

Description

Title of Invention: APPARATUS AND METHOD FOR PREDICTING COLLISION OF LOGISTICS ROBOTS

5 Technical Field

[1] The present disclosure relates to a collision prediction apparatus and method for logistics robots for predicting and preventing a collision of the logistics robots in an operation boundary including a plurality of facilities
10 and the logistics robots.

[2]

Background Art

[3] In general logistics warehouses and factories, as well as in smart factories that manufacture goods having different
15 specifications by using various components, logistics robots have been introduced for flexible and efficient supply and transfer of components.

[4] The logistics robot is a concept collectively referring to an autonomous mobile robot (AMR) and an automated guided
20 vehicle (AGV), and such logistics robots are able to perform movement and operations under the control of a control device.

[5] In a smart factory, a logistics robot may move along an optimal moving path based on path planning in order to
25 perform a mission assigned from the control device.

[6] Multiple logistics robots may be provided in the smart factory, and when moving paths of a plurality of logistics robots overlap, a collision between the logistics robots may occur. For example, when one logistics robot moves downward
5 and another logistics robot move upward in a narrow and small passage of the smart factory, the two logistics robots may fall into a deadlock state and collide. In addition, logistics robots may collide with facilities disposed in the smart factory while moving in the smart factory.

10 [7] As such, when collisions with logistics robots occur, damage due to the breakdown of the logistics robots as well as a great impact on the progress of the entire process may occur, resulting in a large loss. Therefore, there is a need to propose a scheme that can predict and prevent a collision
15 risk in advance before the logistics robots collide.

[8]

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

[10]

Detailed Description of the Invention

Technical Problem

25 [11] The present disclosure is directed to providing a

collision prediction apparatus and method for logistics robots, the apparatus and the method learning in advance collision prediction criteria for the logistics robots through process state information in an operation boundary,
5 and predicting and preventing a collision of the logistics robots according to a result of learning.

[12]

[13] Objectives of the present disclosure are not limited to the above-mentioned objectives, and other objectives not
10 mentioned will be clearly understood by those skilled in the art from the following description.

[14]

Means for Solving the Problem

[15] In order to achieve the above objectives, according to
15 the present disclosure, there is provided a collision prediction apparatus for logistics robots, the collision prediction apparatus including: a collection part configured to collect process state information including facility information on a plurality of facilities disposed in a preset
20 operation boundary, and logistics robot operation information on the plurality of logistics robots that are provided in the operation boundary and move passing through at least one or some of a plurality of facility zones in which the plurality of facilities are disposed; a learning part configured to
25 learn, on the basis of the process state information,

collision prediction criteria for respective collision types including a collision between any one of the plurality of facilities and any one of the plurality of logistics robots, and a collision between the plurality of logistics robots; a
5 prediction part configured to predict, on the basis of the process state information collected after learning and the learnt collision prediction criteria, occurrence of a collision with at least one of the plurality of logistics robots; and an output part configured to output a control
10 signal corresponding to a result of prediction.

[16] For example, the learning part may be configured to label the process state information according to time periods, and learn the collision prediction criteria for the respective collision types on the basis of the labeled
15 process state information.

[17] For example, the learning part may be configured to, with respect to the plurality of logistics robots, classify the labeled process state information depending on whether a preset distance condition for a target object including the
20 facility and another one of the plurality of logistics robots is satisfied.

[18] For example, the learning part may be configured to learn the collision prediction criteria on the basis of the process state information corresponding to a time point
25 before a preset time interval from a time point when the

preset distance condition is satisfied, among the labeled process state information.

[19] For example, the learning part may be configured to perform learning when any one of the plurality of logistics
5 robots satisfies the preset distance condition.

[20] For example, the learning part may be configured to learn the collision prediction criteria on the basis of the process state information corresponding to a time point before a preset time interval from a time point when the
10 preset distance condition is not satisfied, among the labeled process state information.

[21] For example, the facility information may include coordinates of the facility zone corresponding to the facility in the operation boundary or a task state of the
15 facility or both.

[22] For example, the facility information may vary according to an operation characteristic of the facility.

[23] For example, the logistics robot operation information may include at least one selected from a group of a speed, a
20 moving direction, a moving path, a size, a normal operation status, a sensor detection result, braking specification, a real-time clock, a characteristic of a loaded item of each of the plurality of logistics robots, an inter-robot distance among some of the plurality of logistics robots, and an
25 operation priority order among the plurality of logistics

robots.

[24] For example, the process state information may further include detection information measured through a detection device for detecting the facility and the logistics robot in
5 the operation boundary.

