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(54) **MOVEMENT CONTROL METHOD FOR OMNIDIRECTIONAL AUTOMATIC FORKLIFT, AND OMNIDIRECTIONAL AUTOMATIC FORKLIFT**

(57) The present invention relates to a movement control method for an omnidirectional automatic forklift (100), wherein the omnidirectional automatic forklift (100) comprises a vehicle body (110) and fork arms (120), the movement control method comprising: S101: controlling the omnidirectional automatic forklift (100) to travel at a first preset speed; S102: judging, when an obstacle is detected, the obstacle and determining an effective obstacle; S103: calculating a distance between the effective

obstacle and the omnidirectional automatic forklift (100), and determining an obstacle-avoiding deceleration according to the distance; S104: controlling the omnidirectional automatic forklift (100) to travel at the obstacle-avoiding deceleration; and S105: judging whether the obstacle disappears, and returning to step S101 if the obstacle disappears. With the examples of the present invention, the omnidirectional safe obstacle avoidance is realized in an omnidirectional automatic forklift (100).

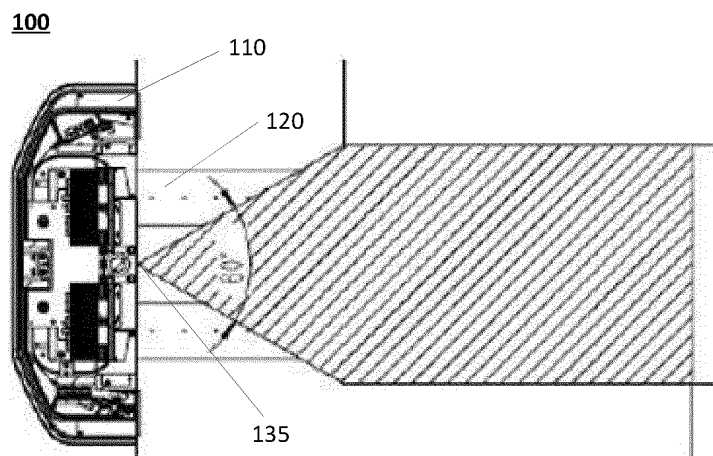


FIG. 5B

DescriptionTECHNICAL FIELD

[0001] The present invention relates to the intelligent warehousing field, especially to a movement control method for an omnidirectional automatic forklift, and an omnidirectional automatic forklift.

BACKGROUND ART

[0002] In warehousing systems and logistics & transportation links, omnidirectional automatic forklifts have been more and more used to replace or supplement manual labor. An omnidirectional automatic forklift can automatically receive a goods carrying task, i.e., under the program control, reaching a first position, obtaining the goods, then walking to a second position, unloading the goods and continuing to perform other tasks. When the omnidirectional automatic forklift moves in the logistics warehouse, it may usually encounter an obstacle in front or side front thereof. Then how to formulate an omnidirectional obstacle-avoiding strategy and obstacle-avoiding stop logic for the omnidirectional automatic forklift has become an urgent problem to be solved in the field of intelligent warehousing.

[0003] The contents in the Background Art are merely the technologies known by the inventors, and do not necessarily represent the prior art in the field.

SUMMARY OF THE INVENTION

[0004] In view of the above, the present invention provides a movement control method for an omnidirectional automatic forklift, wherein the omnidirectional automatic forklift comprises a vehicle body and fork arms, the movement control method comprising:

S101: controlling the omnidirectional automatic forklift to travel at a first preset speed;

S102: judging, when an obstacle is detected, the obstacle and determining an effective obstacle;

S103: calculating a distance between the effective obstacle and the omnidirectional automatic forklift, and determining an obstacle-avoiding deceleration according to the distance;

S104: controlling the omnidirectional automatic forklift to travel at the obstacle-avoiding deceleration; and S105: judging whether the obstacle disappears, and returning to step S101 if the obstacle disappears.

