

DESCRIPTION

Disclosure Title: LOGISTICS ROBOT SIMULATION SYSTEM AND METHOD

Technical Field

[1] The present disclosure relates to a simulation system and method for logistics robots for optimally operating logistics robots within an operation boundary including logistics robots.

[2]

Background Art

[3] Recently, logistics robots are being introduced for flexible and efficient supply and transport of parts and the like in general logistics warehouses and factories, as well as in operation boundaries where products of different specifications are manufactured using various parts.

[4] A logistics robot is a concept collectively referring to an autonomous mobile robot (AMR: Autonomous Mobile Robot) and an automated guided vehicle (AGV: Automated Guided Vehicle), and such logistics robots may perform movement and tasks according to control of a control system.

[5] In particular, recently, interest in simulation for inspecting the operation environment of logistics robots has been increasing with the introduction of logistics robots.

[6] However, in a case of a majority of commercial simulations, result values such as operation efficiency and task time of logistics robots are derived by using the operation quantity of logistics robots as a fixed variable. In a case of a factory where a production target is determined, such as a conventional conveyor factory, such a simulation method may

be appropriate, but in a case of a factory equipped with a cell (Cell) production method for multi-model flexible production, the operation quantity of logistics robots may vary according to market conditions, consumption tendencies of consumers, and production plans, and such a simulation method is not appropriate.

[7] Therefore, in a case of a factory equipped with a cell (Cell) production method for multi-model flexible production, a simulation method different from conventional ones needs to be applied.

[8]

[9] The matters described as the background art above are merely for enhancing understanding of the background of the present disclosure and should not be taken as an acknowledgment that they constitute prior art already known to those of ordinary skill in the art.

[10]

Disclosure

Technical Problem

[11] The present disclosure is proposed in order to achieve the above-described object, and is to provide a simulation system and method for logistics robots that may determine an optimal operation quantity of logistics robots by dynamically changing the operation quantity of logistics robots and performing a simplified simulation before setting the operation quantity of logistics robots and performing a normal simulation.

[12]

[13] Technical problems to be achieved in the present disclosure are not limited to the technical problems mentioned above, and other technical problems not mentioned may be clearly

understood by those of ordinary skill in the art to which the present disclosure belongs from the description below.

[14]

Technical Solution

[15] A simulation system for logistics robots according to the present disclosure for achieving the above object may comprise: a performance unit performing simulation based on an operation quantity of logistics robots; and an operation control unit determining a reference operation quantity of the logistics robots based on a performance result of a simplified simulation performed by the performance unit based on a preset initial operation quantity of the logistics robots, changing the reference operation quantity according to a preset change rule, and determining an optimal operation quantity of the logistics robots based on an additional performance result of the simplified simulation additionally performed by the performance unit based on the changed reference operation quantity.

[16]

[17] Also, a simulation method for logistics robots according to the present disclosure for achieving the above object may comprise: determining a reference operation quantity of the logistics robots based on a performance result of a simplified simulation performed based on a preset initial operation quantity of logistics robots; changing the reference operation quantity according to a preset change rule; additionally performing the simplified simulation based on the changed reference operation quantity; and determining an optimal operation quantity of the logistics robots based on an additional performance result of the simplified simulation.

[18]

Advantageous Effects

[19] According to the above description, the simulation system and method for logistics robots of the present disclosure may flexibly change operating conditions such as the operation quantity of logistics robots, and may cause result values of simulation considering the changed operating conditions to be derived according to the change of the operating conditions.

[20] Also, time resources for deriving an optimal value may be saved by determining the optimal operation quantity of logistics robots based on a result of performing a simplified simulation while changing operating conditions before a normal simulation is performed.

[21]

[22] Effects obtainable in the present disclosure 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 disclosure belongs from the description below.

[23]

Description of Drawings

[24] FIG. 1 is a block diagram for describing a simulation system for logistics robots according to an embodiment of the present disclosure.