[25] For example, the control signal may include a control signal for causing a warning notification based on the result of prediction to be expressed.

[26] For example, the control signal may include a signal
10 for controlling a speed or a moving direction or both of at least one of the plurality of logistics robots when the collision type corresponds to the collision between the plurality of logistics robots.

[27] For example, the control signal may include a signal
15 for controlling the plurality of logistics robots so that the plurality of logistics robots operate according to an operation priority order therebetween.

[28] For example, the control signal may include a signal for, when the collision type corresponds to the collision
20 between any one of the plurality of facilities and any one of the plurality of logistics robots, being forwarded to the facility and controlling a task state of the facility.

[29] For example, the control signal may include a signal for, when the collision type corresponds to the collision
25 between any one of the plurality of facilities and any one of

the plurality of logistics robots, being forwarded to the logistics robot and controlling a speed or a moving direction or both of the logistics robot.

[30]

5 **[31]** In order to achieve the above objectives, according to the present disclosure, there is provided a collision prediction method for logistics robots, the collision prediction method including: collecting process state information including facility information on a plurality of
10 facilities disposed in a preset operation boundary, and logistics robot operation information on the plurality of logistics robots that are provided in the operation boundary and move passing through at least one or some of a plurality of facility zones in which the plurality of facilities are
15 disposed; learning, on the basis of the process state information, collision prediction criteria for respective collision types including a collision between any one of the plurality of facilities and any one of the plurality of logistics robots, and a collision between the plurality of
20 logistics robots; predicting, on the basis of the process state information collected after learning and the learnt collision prediction criteria, occurrence of a collision with at least one of the plurality of logistics robots; and outputting a control signal corresponding to a result of
25 prediction.

[32]

Effects of the Invention

[33] According to the embodiments of the present disclosure as described above, collisions of logistics robots can be
5 predicted in advance. In particular, by learning collision prediction criteria for collision types that may occur in the operation boundary, the performance of collision prediction can be improved.

[34] In addition, logistics robots or facilities are
10 controlled according to a result of collision prediction, thereby preventing the occurrence of collisions.

[35] Through the above effects, damage to logistics robots or facilities can be prevented, and, furthermore, process delays caused by the occurrence of collision events can be
15 prevented, thereby enabling the process to proceed in a stable manner.

[36]

[37] Effects that may be obtained from the present disclosure will not be limited to only the above-described
20 effects. In addition, other effects which are not described herein will become apparent to those skilled in the art from the following description.

[38]

Brief Description of Drawings

25 [39] FIG. 1 is a block diagram illustrating an example of

the configuration of an operation boundary applicable to embodiments of the present disclosure.

[40] FIG. 2 is a diagram illustrating an example of the implementation of an operation boundary applicable to
5 embodiments of the present disclosure.

[41] FIG. 3 is a block diagram illustrating an example of the configuration of a control device applicable to embodiments of the present disclosure.

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

[43] FIG. 5 is a sequence diagram illustrating a process of predicting a collision of logistics robots according to an embodiment of the present disclosure.

15 [44]

Mode for Carrying Out the Invention

[45] Hereinafter, embodiments described in the present specification will be described in detail with reference to the accompanying drawings. Throughout the drawings, like or
20 similar elements are denoted by the same reference numerals, and a redundant description thereof will be omitted. The suffixes "module" and "part" for elements used in the following description are given or used interchangeably only for the sake of easiness in making the specification, and do
25 not have distinctive meanings or roles by themselves. In

addition, in describing an embodiment disclosed in the present specification, if it is determined that a detailed description of the known art related to the present disclosure makes the subject matter of the embodiment disclosed in the present specification unclear, the detailed description will be omitted. In addition, the accompanying drawings are only for easy understanding of the embodiment disclosed in the present specification, and do not limit the technical idea disclosed in the present specification. In addition, it is to be understood that the present disclosure includes all modifications, equivalents, and substitutions included in the spirit and the scope of the present disclosure.

[46] The terms "first", "second", etc. used in the specification can be used to describe various elements, but the elements are not to be construed as being limited to the terms. The terms are only used to differentiate one element from other elements.

[47] It will be understood that when an element is referred to as being "coupled" or "connected" to another element, it can be directly coupled or connected to the other element or intervening elements may be present therebetween. In contrast, it will be understood that when an element is referred to as being "directly coupled" or "directly connected" to another element, there are no intervening

elements present.

[48] As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

5 **[49]** In the present specification, it is to be understood that terms such as "including", "having", etc. are intended to indicate the existence of the features, numbers, steps, actions, elements, parts, or combinations thereof disclosed in the specification, and are not intended to preclude the
10 possibility that one or more other features, numbers, steps, actions, elements, parts, or combinations thereof may exist or may be added.