[0005] According to one aspect of the present invention, the step S103 comprises:

determining that the obstacle-avoiding deceleration is an emergency stop deceleration when the distance is less than an emergency obstacle-avoiding distance;

determining that the obstacle-avoiding deceleration is a short-range obstacle-avoiding deceleration when the distance is greater than the emergency obstacle-avoiding distance and less than a short-range obstacle-avoiding distance;

determining that the obstacle-avoiding deceleration is a long-range obstacle-avoiding deceleration when the distance is greater than the short-range obstacle-avoiding distance.

[0006] According to one aspect of the present invention, the step S102 comprises:

determining an obstacle-avoiding zone for the omnidirectional automatic forklift under different working conditions;

determining the obstacle in the obstacle-avoiding zone;

calculating a distance between the obstacle in the obstacle-avoiding zone and a center of the vehicle body;

selecting an obstacle closest to the center of the vehicle body as an effective obstacle.

[0007] According to an aspect of the present invention, the determining the obstacle in the obstacle-avoiding zone in the step S102 comprises:

calculating coordinate values of the obstacle by taking the center of the vehicle body as a coordinate origin;

calculating an equation of a straight line constituting each side of the obstacle-avoiding zone;

judging whether the obstacle is on an inner side of the straight line;

judging that the obstacle is in the obstacle-avoiding zone if the obstacle is on the inner side of the straight line.

[0008] According to one aspect of the present invention, the obstacle-avoiding zone includes a straight travel obstacle-avoiding zone when the omnidirectional automatic forklift is travelling straight, a lateral movement obstacle-avoiding zone when the omnidirectional automatic forklift is moving laterally, and a rotation obstacle-avoiding zone when the omnidirectional automatic forklift is

rotating.

[0009] According to one aspect of the present invention, it further comprises: controlling the fork arms to move to perform a goods picking or placing task; and the omnidirectional automatic forklift further comprises a tray placed on the fork arms for carrying goods.

[0010] According to one aspect of the present invention, the controlling the fork arms to move to perform a goods picking or placing task comprises:

controlling the fork arms to rise or descend at a second preset speed;

controlling the fork arms to suspend rising or descending when it is detected that there is an obstacle below the fork arms;

judging whether the obstacle below the fork arms disappears, and controlling the fork arms to rise or descend at a second preset speed if the obstacle disappears; and controlling the fork arms to stay still and cancelling the goods picking or placing task this time if the obstacle does not disappear after a preset time.

[0011] According to one aspect of the present invention, the controlling the fork arms to move to perform a goods picking or placing task comprises:

controlling the fork arms to rise or descend at a second preset speed;

cancelling the goods picking or placing task this time, and controlling the fork arms to move downward or upward by a preset distance when the fork arms suspend rising or descending and no obstacle below the fork arms is detected.

[0012] According to one aspect of the present invention, the controlling the fork arms to move to perform a goods picking or placing task comprises:

controlling the fork arms to rise or descend at a second preset speed;

judging whether the obstacle disappears after a preset time when the fork arms suspend rising or descending and no obstacle below the fork arms is detected;

controlling the fork arms to rise or descend at a second preset speed if the obstacle disappears;

controlling the fork arms to stay still, and cancelling the goods picking or placing task this time if the obstacle does not disappear.

[0013] The present invention also relates to an omni-

directional automatic forklift, comprising:

a vehicle body;

5 a chassis connected with the vehicle body and configured to drive the omnidirectional automatic forklift to move under different working conditions;

10 fork arms connected with the vehicle body and configured to move upward and downward in a vertical direction;

a tray placed on the fork arms for carrying goods;

15 a controller communicating with the omnidirectional automatic forklift and configured to implement any one of the movement control methods as described above on the omnidirectional automatic forklift.

20 **[0014]** According to one aspect of the present invention, it further comprises lidars and 3D cameras, both mounted on the vehicle body and configured to detect an obstacle.