[25] FIG. 2 is a block diagram for describing an operation control unit provided in the simulation system for logistics robots according to an embodiment of the present disclosure.

[26] FIG. 3 is a drawing for describing a process of determining a reference operation quantity according to an embodiment of the present disclosure.

[27] FIG. 4 is a flowchart for describing a simulation method for logistics robots according to an embodiment of the present disclosure.

[28]

Mode for Disclosure

- [29] In describing the embodiments disclosed in this specification, when it is determined that 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 provided only to facilitate easy understanding of the embodiments disclosed in this specification, the technical spirit disclosed in this specification is not limited by the accompanying drawings, and it should be understood that all modifications, equivalents, and substitutes included in the spirit and technical scope of the present disclosure are encompassed.
- [30] Terms including ordinal numbers such as first, second, etc. 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.
- [31] When it is mentioned that a certain component is "connected to" or "in contact with" another component, it should be understood that it may be directly connected to or in contact with the other component, but other components may exist in between. On the other hand, when it is mentioned that a certain component is "directly connected to" or "directly in contact with" another component, it should be understood that no other component exists in between.
- [32] Singular expressions include plural expressions unless the context clearly dictates otherwise.
- [33] In this specification, terms such as "includes" or "has" should be understood as not pre-excluding the possibility of existence or addition of one or more other features, numbers, steps, operations, components, parts, or combinations thereof,

but as designating the existence of the features, numbers, steps, operations, components, parts, or combinations thereof described in the specification.

- [34] In addition, a unit (Unit) or a control unit (Control Unit) included in the internal configuration name of a logistics robot or a control device is merely a term widely used in naming a controller that controls specific functions, and does not mean a generic function unit (Generic function unit). For example, each controller may include a modem/transceiver that communicates with other controllers or sensors for controlling the assigned function, a memory that stores an operating system, logic commands, and input/output information, and one or more processors that perform determination, computation, and decision necessary for controlling the assigned function. Depending on the implementation, one processor may be in charge of computation for a plurality of controllers.
- [35] Hereinafter, the embodiments disclosed in this specification will be described in detail with reference to the accompanying drawings, and identical or similar components will be assigned the same reference numbers regardless of drawing reference numerals, and redundant description thereof will be omitted.
- [36]
- [37] The present disclosure is aimed at dynamically changing the operation quantity of logistics robots and performing simplified simulation to determine the optimal operation quantity of logistics robots, and performing normal simulation based on the determined optimal operation quantity. The simulation system and method for a logistics robot according to an embodiment of the present disclosure for achieving this object will be described hereinafter.

- [38] Meanwhile, the normal simulation mentioned in the above description may refer to a simulation that is repeatedly performed one or more times by setting the optimal operation quantity of logistics robots accordingly. And, the simplified simulation is named to distinguish from such normal simulation, and may refer to a simulation that is performed only once while changing the operation quantity of logistics robots accordingly. This is named for convenience of description, and it goes without saying that the meaning of each simulation performed is not limited to its name.
- [39] In addition, the logistics robot mentioned in this specification hereinafter is used as a concept collectively referring to an autonomous mobile robot (AMR : Autonomous Mobile Robot), an automated guided vehicle (AGV : Automated Guided Vehicle), and an unmanned forklift, which are smart logistics vehicles provided in an operation boundary.
- [40]
- [41] Hereinafter, the simulation system for a logistics robot according to an embodiment of the present disclosure will be described with reference to FIG. 1.
- [42] FIG. 1 is a block diagram for describing the simulation system for a logistics robot according to an embodiment of the present disclosure.
- [43] Referring to FIG. 1, the simulation system 100 for a logistics robot according to an embodiment of the present disclosure may include a planning unit 110, a performance unit 120, and an operation control unit 130. FIG. 1 illustrates mainly the components related to an embodiment of the present disclosure, and it goes without saying that fewer or more components may be included in actually implementing the simulation system.
- [44] Hereinafter, each component will be described.