[50] In addition, a unit or control unit included in names of the internal configuration of a logistics robot or a control
15 device is only a term that is widely used to name a controller that controls a particular function, and does not mean a generic function unit. For example, each controller may include a modem/transceiver communicating with another controller or a sensor in order to control a function in
20 charge, a memory storing operating system or logic instructions and input/output information, and at least one processor performing determination, operation, and decision required for controlling a function in charge. Depending on the implementation, a single processor may be responsible for
25 operation for a plurality of controllers.

[51] First, the configuration of an operation boundary according to an embodiment in which logistics robots are disposed and operated will be described with reference to FIGS. 1 and 2.

5 **[52]**

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

10 **[54]** Referring to FIG. 1, an operation boundary 100 may include a logistics robot 110, a facility 120, a detection device 130, and a control device 140.

[55] According to a production process and a target production speed of a product, a plurality of logistics robots 110, a plurality of facilities 120, and a plurality of
15 detection devices 130 may be provided in the operation boundary 100. The operation boundary 100 may be implemented as a smart factory and the plurality of facilities may be implemented as production devices, but are not necessarily limited thereto. Hereinafter, each element will be
20 described.

[56] First, the logistics robot 110 may include an autonomous mobile robot (hereinafter, referred to as the "AMR" for convenience) and an automated guided vehicle (hereinafter, referred to as the "AGV" for convenience). According to an
25 operation policy of the logistics robot 110, only one type,

either the AGV or the AMR, may be operated in the operation boundary 100, or both types, the AGV and the AMR, may be operated together in the operation boundary 100.

[57] The AGV generally performs required operations (such as
5 movement, direction change, and stop) in the operation boundary 100 by recognizing and following guidance facilities disposed on the floor for guidance for the AGV. Herein, the guidance facilities may refer to optically recognizable markers (such as spots, and 2D codes), tags (for example, NFC
10 tags, and RFID tags) contactlessly recognizable at short distances, magnetic strips, and wires, but are merely illustrative and are not necessarily limited thereto. The guide facilities may be continuously disposed on the floor, or may be discontinuously disposed, spaced apart from each
15 other. Since the AGV fundamentally performs operations by recognizing and following the guidance facilities, the guidance facilities are required to be pre-installed before the operations. When the AGV needs to be moved to a new path or an original path needs to be modified, new-installation or
20 modification of the guidance facility needs to be physically performed. In addition, the AGV does not deviate from a path set through the guidance facilities. Therefore, when an obstacle is detected on or near the path, it is typical for the AGV to stop until the detected obstacle disappears or
25 separate control is received. In operation of the AGV, the

control device 140 needs to control the AGV on the basis of the guidance facilities, and may forward, to the AGV, commands, such as "travel until the third marker is recognized" and "change the heading direction by 90 degrees
5 when the third marker is recognized", from the current position on an individual command basis or a mission basis (for example, withdrawal, supply, charging, and patrol) including a plurality of commands.

[58] The AMR is capable of determining (that is,
10 localization) the current position through surrounding detection, and is capable of self path setting (path planning) using localization and a map, which is the most distinguishing feature from the AGV. Accordingly, when the AMR and the control device 140 share a map with compatible
15 coordinates, the control device 140 may control the AMR by directing the AMR to a path based on coordinates. In addition, when an obstacle is detected during travel, the AMR may autonomously set an avoidance path to avoid the obstacle and return to the original path. A function in which the
20 control device 140 sets a path of the AMR using one or more via coordinates may be referred to as global path planning. A function in which the AMR sets a moving path or an avoidance path between the via coordinates according to the global path planning may be referred to as local path
25 planning.

[59]

[60] Next, the facility 120 may refer to a device (such as a robotic arm, and a conveyor belt) that performs a production process of a product in the operation boundary 100, for example. In a broader sense, the facility 120 may refer to a device disposed to assist in the execution of missions, such as entry or exit of the logistics robot 110, when a production process is performed by a human. The device disposed to assist in the execution of missions may be a device for detecting a state of a designated position at which a pallet carried by the logistics robot 110 may be put down or removed in a zone in which a particular production process is performed, a device for determining the progress of a process, or a means for preventing entry into or exit from a zone, but is not necessarily limited thereto.

[61] For example, the facility 120 may be controlled through a programmable logic controller (PLC), and may communicate with the control device 140 in relation to the progress of a process.

[62] The detection device 130 may perform a function of obtaining information for determinating a situation in the operation boundary 100 and forwarding the information to the control device 140. For example, the detection device 130 may include a camera, and a proximity sensor, but is not necessarily limited thereto.