25 **[0015]** According to one aspect of the present invention, it comprises two of the fork arms, two of the lidars and five of the 3D cameras, wherein two of the lidars are respectively mounted on both left and right sides of a head portion of the vehicle body, and five of the 3D cameras are respectively mounted on an upper side of a front portion of the vehicle body, an upper side of a rear portion of the vehicle body, a lower side of one of the fork arms and ends of two of the fork arms.

30 **[0016]** According to one aspect of the present invention, the controller is configured to determine an obstacle-avoiding zone for the omnidirectional automatic forklift under different working conditions according to a detection zone of the lidars and the 3D cameras, wherein the obstacle-avoiding zone includes a straight travel obstacle-avoiding zone when the omnidirectional automatic forklift is travelling straight, a lateral movement obstacle-avoiding zone when the omnidirectional automatic forklift is moving laterally, and a rotation obstacle-avoiding zone when the omnidirectional automatic forklift is rotating.

35 **[0017]** According to one aspect of the present invention, the controller is configured to switch combinations of the lidars and the 3D cameras and types of the obstacle-avoiding zones under different working conditions of the omnidirectional automatic forklift so as to perform movement control of the omnidirectional automatic forklift.

50 **[0018]** According to one aspect of the present invention, it further comprises a storage unit coupled with the controller and configured to store the movement control method implemented by the controller.

55 **[0019]** The present invention provides a movement control method for an omnidirectional automatic forklift, and an omnidirectional automatic forklift, and realizes the omnidirectional safe obstacle avoidance of the omni-

rectional automatic forklift by configuring the sensors of the omnidirectional automatic forklift and integrating the sensor data with the obstacle-avoiding stop logic.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The drawings that constitute part of the specification are provided for the purpose of further understanding the present invention, and the exemplary embodiments of the present invention and description thereof are provided to explain the present invention but do not make any inappropriate limitation of the same. In the drawings:

FIG. 1 is a flowchart of a movement control method for an omnidirectional automatic forklift according to one example of the present invention;

FIGS. 2A and 2B are schematic diagrams illustrating a detection zone of a 3D camera mounted on an upper side of a front portion of a vehicle body according to one example of the present invention;

FIGS. 3A and 3B are schematic diagrams illustrating a detection zone of a 3D camera mounted on an upper side of a rear portion of a vehicle body according to one example of the present invention;

FIG. 4 is a schematic diagram illustrating detection zones of 3D cameras mounted on ends of the fork arms according to one example of the present invention;

FIG. 5A is a schematic diagram after the fork arms rise according to one example of the present invention;

FIG. 5B is a schematic diagram illustrating a detection zone of a 3D camera mounted on a lower side of the fork arms according to one example of the present invention;

FIG. 6 is a flowchart for determining an obstacle in the obstacle-avoiding zone according to one example of the present invention;

FIG. 7 is a schematic diagram illustrating a straight travel obstacle-avoiding zone according to one example of the present invention;

FIG. 8 is a schematic diagram illustrating a lateral movement obstacle-avoiding zone according to one example of the present invention;

FIG. 9 is a schematic diagram illustrating a rotation obstacle-avoiding zone according to one example of the present invention;

FIG. 10 is a flowchart showing that the fork arms perform a goods picking or placing task according to one example of the present invention;

FIG. 11 is a flowchart showing that the fork arms perform a goods picking or placing task according to one example of the present invention;

FIG. 12 is a flowchart showing that the fork arms perform a goods picking or placing task according to one example of the present invention; and

FIGS. 13A, 13B and 13C respectively show a schematic diagram of a chassis according to one example of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

[0021] Certain exemplary examples will be described below only in a brief manner. Just as those skilled in the art will recognize, changes in various ways to the examples described herein can be carried out without departing from the spirit or scope of the present invention. Therefore, the drawings and the following description are deemed essentially exemplary, instead of limitative.