- [45] The planning unit 110 may collect demand information, logistics information, and material information and establish a product production plan based thereon. And, the planning unit 110 may generate a task list to be performed by logistics robots in order to produce products according to the established product production plan. The planning unit 110 may provide the product production plan and the task list to the performance unit 120.
- [46] The performance unit 120 may perform a simulation simulating the operation environment of logistics robots, and may set the operation quantity of logistics robots based on the product production plan and the task list provided from the planning unit 110 and perform a simulation based on the set operation quantity. For example, the performance unit 120 may include a constraint generation module (not shown) that generates constraint conditions for the operation of logistics robots such as the starting position, movement path, and operation quantity of logistics robots that will perform tasks based on the task list generated by the planning unit 110, and a simulation execution module (not shown) in which a simulation is performed based on the product production plan and the task list provided from the planning unit 110 in consideration of the constraint conditions provided from the driving model by simulating the operation environment of logistics robots on a 3D-based basis.
- [47] For example, the simulation system 100 for a logistics robot may refer to a system equipped with a Digital Twin function, but this is merely exemplary, and it goes without saying that the present disclosure is not necessarily limited thereto.
- [48]
- [49] In the case of the existing simulation system 100, the operation quantity of logistics robots was set on a code-based basis, and logistics robots were allocated for each task list to perform a simulation. However, since the

operation quantity of logistics robots was set on a code-based basis, there was a problem that when the operation quantity needed to be changed, a long time was required to change the operation quantity, resulting in a waste of time.

[50] In order to solve this problem, an operation control unit 130 may be provided in the simulation system 100 for a logistics robot according to an embodiment of the present disclosure.

[51] The operation control unit 130 according to an embodiment of the present disclosure may determine the optimal operation quantity of logistics robots by setting the operation quantity of logistics robots and dynamically changing the operation quantity of logistics robots and performing simplified simulation before the normal simulation is performed by the performance unit 120. Detailed description of the operation control unit 130 will be described with reference to FIGS. 1 and 2 together.

[52] FIG. 2 is a block diagram for describing the operation control unit provided in the simulation system for a logistics robot according to an embodiment of the present disclosure.

[53] Referring to FIG. 2, the operation control unit 130 according to an embodiment of the present disclosure may include a dynamic adjustment unit 131, an allocation unit 132, and a result analysis unit 133. FIG. 2 illustrates mainly the components related to an embodiment of the present disclosure, and it goes without saying that fewer or more components may be included in actually implementing the operation control unit 130.

[54] Hereinafter, the functions of each component of the operation control unit 130 that may be applied to an embodiment of the present disclosure will be briefly described.

[55] The dynamic adjustment unit 131 may set the operation quantity of logistics robots or change the operation quantity when the change of the operation quantity is necessary. At this time,

the dynamic adjustment unit 131 may pop up a logistics robot list to cause the operation quantity of logistics robots to be set or changed through a worker, and may cause the operation quantity to be set or changed according to a preset setting or change logic. And, the dynamic adjustment unit 131 may provide information on the set or changed operation quantity to the allocation unit 132.

- [56] The allocation unit 132 collects information on the task list generated by the planning unit 110, and collects information on the operation quantity set by the dynamic adjustment unit 131 or the changed operation quantity, and may sequentially allocate the task list to each of the logistics robots corresponding to the set or changed operation quantity. For example, the allocation unit 132 may sort the task list to be performed first based on the planned start time so that the task list is sequentially allocated to the logistics robots first, and then the task list is sequentially allocated to the logistics robots that have completed the task.
- [57] And, the allocation unit 132 may generate a work schedule by sequentially allocating the task list to each of the logistics robots corresponding to the operation quantity. The allocation unit 132 may transmit the generated work schedule to the performance unit 120 so that the simulation is performed according to the work schedule by the performance unit 120.
- [58] The result analysis unit 133 may collect the performance result of the simulation performed by the performance unit 120 based on the work schedule generated by the allocation unit 132, and may analyze the determination of the change of the operation quantity and the operation efficiency of logistics robots based on the performance result.
- [59] And, the dynamic adjustment unit 131, the allocation unit 132, and the result analysis unit 133 may transmit and receive data to and from each other and perform cooperative control.