[63] The control device 140 may communicate with the above-described elements 110, 120, and 130 to obtain information required for the operation of the operation boundary 100 or control each of the elements. For example, the control
5 device 140 may perform allocation of the logistics robot 110, path setting, mission assignment, process management for each product, and material management.

[64] In an implementation, the control device 140 may include an AMR/AGV control system (ACS) that controls surrounding
10 process facilities on the basis of the position of the AGV/AMR and performs control based on a mission of the AGV/AMR, and a mobile robot integrated monitoring system (MoRIMS) that controls two or more AMR/AGV control systems in an integrated manner. The mobile robot integrated monitoring
15 system may perform acquisition of states and paths of all the logistics robots 110 in the operation boundary 100 from each of a plurality of AMR/AGV control systems, logistics flow setting, and traffic control. For example, when the AMR/AGV control systems (ACSSs) are provided with respective logistics
20 robots of the same manufacturer or the same model, the mobile robot integrated monitoring system may perform integrated control, such as analysis of bottleneck levels of overlapping /intersecting zones, travel acceleration/deceleration control, and avoidance path regeneration, for collision
25 avoidance through traffic distribution control between

heterogeneous types on the basis of information obtained through the plurality of AMR/AGV control systems (ACSS).

[65] In addition, the mobile robot integrated monitoring system may have a manufacturing execution system (MES) as a higher-level controller, and the manufacturing execution system (MES) may be linked with an advanced planning & scheduling (APS) system.

[66] It is to be understood that in addition to the above-described elements 110, 120, 130, and 140 of the operation boundary 100, a device for intercommunication between elements, such as a beacons, repeaters, and access points (APs), a charger for charging the logistics robots 110, a loading space for storing or loading components, a space for storing finished products or intermediate products, a traffic light, an automatic gate, and a standby space for idle logistics robots 110 may be appropriately disposed in the operation boundary 100.

[67] Hereinafter, an example of the implementation of the operation boundary 100 applicable to embodiments of the present disclosure will be described with reference to FIG. 2.

[68] FIG. 2 is a diagram illustrating an example of the implementation of an operation boundary applicable to embodiments of the present disclosure. The example of the implementation shown in FIG. 2 mainly shows the elements

related to the description of the present disclosure, and in an actual implementation of the operation boundary 100, more or fewer elements may be included.

[69] Referring to FIG. 2, a plurality of facility zones (Zs) may be provided in the operation boundary 100, and facilities 120 of the same or different types may be disposed in the respective facility zones (Zs). The logistics robot 110 moves in the operation boundary 100 while passing through at least one or some of the plurality of facility zones (Zs), and the plurality of logistics robots 110 may be disposed in the operation boundary 100.

[70] In the process in which the logistics robots 110 move within the operation boundary 100, collisions between the logistics robots 110, or collisions between the logistics robot 110 and the facility 120 may occur. As such, when a collision with the logistics robot 110 occurs, the logistics robot 110 is broken and causes loss and the entire process may be stopped, resulting in a decrease in process efficiency. Therefore, it is proposed to predict and prevent such a collision of the logistics robots 110 in advance through a collision prediction apparatus 150 according to an embodiment of the present disclosure.

[71] Hereinafter, the configuration of the control device 140 applicable to embodiments of the present disclosure will be described with reference to FIG. 3.

[72]

[73] FIG. 3 is a block diagram illustrating an example of the configuration of a control device applicable to embodiments of the present disclosure. Each element shown in FIG. 3
5 mainly shows the elements related to embodiments of the present disclosure, and in an actual implementation of the control device 140, more or fewer elements may be included.

[74] Referring to FIG. 3, the control device 140 may include a firmware management part 141, a traffic control part 142, a
10 process management part 143, a production/logistics management part 144, an inventory management part 145, a communication part 146, a monitoring part 147, a map management part 148, and a task schedule management part 149.

[75] The firmware management part 141 may obtain the latest
15 firmware of the logistics robot 110 through the communication part 146 and may transmit the latest firmware to the logistics robot 110 for updating the firmware, thereby maintaining the firmware of the logistics robot 110 in an up-to-date state.

20 **[76]** The traffic control part 142 may control a traffic light and an automatic gate on the basis of a path of the logistics robot 110, and may re-calculate the path of the logistics robot 110 according to traffic.

[77] The process management part 143 may define a process for
25 each product, and may manage missions, such as process

progress and progress positions.

[78] The production/logistics management part 144 may allocate the logistics robot 110 on the basis of a mission.