[0022] In the description of the present invention, it needs to be understood that the orientation or position relations denoted by such terms as "central" "longitudinal" "latitudinal" "length" "width" "thickness" "above" "below" "front" "rear" "left" "right" "vertical" "horizontal" "top" "bottom" "inside" "outside" "clockwise" "counterclockwise" and the like are based on the orientation or position as shown in the accompanying drawings, and are used only for the purpose of facilitating description of the present invention and simplification of the description, instead of indicating or suggesting that the denoted devices or elements must be oriented specifically, or configured or operated in some specific orientation. Thus, such terms should not be construed to limit the present invention. In addition, such terms as "first" and "second" are only used for the purpose of description, rather than indicating or suggesting relative importance or implicitly indicating the number of the designated technical features. Accordingly, features defined with "first" or "second" may, expressly or implicitly, include one or more of such features. In the description of the present invention, "plurality" means two or above, unless otherwise defined explicitly and specifically.

[0023] In the description of the present invention, it needs to be noted that, unless otherwise specified and defined explicitly, such terms as "mount" "link" and "connect" should be understood as generic terms. For example, connection may refer to fixed connection, dismountable connection, or integrated connection; also to mechanical connection, electrical connection or intercommunication; further to direct connection, or connection by an intermediary medium; or even to internal commu-

nication between two elements or interaction between two elements. For those skilled in the art, they can construe the specific meaning of such terms herein in light of the specific circumstances.

[0024] Herein, unless otherwise specified and defined explicitly, if a first feature is "above" or "below" a second one, this may cover the direct contact between the first and second features, also cover the contact via another feature therebetween, instead of the direct contact. Furthermore, if a first feature "above", "over" or "on the top of" a second one, this may cover the case that the first feature is right above or on the inclined top of the second feature, or just indicate that the first feature has a horizontal height higher than that of the second feature. If a first feature is "below", "under" or "on the bottom of" a second feature, this may cover the case that the first feature is right below and on the inclined bottom of the second feature, or just indicates that the first feature has a horizontal height lower than that of the second feature.

[0025] The disclosure below provides many different embodiments and instances so as to achieve different structures described herein. In order to simplify the disclosure herein, the following will give the description of the parts and arrangements embodied in specific instances. Surely, they are just for the exemplary purpose, not intended to limit the present invention. Besides, the present invention may repeat a reference number and/or reference letter in different instances, and such repeat is for the purpose of simplification and clarity, which does not represent any relation among various embodiments and/or arrangements as discussed. In addition, the present invention provides instances of various specific techniques and materials, but those skilled in the art can also be aware of application of other techniques and/or use of other materials.

[0026] The preferred examples of the present invention will be introduced below referring to the drawings. It should be appreciated that the preferred examples described herein are only for the purpose of illustrating and explaining, instead of restricting, the present invention.

[0027] FIG. 1 is a flowchart of a movement control method for an omnidirectional automatic forklift according to one example of the present invention. Among them, the omnidirectional automatic forklift 100 comprises a vehicle body 110 and fork arms 120. As shown in FIG. 1, the movement control method comprises the following steps.

[0028] In step S101, controlling the omnidirectional automatic forklift 100 to travel at a first preset speed. Among them, the omnidirectional automatic forklift 100 alternatively comprises four differential wheels, which can realize omnidirectional movement, including advance, retreat, left lateral movement, right lateral movement, rotation and curve movement.

[0029] In step S102, judging, when an obstacle is detected, the obstacle and determining an effective obstacle. Alternatively, lidars and 3D cameras are mounted on the vehicle body 110 of the omnidirectional automatic

forklift 100 to detect obstacles during its travelling. The lidars are alternatively installed on both left and right sides of a head portion of the vehicle body 110 of the omnidirectional automatic forklift 100, and the scanning range of the lidars is between $\pm 135^\circ$. One or more obstacles, when detected, are judged and then an effective obstacle is determined.