[60]

[61] Hereinafter, the functions of the operation control unit 130 will be described in detail with reference to FIGS. 1 to 2 based on the functions of the dynamic adjustment unit 131, the allocation unit 132, and the result analysis unit 133 described above.

[62] The operation control unit 130 according to an embodiment of the present disclosure may determine the reference operation quantity of logistics robots based on the performance result of the simplified simulation performed by the performance unit 120 based on the preset initial operation quantity for the logistics robots, change the reference operation quantity according to a preset change rule, and determine the optimal operation quantity of logistics robots based on the additional performance result of the simplified simulation additionally performed by the performance unit 120 based on the changed reference operation quantity.

[63] Specifically, the dynamic adjustment unit 131 may set the initial operation quantity for the logistics robots, and may transmit information on the set initial operation quantity to the allocation unit 132. The allocation unit 132 may generate a work schedule by sequentially allocating the task list to each of the logistics robots corresponding to the initial operation quantity based on the information on the initial operation quantity. The allocation unit 132 may transmit the generated work schedule to the performance unit 120, and the performance unit 120 may perform the simplified simulation until the number of executions of the simplified simulation reaches a preset reference count based on the work schedule.

[64] At this time, the dynamic adjustment unit 131 may change the initial operation quantity until the number of executions of the simplified simulation performed by the performance unit 120 reaches the reference count. More specifically, the dynamic adjustment unit 131 may change the initial operation

quantity so that the initial operation quantity is reduced at a constant ratio as the number of executions increases until the number of executions of the simplified simulation reaches the reference count. For example, when the initial operation quantity is set to 48 units, the dynamic adjustment unit 131 may change the initial operation quantity from 48 units to 24 units and from 24 units to 12 units as the number of executions of the simplified simulation increases so that the initial operation quantity is reduced by half. However, this is merely exemplary and is not necessarily limited thereto, and it goes without saying that the initial operation quantity may be changed by applying various ratios.

[65] Meanwhile, each time the initial operation quantity is changed by the dynamic adjustment unit 131, the allocation unit 132 may change the work schedule based on the changed initial operation quantity and transmit it to the performance unit 120, and each time the initial operation quantity is changed, the performance unit 120 may receive the changed work schedule from the allocation unit 132 and perform the simplified simulation based thereon.

[66] And, when the number of executions of the simplified simulation reaches the preset reference count, the dynamic adjustment unit 131 may determine the reference operation quantity based on the performance result of the simplified simulation performed the reference count number of times. This will be described with reference to FIG. 3.

[67]

[68] FIG. 3 is a drawing for describing the process of determining the reference operation quantity according to an embodiment of the present disclosure.

[69] The graph shown in FIG. 3 may be a graph based on the performance result of the simplified simulation performed the reference count number of times. Accordingly, referring to

FIG. 3, the x-axis of the graph may represent the operation quantity of logistics robots, and the y-axis may represent the total driving time of logistics robots according to the performance result of the simplified simulation. For example, the initial operation quantity may be M_1 , and the operation quantities changed until the number of executions of the simplified simulation reaches the reference count may be M_2 and M_3 , respectively.

- [70] The dynamic adjustment unit 131 may determine the reference operation quantity by performing a least square method (LSM : Least Square Method) based on the performance result of the simplified simulation performed the reference count number of times according to the change of the operation quantity of logistics robots. For example, the dynamic adjustment unit 131 may predict a quadratic function based on the performance results for the respective operation quantities of M_1 , M_2 , and M_3 , and may determine the operation quantity (for example, M_s shown in FIG. 3) corresponding to the time (for example, t shown in FIG. 3) at which the total driving time according to the performance result corresponds to the minimum value in the predicted quadratic function as the reference operation quantity.
- [71] When the reference operation quantity is determined, the dynamic adjustment unit 131 may transmit the determined reference operation quantity to the allocation unit 132, and the allocation unit 132 may generate a work schedule based on the reference operation quantity and transmit it to the performance unit 120. The performance unit 120 may perform the simplified simulation based on the work schedule according to the reference operation quantity.
- [72] And, after the performance of the simplified simulation based on the work schedule according to the reference operation quantity, the performance unit 120 may additionally perform the simplified simulation based on the reference operation