[79] The inventory management part 145 may manage the
5 position of each material and quantity, and this information
may be useful for more efficient process operation, such as
sending the logistics robots 110 to a destination in advance
for pallet pickup or withdrawal before the time point at
which the actual assembly/consumption of materials is
10 detected.

[80] The communication part 146 may communicate with the
internal elements, such as the logistics robot 110, the
facility 120, and the detection device 130, of the operation
boundary 100 as well as an external entity, such as a
15 firmware update server.

[81] The monitoring part 147 may monitor the position, path,
battery state, communication state, and powertrain state of
each individual logistics robot 110. Herein, the path is a
concept including a waypoint-based global path and a real-
20 time local path. In addition, the battery state may include
voltage, current, temperature, peak values of voltage and
current, state of charge (SOC), and state of health (SOH).
The communication state may include information on a
currently activated communication protocol (such as Wi-Fi), a
25 connected AP, a distance to an AP, and a channel in use. In

addition, the powertrain state may include load, temperature, and RPM of the drive system.

[82] In addition, the monitoring part 147 may identify a currently assigned mission, an operation mode, and a firmware
5 version of each individual logistics robot 110.

[83]

[84] The map management part 148 may obtain map data in the form of a grid map obtained while the AMR among the logistics robots 110 travels within the operation boundary 100, and may
10 provide a tool by which a factory manager edits the obtained map data. Through editing of the map data, zones in which the logistics robot 110 performs one or more preset operations upon entry, virtual lanes, intersections, and entry-restricted zones may be set, but these are merely
15 examples and are not limited thereto. In addition, map management part 148 may distribute the grid map initially obtained by the logistics robot 110 through actual travel, to the other logistics robots 110 through the communication part 146.

20 **[85]** The task schedule management part 149 may manage and monitor a mission of the logistics robots 110 on the basis of process information of the operation boundary 100 received from the facility 120 and the detection device 130 through the communication part 146. In addition, the task schedule
25 management part 149 may select a particular logistics robot

110 and assign a mission thereto, and may set a global path the logistics robot 110 according to the assigned mission.

[86] Next, a logistics robot will be described with reference to FIG. 4.

5 **[87]**

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

[89] Referring to FIG. 4, a logistics robot 110 may include a
10 driving part 111, a sensing part 112, a loading part 113, a communication part 114, and a control part 115. Hereinafter, each element will be described.

[90] The driving part 111 may include a driving source, wheels, and suspension that are involved in movement,
15 steering, and stopping of the logistics robot 110. As the driving source, an electric motor that receives power from a built-in battery (not shown) may be used. The wheels may include one or more driving wheels that receive driving force from the driving source, and non-driving wheels that rotate
20 by movement of the vehicle body without receiving driving force. Depending on the implementation, when a plurality of driving wheels are provided, a driving source may be matched to each of the driving wheels so that the rotation of each driving wheel may be independently controlled. In this case,
25 steering may be achieved by rotating the vehicle body without

a separate steering means, by making the rotation directions of different driving wheels different from each other. At least some of the non-driving wheels may be configured as caster-type wheels, but this is merely an example and is not
5 limited thereto.

[91] The sensing part 112 is to detect a surrounding environment of the logistics robot 110 or an operation state thereof, and may include at least one selected from the group of a 2D laser scanner (for example, LiDAR), a 3D vision
10 (stereo) camera, a multi-axis gyro sensor, an acceleration sensor, a wheel encoder, and a proximity sensor.

[92] The encoder may output information for determining how much a wheel has rotated by using light emitted from a light-emitting element (for example, a photodiode). For example,
15 the encoder may count the number of slits disposed in a circumferential direction on a wheel or a disk rotating together with the wheel during a unit time. The control part 115 may perform odometry in which a displacement is estimated by analyzing a change in position over time on the basis of
20 data obtained through the encoder and the gyro sensor. However, there may be an error between an actual displacement and a displacement estimated on the basis of encoder data due to wheel slip or wear (a change in the wheel dynamic radius. Accordingly, when performing odometry, the control part 115
25 may perform correction on noise and errors using a particular

algorithm (for example, the extended Kalman filter (EKF)) on the basis of information collected from the wheel and the gyro sensor, thereby outputting a result having a tendency close to an actual value. This odometry may be particularly
5 useful when determination of the current position (localization) using a 2D laser scanner, which will be described later, is not available.

[93] The 2D laser scanner may scan a surrounding environment by emitting a laser around itself through a rotating mirror,
10 and detecting a signal reflected back. Herein, a point cloud-shaped detection result may be output by analyzing the intensity of the reflected signal and the difference in time between emission and reception.