[0030] According to one example of the present invention, two lidars 136, 137 and five 3D cameras (131, 132, 133, 134, 135) are mounted on the vehicle body 110 of the omnidirectional automatic forklift 100, of which the five 3D cameras (131, 132, 133, 134, 135) are mounted on a front upper side of the vehicle body, a rear upper side of the vehicle body, ends of the fork arms and a lower side of the fork arms respectively. FIGS. 2A and 2B are schematic diagrams illustrating a detection zone of a 3D camera mounted on an upper side of a front portion of a vehicle body according to one example of the present invention. As shown in FIGS. 2A and 2B, the 3D camera 131 mounted on the upper side of the front portion of the vehicle body 110 is used to detect three-dimensional obstacles in a front zone of the vehicle body. FIGS. 3A and 3B are schematic diagrams illustrating a detection zone of a 3D camera mounted on an upper side of a rear portion of a vehicle body according to one example of the present invention. As shown in FIGS. 3A and 3B, the 3D camera 132 mounted on the upper side of the rear portion of the vehicle body 110 is used to detect three-dimensional obstacles in a rear zone of the vehicle body. FIG. 4 is a schematic diagram illustrating detection zones of 3D cameras mounted on ends of the fork arms according to one example of the present invention. As shown in FIG. 4, 3D cameras 133 and 134 mounted on the ends of the fork arms are used to detect obstacles in an end zone of the fork arms, wherein the shadow zones as shown are detection zones. FIGS. 5A and 5B respectively show a schematic diagram after the fork arms rise according to one example of the present invention and a schematic diagram illustrating a detection zone of a 3D camera mounted on a lower side of the fork arms. As shown in FIGS. 5A and 5B, the 3D camera 135 mounted on the lower side of the fork arms is used to detect obstacles below the fork arms when the fork arms 120 rise, wherein the shadow zone as shown in FIG. 5B is a detection zone.

[0031] In step S103, calculating a distance between the effective obstacle and the omnidirectional automatic forklift, and determining an obstacle-avoiding deceleration according to the distance. Alternatively, the obstacle-avoiding deceleration is determined based on the first preset speed (i.e., an initial speed), a target speed (i.e., a final speed having the value of 0) and a distance between the effective obstacle and the omnidirectional automatic forklift.

[0032] In step S104, controlling the omnidirectional automatic forklift 100 to travel at the obstacle-avoiding deceleration.

[0033] In step S105, judging whether the obstacle dis-

appears, and returning to step S101 if the obstacle disappears. In the process of the omnidirectional automatic forklift 100 traveling at the obstacle-avoiding deceleration, it constantly detects the obstacles around the omnidirectional automatic forklift 100 and judges whether the obstacles disappear. If the obstacles have disappeared, the omnidirectional automatic forklift 100 is controlled to continue to travel at the first preset speed.

[0034] According to one example of the present invention, an emergency obstacle-avoiding distance, a short-range obstacle-avoiding distance and a long-range obstacle-avoiding distance are respectively set for the omnidirectional automatic forklift 100, wherein the emergency obstacle-avoiding distance, short-range obstacle-avoiding distance and long-range obstacle-avoiding distance increases successively, then the step S103 comprising:

determining that the obstacle-avoiding deceleration is an emergency stop deceleration when the distance is less than an emergency obstacle-avoiding distance;

determining that the obstacle-avoiding deceleration is a short-range obstacle-avoiding deceleration when the distance is greater than the emergency obstacle-avoiding distance and less than a short-range obstacle-avoiding distance;

determining that the obstacle-avoiding deceleration is a long-range obstacle-avoiding deceleration when the distance is greater than the short-range obstacle-avoiding distance.