quantity. At this time, the dynamic adjustment unit 131 may change the reference operation quantity according to a preset change rule. For example, the preset change rule may be a rule in which the operation quantity is changed with an increment/decrement range as the number of additional executions increases based on the reference operation quantity, and accordingly, the dynamic adjustment unit 131 may change the reference operation quantity in the order of +1, -1, +2, -2 from the reference operation quantity as the number of additional executions increases. As the reference operation quantity is changed by the dynamic adjustment unit 131, the performance unit 120 may additionally perform the simplified simulation based on the changed reference operation quantity.

[73]

[74] The result analysis unit 133 may receive the additional performance result of the simplified simulation additionally performed by the performance unit 120, and may determine the optimal operation quantity of logistics robots based on the received additional performance result.

[75] More specifically, the result analysis unit 133 may determine whether the additional change of the changed reference operation quantity is necessary based on the additional performance result of the additionally performed simplified simulation. For example, the result analysis unit 133 may determine the total driving time of logistics robots according to the changed reference operation quantity included in the additional performance result of the additionally performed simplified simulation, and may determine whether the additional change of the changed reference operation quantity is necessary based on the determined total driving time. The result analysis unit 133 may compare the determined total driving time with the total driving time included in the performance result of the

previously performed simplified simulation, and may determine that the additional change of the changed reference operation quantity is not necessary when the determined total driving time is equal to or greater than the total driving time included in the previously performed performance result.

[76] Meanwhile, when the determined total driving time is less than the total driving time included in the previously performed performance result, the result analysis unit 133 may determine that the additional change of the changed reference operation quantity is necessary. Accordingly, the result analysis unit 133 may generate a command for the additional change and transmit it to the dynamic adjustment unit 131, and the dynamic adjustment unit 131 may additionally change the changed reference operation quantity according to the preset change rule based on the command for the additional change. And, the dynamic adjustment unit 131 may transmit the additionally changed operation quantity to the allocation unit 132, and the allocation unit 132 may generate a work schedule according to the additionally changed operation quantity and transmit it to the performance unit 120. The performance unit 120 may additionally perform the simplified simulation based on the work schedule generated according to the additionally changed operation quantity, and the result analysis unit 133 may re-determine whether the additional change of the additionally changed operation quantity is necessary based on the performance result of the additionally performed simplified simulation.

[77] When the additional change of the changed reference operation quantity is not necessary, the result analysis unit 133 may determine the optimal operation quantity based on the performance results of all simplified simulations performed before the point in time at which it was determined that the additional change is not necessary. For example, the performance result of the simplified simulation may include at least one of the operation quantity as well as the total

driving time, the deviation degree, the number of bottleneck occurrences, and the delay occurrence time. Accordingly, the result analysis unit 133 may determine at least one of the total driving time, the deviation degree, the number of bottleneck occurrences, and the delay occurrence time included in the performance results of all simplified simulations performed before the point in time at which it was determined that the additional change is not necessary, and may compare the determined at least one among all simplified simulations.