[94] A 3D vision camera may calculate a distance to an object
15 on the basis of a parallax between two cameras spaced apart from each other by a predetermined distance, that is, a pixel distance between images obtained through the respective cameras. Herein, a texture projector for projecting infrared light having a particular pattern may be provided so as to
20 enable detection even for planar objects having the same color (for example, a white wall).

[95] In general, the 2D laser scanner may be used for mapping, navigation, and object recognition, and the 3D camera may be used for obstacle avoidance during navigation.
25 However, this is merely an example and is not necessarily

limited thereto.

[96] The loading part 113 is a means for loading an object to be transported, and may be implemented as an upper plate of a vehicle body, a table disposed on the upper plate, a lift, a
5 turntable rotating along a vertical axis, a fork lift, a conveyor, or a combination thereof. In the case of the fork lift, telescopic and tilting functions may be supported similarly to a forklift.

[97] The communication part 114 may perform communication
10 with other elements, such as the facility 120 and the control device 140, within the operation boundary 100, and may support communication between the logistics robots 110, and may communicate with a charger when a charging mission is performed.

[98] The control part 115 is a controller that performs
15 overall control of the above-described elements 111, 112, 113, and 114, and may perform determination of a current mission, determination of the current position, determination of a destination, path planning, and control of the loading
20 part on the basis of information obtained from the control device 140 through the communication part 114.

[99] Hereinafter, a process of predicting a collision of logistics robots according to an embodiment of the present disclosure will be described in detail with reference to FIG.
25 5.

[100] FIG. 5 is a sequence diagram illustrating a process of predicting a collision of logistics robots according to an embodiment of the present disclosure.

[101] Referring to FIG. 5, a collision prediction apparatus 150 according to an embodiment of the present disclosure may include a collection part 151, a learning part 152, a prediction part 153, and an output part 154, and may be connected to a control device 140. However, FIG. 5 mainly shows the elements related to the description of the present disclosure, and in an actual implementation of the actual collision prediction apparatus 150, more or fewer elements may be included. In addition, the collision prediction apparatus 150 may be implemented as a part of the control device 140, instead of being connected to the control device 140. Hereinafter, a collision prediction process according to an embodiment of the present disclosure will be described in detail.

[102] First, the collection part 151 may collect process state information in step S510, wherein the process state information includes facility information on a plurality of facilities 120 disposed in a preset operation boundary 100, and logistics robot operation information on operations of a plurality of logistics robots 110 that are provided in the operation boundary 100 and move passing through at least one or some of a plurality of facility zones (Zs) in which the

plurality of facilities 120 are disposed. In this case, the process state information may be obtained from the control device 140, and the control device 140 may obtain the logistics robot operation information through communication
5 with the logistics robots 110 in step S501'. In addition, the control device 140 may obtain the facility information and the detection information through communication with the facilities 120 and the detection device 130 and may forward the facility information and the detection information to the
10 collection part 151.

[103] More specifically, the facility information may include at least one selected from the group of coordinates of the facility zone (Z) corresponding to the facility in the operation boundary 100, and a task state of the facility. In
15 particular, the facility information may vary according to an operation characteristic of the facility 120. For example, when the facility 120 has an operation characteristic in which the facility 120 is not fixed as a particular position in the facility zone (Z) and a range occupied by the
20 facility in the facility zone (Z) varies according to the task state, such a variation may be applied to the facility information, thereby improving learning and judgment performance of collision prediction.

[104] In the meantime, the logistics robot operation
25 information may include at least one selected from the group

of a speed, a moving direction, a moving path, a size, a normal operation status, a sensor detection result, braking specification, a real-time clock, a characteristic of a loaded item of each of the plurality of logistics robots 110,
5 an inter-robot distance among some of the plurality of logistics robots, and an operation priority order among the plurality of logistics robots.

[105]

[106] The collection part 151 may input the collected process
10 state information to the learning part 512 in step S502, and the learning part 512 may learn, on the basis of the process state information, collision prediction criteria for respective collision types including a collision between any one of the plurality of facilities 120 and any one of the
15 plurality of logistics robots 110 and a collision among some of the plurality of logistics robots in step S503. Afterward, the learning part 512 may input the learnt collision prediction criteria to the prediction part 153 in step S504.

20 **[107]** In particular, the learning part 152 may label the process state information according to time periods, and may learn the collision prediction criteria for the respective collision types on the basis of the labeled process state information.

