indicator is determined by a part supply required time relative to a part supply request time in a predetermined process.

[Claim 9]

The method of claim 2, wherein the setting comprises:

assigning logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups, and

the adjusting comprises:

reassigning logistics robots for each of the plurality of work groups by adjusting the operation limit number or the distribution ratio limit of logistics robots set for each of the plurality of work groups.

[Claim 10]

The method of claim 1, wherein in the setting, at least one individual logistics robot among the logistics robots is concurrently grouped in a plurality of work groups.

[Claim 11]

A control device for controlling a plurality of logistics robots operating within a preset operation boundary, the control device comprising:

a group management unit configured to group the plurality of logistics robots to set a plurality of work groups; and

a work schedule management unit configured to determine a result of performing a mission defined for each of the set plurality of work groups by a plurality of logistics robots grouped in a corresponding work group.

[Claim 12]

The control device of claim 11, further comprising:

a group adjustment unit configured to adjust a group setting of the plurality of logistics robots grouped in each of the plurality of work groups based on the result.

[Claim 13]

The control device of claim 11, wherein the group management unit sets a number of logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups.

[Claim 14]

The control device of claim 11, wherein the group management unit generates a work command for the plurality of logistics robots according to a priority set for each of the plurality of work groups.

[Claim 15]

The control device of claim 11, wherein the plurality of work groups are defined according to a plurality of group classifications, and the group classification is configured as a tree structure including a top-level group classification and at least one or more lower group classifications.

[Claim 16]

The control device of claim 11, wherein the work schedule management unit determines the result for each of the plurality of work groups according to an operation state or an operation indicator of the plurality of logistics robots.

[Claim 17]

The control device of claim 16, wherein the operation state corresponds to one of an idle state or an operation state.

[Claim 18]

The control device of claim 16, wherein the operation indicator is determined by a part supply required time relative to a part supply request time in a predetermined process.

[Claim 19]

The control device of claim 12, wherein the group management unit assigns logistics robots for each of the plurality of work groups under an operation limit number or a distribution ratio limit of logistics robots set for each of the plurality of work groups, and the group adjustment unit reassigns logistics robots for each of the plurality of work groups by adjusting the operation limit number or the distribution ratio limit of logistics robots set for each of the plurality of work groups.

[Claim 20]

The control device of claim 11, wherein the group management unit assigns at least one individual logistics robot among the logistics robots to a plurality of work groups concurrently.