- [78] The result analysis unit 133 may determine the operation quantity for the logistics robots corresponding to the performance result of the simplified simulation having the smallest value by comparing the determined at least one among all simplified simulations as the optimal operation quantity. For example, the result analysis unit 133 may determine the operation quantity for the logistics robots corresponding to the simplified simulation having the smallest total driving time, or the smallest deviation degree, or the fewest number of bottleneck occurrences, or the shortest delay occurrence time among all simplified simulations performed before the point in time at which it was determined that the additional change is not necessary as the optimal operation quantity.
- [79] In addition, when the result analysis unit 133 determines and compares two or more of the total driving time, the deviation degree, the number of bottleneck occurrences, and the delay occurrence time included in the performance result of the simplified simulation, a determination priority may be preset among the total driving time, the deviation degree, the number of bottleneck occurrences, and the delay occurrence time, and a comparison result may be derived by sequentially comparing the respective result data according to the preset determination priority. However, this is merely exemplary, and it goes without saying that the present disclosure is not necessarily limited thereto.

- [80] The result analysis unit 133 may determine the optimal operation quantity and transmit information on the determined optimal operation quantity to the allocation unit 132. The allocation unit 132 may generate a work schedule according to the optimal operation quantity and provide it to the performance unit 120, and the performance unit 120 may perform the normal simulation based on the work schedule generated according to the optimal operation quantity.
- [81] That is, by operating the simplified simulation once before repeatedly operating the normal simulation by the performance unit 120, and determining the optimal operation quantity through the operation control unit 130 based on the performance result of the simplified simulation, the time resources for deriving the optimal value may be saved.
- [82]
- [83] Hereinafter, the simulation method for a logistics robot according to an embodiment of the present disclosure will be described with reference to FIG. 4 based on the configuration of the simulation system for a logistics robot described above through FIGS. 1 to 3.
- [84] Hereinafter, for convenience of description, it is assumed that the functions of the dynamic adjustment unit 131, the allocation unit 132, and the result analysis unit 133 are all performed by the operation control unit 130, and description of each step will be omitted as it has been specifically described above through FIGS. 1 to 3.
- [85] FIG. 4 is a flowchart for describing the simulation method for a logistics robot according to an embodiment of the present disclosure.
- [86] Referring to FIG. 4, the operation control unit 130 may preset the initial operation quantity in step S401, and may generate a work schedule by sequentially allocating the task list to

each of the logistics robots corresponding to the initial operation quantity in step S402.

- [87] The operation control unit 130 transmits the generated work schedule to the performance unit 120, and the performance unit 120 may perform the simplified simulation based on the generated work schedule in step S403. The performance unit 120 determines whether the number of executions of the simplified simulation reaches the reference count in step S404, and may perform the simplified simulation until the number of executions of the simplified simulation reaches the reference count. At this time, when the number of executions of the simplified simulation does not reach the reference count (No in step S404), the operation control unit 130 changes the initial operation quantity in step S405, and may perform steps S402 to S404 again.
- [88] When the number of executions of the simplified simulation reaches the reference count (Yes in step S404), the operation control unit 130 may determine the reference operation quantity based on the performance result of the simplified simulation performed the reference count number of times in step S406. And, the operation control unit 130 may generate a work schedule according to the determined reference operation quantity in step S407, and may transmit the generated work schedule to the performance unit 120. The performance unit 120 may perform the simplified simulation based on the work schedule generated according to the reference operation quantity in step S408.
- [89] Thereafter, when the simplified simulation is additionally performed exceeding the reference count, the operation control unit 130 may change the reference operation quantity according to the preset change rule in step S409. And, the operation control unit 130 may generate a work schedule based on the changed reference operation quantity in step S410, and may transmit the generated work schedule to the performance

unit 120 again. The performance unit 120 may additionally perform the simplified simulation based on the transmitted work schedule in step S411.

- [90] The operation control unit 130 may determine whether the additional change of the changed reference operation quantity is necessary based on the total driving time included in the additional performance result of the simplified simulation additionally performed by the performance unit 120 in step S412. When the total driving time according to the additional performance result of the additionally performed simplified simulation is less than the total driving time according to the performance result of the previously performed simplified simulation (No in step S412), the operation control unit 130 determines that the additional change of the changed reference operation quantity is necessary in step S413, and may return to step S409 to additionally change the changed reference operation quantity according to the preset change rule.
- [91] When the total driving time according to the additional performance result of the additionally performed simplified simulation is equal to or greater than the total driving time according to the performance result of the previously performed simplified simulation (Yes in step S412), the operation control unit 130 determines that the additional change of the changed reference operation quantity is not necessary, and may determine the optimal operation quantity based on the performance results of all simplified simulations performed before the point in time at which it was determined that the additional change is not necessary in step S414.
- [92] Thereafter, the operation control unit 130 may finally generate a work schedule based on the determined optimal operation quantity in step S415, and may transmit the finally generated work schedule to the performance unit 120. The

performance unit 120 may perform the normal simulation based on the finally generated work schedule in step S416.