25 **[108]** More specifically, for each collision type, the learning

part 152 may classify the labeled process state information with respect to the plurality of logistics robots 110 depending on whether a preset distance condition for a target object including the facility 120 and another one of the plurality of logistics robots 110 is satisfied. In this case, the preset distance condition may be satisfied when the logistics robot 110 and the target object approach each other within a predetermined distance, for example.

[109] In addition, the learning part 152 may also learn the collision prediction criteria on the basis of the process state information corresponding to a time point before a preset time interval from a time point when the preset distance condition is satisfied, among the labeled process state information. In this case, the learning of the collision prediction criteria may be performed when any one of the plurality of logistics robots 110 satisfies the preset distance condition.

[110] In contrast, the learning part 152 may also learn the collision prediction criteria on the basis of the process state information corresponding to a time point before a preset time interval from a time point when the preset distance condition is not satisfied, among the labeled process state information.

[111]

[112] The prediction part 153 may be continuously supplied

with not only the learning information and learning result,
but also the process state information as determination
information for predicting a collision in step S505. On the
basis of the process state information collected after
5 learning and the learnt collision prediction criteria, the
prediction part 153 may predict the occurrence of a collision
with at least one of the plurality of logistics robots 110.

[113]Afterward, the prediction part 153 may input a result of
prediction to the output part 154 in step S506, and the
10 output part 154 may output a control signal corresponding to
the input result of prediction in step S507. In this case,
the output control signal may be forwarded to the control
device 140 and may be forwarded to the logistics robot 110 or
the facility 120, or may be directly forwarded to the
15 logistics robot 110 and the facility 120.

[114]More specifically, the control signal may include a
control signal for causing a warning notification based on
the result of prediction to be expressed, and the warning
notification may be forwarded to the control device 140, the
20 facility 120, and the logistics robot 110.

[115]In addition, when the collision type corresponds to a
collision among some of the plurality of logistics robots
110, the control signal may include a signal for controlling
the speed or the moving direction or both of at least one of
25 the logistics robots 110. Through this, when the collision

is predicted, the logistics robot 110 may be controlled to decelerate, stop, or perform avoidance travel. For example, the control signal may be a control signal for causing the logistics robot to stop in advance and wait, and may be
5 forwarded to the logistics robot 110 via the control device 140 in step S508.

[116] In addition, the control signal may control some of the logistics robots 110 so that the logistics robots operate according to an operation priority order between the
10 logistics robots 110. For example, the logistics robots may be controlled so that the logistics robot 110 having a high priority may maintain its operation state and the logistics robot 110 having a low priority may stop, decelerate, or perform avoidance travel.

[117] In addition, when the collision type corresponds to a collision between any one of the plurality of facilities 120 and any one of the plurality of logistics robots 110, the control signal may be forwarded to the facility 120 and may include a signal for controlling the task state of the
20 facility 120. For example, through such a control signal, the facility 120 may be controlled to stop its task.

[118] In addition, when the collision type corresponds to a collision between any one of the plurality of facilities 120 and any one of the plurality of logistics robots 110, the
25 control signal may be forwarded to the logistics robot 110

and may include a signal for controlling the speed or the moving direction or both of the logistics robot 110.

[119] That is, the collision prediction apparatus 150 may prevent a collision by controlling the operation of the logistics robot 110 or the facility 120 or both.

[120] In the meantime, after a collision issue related to the logistics robot 110 is resolved, the control device 140 may request the logistics robot 110 or the facility 120 to resume the task in step S509, and the logistics robot 110 having received the request may supplement its travel algorithm according to the result of collision prediction in step S510. After supplementing the algorithm, the logistics robot 110 may recheck a mission with the control device 140 in step S511. After the mission is checked, the control device 140 may request the logistics robot 110 to proceed with the mission operation in step S512, and finally the logistics robot may resume the operation.

[121]

[122] According to the embodiments of the present disclosure as described above, collisions of logistics robots can be predicted in advance. In particular, by learning collision prediction criteria for collision types that may occur in the operation boundary, the performance of collision prediction can be improved.

[123] In addition, logistics robots or facilities are

controlled according to a result of collision prediction,
thereby preventing the occurrence of collisions.

[124] Through the above effects, damage to logistics robots or
facilities can be prevented, and, furthermore, process delays
5 caused by the occurrence of collision events can be
prevented, thereby enabling the process to proceed in a
stable manner.

[125]

[126] Although a particular embodiment of the present
10 disclosure has been described for illustrative purposes,
those skilled in the art will appreciate that various
modifications, additions, and substitutions are possible,
without departing from the technical idea of the disclosure
as disclosed in the accompanying claims.