[93]

[94] According to the above description, the simulation system and method for a logistics robot of the present disclosure may flexibly change operating conditions such as the operation quantity for logistics robots, and may cause a result value of the simulation considering the changed operating conditions according to the change of the operating conditions to be derived.

[95] In addition, by determining the optimal operation quantity for logistics robots based on the result of simply performing the simulation while changing the operating conditions before the normal simulation is performed, the time resources for deriving the optimal value may be saved.

[96]

[97] Although illustrated and described in relation to specific embodiments of the present disclosure, it will be apparent to those of ordinary skill in the art that the present disclosure may be variously improved and changed within the scope that does not depart from the technical spirit of the present disclosure provided by the following claims.

[98] The above-described present disclosure may be implemented as computer-readable code on a medium having a program recorded thereon. The computer-readable medium includes all kinds of recording devices in which data that may be read by a computer system is stored. Examples of the computer-readable medium include HDD (Hard Disk Drive), SSD (Solid State Disk), SDD (Silicon Disk Drive), ROM, RAM, CD-ROM, magnetic tape, floppy disk, optical data storage device, and the like. Therefore, the above detailed description should not be construed as limiting in all respects and should be considered as illustrative. The scope of the present disclosure should be

determined by reasonable interpretation of the appended claims, and all changes within the equivalent scope of the present disclosure are included in the scope of the present disclosure.

CLAIMS

[Claim 1]

A simulation system for a logistics robot, comprising:

a performance unit performing simulation based on an operation quantity of logistics robots; and

an operation control unit determining a reference operation quantity of the logistics robots based on a performance result of a simplified simulation performed by the performance unit based on a preset initial operation quantity of the logistics robots, changing the reference operation quantity according to a preset change rule, and determining an optimal operation quantity of the logistics robots based on an additional performance result of the simplified simulation additionally performed by the performance unit based on the changed reference operation quantity.

[Claim 2]

The simulation system for a logistics robot of claim 1, wherein the operation control unit, when an operation quantity of the logistics robots is set or changed, generates a work schedule by sequentially allocating a task list to each of the logistics robots corresponding to the set or changed operation quantity.

[Claim 3]

The simulation system for a logistics robot of claim 1, wherein

the performance unit performs the simplified simulation until a number of executions of the simplified simulation reaches a preset reference count, and

the operation control unit changes the initial operation quantity until the number of executions of the simplified simulation performed by the performance unit reaches the reference count, and determines the reference operation quantity based on a performance result of the simplified simulation performed for the

reference count when the number of executions reaches the preset reference count.

[Claim 4]

The simulation system for a logistics robot of claim 3, wherein the operation control unit changes the initial operation quantity such that the initial operation quantity is reduced at a constant ratio as the number of executions increases until the number of executions reaches the reference count.

[Claim 5]

The simulation system for a logistics robot of claim 1, wherein the operation control unit determines a necessity of additional change of the changed reference operation quantity based on the additional performance result of the additionally performed simplified simulation, and when additional change of the changed reference operation quantity is not necessary, determines the optimal operation quantity based on performance results of all simplified simulations performed before a time point at which it is determined that the additional change is not necessary.

[Claim 6]

The simulation system for a logistics robot of claim 5, wherein the operation control unit determines a total driving time of the logistics robots according to the changed reference operation quantity included in the additional performance result of the additionally performed simplified simulation, and determines the necessity of additional change of the changed reference operation quantity based on the determined total driving time.

[Claim 7]

The simulation system for a logistics robot of claim 6, wherein the operation control unit determines that additional change of the changed reference operation quantity is not necessary when the determined total driving time is equal to or greater than

a total driving time included in a performance result of a previously performed simplified simulation.

[Claim 8]

The simulation system for a logistics robot of claim 5, wherein the operation control unit determines at least one of a total driving time, a deviation degree, a number of bottleneck occurrences, and a delay occurrence time included in performance results of all the simplified simulations for each of all the simplified simulations, and compares the determined at least one among all the simplified simulations to determine an operation quantity of the logistics robots corresponding to a performance result of a simplified simulation having a smallest value as the optimal operation quantity.

[Claim 9]

The simulation system for a logistics robot of claim 1, wherein

the operation control unit generates a work schedule according to the determined optimal operation quantity and provides the work schedule to the performance unit, and

the performance unit performs a normal simulation based on the provided work schedule.

[Claim 10]

A simulation method for a logistics robot, comprising:

determining a reference operation quantity of logistics robots based on a performance result of a simplified simulation performed based on a preset initial operation quantity of the logistics robots;

changing the reference operation quantity according to a preset change rule;

additionally performing the simplified simulation based on the changed reference operation quantity; and

determining an optimal operation quantity of the logistics robots based on an additional performance result of the simplified simulation.

[Claim 11]

The simulation method for a logistics robot of claim 10, wherein the determining the reference operation quantity comprises:

generating a work schedule by sequentially allocating a task list to each of the logistics robots corresponding to the initial operation quantity; and

performing the product production simulation based on the generated work schedule.

[Claim 12]

The simulation method for a logistics robot of claim 10, wherein the determining the reference operation quantity comprises:

performing, by the performance unit, the simplified simulation while changing the initial operation quantity until a number of executions of the simplified simulation reaches a preset reference count; and

determining the reference operation quantity based on a performance result of the simplified simulation performed for the reference count when the number of executions reaches the preset reference count.

[Claim 13]

The simulation method for a logistics robot of claim 12, wherein the performing the product production simulation comprises:

changing the initial operation quantity such that the initial operation quantity is reduced at a constant ratio as the number of executions increases until the number of executions reaches the reference count; and

performing the simplified simulation based on the changed initial operation quantity.

[Claim 14]

The simulation method for a logistics robot of claim 10, wherein the determining the optimal operation quantity comprises:

determining a necessity of additional change of the changed reference operation quantity based on the additional performance result of the simplified simulation; and

when additional change of the changed reference operation quantity is not necessary, determining the optimal operation quantity based on additional performance results of all simplified simulations performed before a time point at which it is determined that the additional change is not necessary.

[Claim 15]

The simulation method for a logistics robot of claim 14, wherein the determining the necessity comprises:

determining a total driving time of the logistics robots according to the changed reference operation quantity included in the additional performance result of the simplified simulation; and

determining the necessity of additional change of the changed reference operation quantity based on the determined total driving time.

[Claim 16]

The simulation method for a logistics robot of claim 15, wherein the determining the necessity of additional change determines that additional change of the changed reference operation quantity is not necessary when the determined total driving time is equal to or greater than a total driving time included in a performance result of a previously performed simplified simulation.

[Claim 17]

The simulation method for a logistics robot of claim 14, wherein the determining the optimal operation quantity comprises:

determining at least one of a total driving time, a deviation degree, a number of bottleneck occurrences, and a delay occurrence time included in performance results of all the simplified simulations for each of all the simplified simulations; and

comparing the determined at least one among all the simplified simulations to determine an operation quantity of the logistics robots corresponding to a performance result of a simplified simulation having a smallest value as the optimal operation quantity.

[Claim 18]

The simulation method for a logistics robot of claim 10, further comprising, after the determining the optimal operation quantity:

generating a work schedule according to the determined optimal operation quantity; and

performing a normal simulation based on the generated work schedule.