15

CLAIMS

[Claim 1] A collision prediction device for logistics robot, the collision prediction device comprising:

5 a collection part configured to collect process state information including facility information on a plurality of facilities disposed in a preset operation boundary, and logistics robot operation information on a plurality of logistics robots that are provided in the operation boundary
10 and move passing through at least one or some of a plurality of facility zones in which the plurality of facilities are disposed;

 a learning part configured to learn, based on the process state information, collision prediction criteria for
15 respective collision types including a collision between any one of the plurality of facilities and any one of the plurality of logistics robots, and a collision between the plurality of logistics robots;

 a prediction part configured to predict, based the
20 process state information collected after learning the collision prediction criteria and the learnt collision prediction criteria, occurrence of a collision of at least one of the plurality of logistics robots; and

 an output part configured to output a control signal
25 corresponding to a result of prediction.

[Claim 2] The collision prediction device of claim 1,
wherein the learning part is configured to label the process
state information according to time periods, and learn the
5 collision prediction criteria for the respective collision
types based on the labeled process state information.

[Claim 3] The collision prediction device of claim 2,
wherein the learning part is configured to, with respect to
10 the plurality of logistics robots, classify the labeled
process state information depending on whether a preset
distance condition for a target object including the facility
and another one of the plurality of logistics robots is
satisfied.

15

[Claim 4] The collision prediction device of claim 3,
wherein the learning part is configured to learn the
collision prediction criteria based on the process state
information corresponding to a time point before a preset
20 time interval from a time point when the preset distance
condition is satisfied, among the labeled process state
information.

[Claim 5] The collision prediction device of claim 4,
25 wherein the learning part is configured to perform learning

based on any one of the plurality of logistics robots satisfying the preset distance condition.

[Claim 6] The collision prediction device of claim 3,
5 wherein the learning part is configured to learn the collision prediction criteria based on the process state information corresponding to a time point before a preset time interval from a time point when the preset distance condition is not satisfied, among the labeled process state
10 information.

[Claim 7] The collision prediction device of claim 1, wherein the facility information includes coordinates of the facility zone corresponding to the facility in the operation
15 boundary or a task state of the facility or both.

[Claim 8] The collision prediction device of claim 1, wherein the facility information varies according to an operation characteristic of the facility.

20

[Claim 9] The collision prediction device of claim 1, wherein the logistics robot operation information includes at least one of a speed, a moving direction, a moving path, a size, whether the operation is normal, a sensor detection
25 result, braking specification, a real-time clock, a

characteristic of a loaded item of each of the plurality of logistics robots, an inter-robot distance among some of the plurality of logistics robots, or an operation priority order among the plurality of logistics robots.

5

[Claim 10] The collision prediction device of claim 1, wherein the process state information further includes sensor information measured through a detection device for detecting the facility and the logistics robot in the operation
10 boundary.

[Claim 11] The collision prediction device of claim 1, wherein the control signal includes a control signal for causing a warning notification based on the result of
15 prediction to be expressed.

[Claim 12] The collision prediction device of claim 1, wherein the control signal includes a signal for controlling a speed or a moving direction or both of at least one of the
20 plurality of logistics robots based on the collision type corresponding to the collision between the plurality of logistics robots.

[Claim 13] The collision prediction device of claim 1,
25 wherein the control signal includes a signal for controlling

the plurality of logistics robots so that the plurality of logistics robots operate according to an operation priority order therebetween.

5 [Claim 14] The collision prediction device of claim 1, wherein the control signal includes a signal for, based on the collision type corresponding to the collision between any one of the plurality of facilities and any one of the plurality of logistics robots, being forwarded to the
10 facility and controlling a task state of the facility.

 [Claim 15] The collision prediction device of claim 1, wherein the control signal includes a signal for, based on the collision type corresponding to the collision between any
15 one of the plurality of facilities and any one of the plurality of logistics robots, being forwarded to the logistics robot and controlling a speed or a moving direction or both of the logistics robot.

20 [Claim 16] A collision prediction method for logistics robot, the collision prediction method comprising:

 collecting process state information including facility information on a plurality of facilities disposed in a preset operation boundary, and logistics robot operation information
25 on a plurality of logistics robots that are provided in the

operation boundary and move passing through at least one or some of a plurality of facility zones in which the plurality of facilities are disposed;

learning, based on the process state information,
5 collision prediction criteria for respective collision types including a collision between any one of the plurality of facilities and any one of the plurality of logistics robots, and a collision between the plurality of logistics robots;

predicting, based on the process state information
10 collected after learning the collision prediction criteria and the learnt collision prediction criteria, occurrence of a collision with at least one of the plurality of logistics robots; and

outputting a control signal corresponding to a result of
15 prediction.