[0035] According to one example of the present invention, the step S102 comprises:

determining an obstacle-avoiding zone for the omnidirectional automatic forklift 100 under different working conditions. Alternatively, when the omnidirectional automatic forklift 100 travels under different working conditions, the obstacle-avoiding zone corresponds to a zone covered around the omnidirectional automatic forklift 100 under different working conditions.

determining the obstacle in the obstacle-avoiding zone. The obstacle, for example one or more, in the obstacle-avoiding zone is detected as an obstacle as long as it falls in the obstacle-avoiding zone.

calculating a distance between the obstacle in the obstacle-avoiding zone and a center O of the vehicle body 110.

selecting an obstacle closest to the center O of the vehicle body 110 as an effective obstacle. All the obstacles, including those in the detection zones of

the lidars 136 and 137 and those in the detection zones of the 3D cameras (131, 132, 133, 134 and 135), are sorted according to the distances between such obstacles and the center O of the vehicle body, and an obstacle closest to the center O of the vehicle body 110 is selected as the effective obstacle.

[0036] FIG. 6 is a flowchart for determining an obstacle in the obstacle-avoiding zone according to one example of the present invention. As shown in FIG. 6, determining the obstacle in the obstacle-avoiding zone in the step S102 comprises:

[0037] In step S1021, calculating coordinate values of the obstacle by taking the center O of the vehicle body 110 as a coordinate origin. Alternatively, a coordinate system is established with the center O of the vehicle body 110 as the coordinate origin, the obstacle is regarded as a point, and the coordinate values of the obstacle are calculated according to the coordinate system.

[0038] In step S1022, calculating an equation of a straight line constituting each side of the obstacle-avoiding zone. The obstacle-avoiding zone is represented by a polygon composed of a plurality of sides, and equations of straight lines composed of a starting point and an ending point of various sides are respectively calculated by traversing various sides constituting the polygon.

[0039] In step S1023, judging whether the obstacle is on an inner side of the straight line. That is, it is judged whether the obstacle falls in the interior of the polygon according to the coordinates of the obstacle.

[0040] In step S1024, judging that the obstacle is in the obstacle-avoiding zone if the obstacle is on the inner side of the straight line. Alternatively, if the obstacle is not on the inner side of the straight line, it is judged that the obstacle is not in the obstacle-avoiding zone, and the process returns to step S1022.

[0041] FIGS. 7, 8 and 9 respectively show schematic diagrams illustrating a straight travel obstacle-avoiding zone, a lateral movement obstacle-avoiding zone and a rotation obstacle-avoiding zone according to one example of the present invention. According to one example of the present invention, the omnidirectional automatic forklift further comprises a chassis (see FIGS. 13A, 13B and 13C) connected with the vehicle body 110 and alternatively comprising four differential wheels, or two differential wheels and one steering wheel, or two differential wheels and two steering wheels. The chassis is configured to drive the omnidirectional automatic forklift 100 to move under different working conditions, so as to realize the advance and retreat, left and right lateral movement, rotation or curve movement of the vehicle body 110. As shown in FIG. 7, when the omnidirectional automatic forklift is traveling straight, the shadow zone around the same is a straight travel obstacle-avoiding zone corresponding to the working conditions under which the omnidirectional automatic forklift 100 is moving forward and backward. As shown in FIG. 8, two of the lidars 136 and 137 are mounted on both left and right sides of the head portion

of the vehicle body 110, and when the omnidirectional automatic forklift 100 is moving laterally, the shadow zone around the same is a lateral movement obstacle-avoiding zone corresponding to the working conditions under which the omnidirectional automatic forklift 100 is moving laterally to the left and right. As shown in FIG. 9, when the omnidirectional automatic forklift 100 is rotating, the shadow zone around the same is a rotation obstacle-avoiding zone corresponding to the working conditions under which the omnidirectional automatic forklift 100 is rotating and moving along a curve.

[0042] According to one example of the present invention, the movement control method further comprises: controlling the fork arms to move to perform a goods picking or placing task. The omnidirectional automatic forklift also includes a tray placed on the fork arms for carrying goods.

[0043] FIG. 10 is a flowchart showing that the fork arms perform a goods picking or placing task according to one example of the present invention. As shown in FIG. 10, the process 200 of controlling the fork arms to move to perform a goods picking or placing task comprises the following steps:

[0044] In step S201, controlling the fork arms 120 to rise or descend at a second preset speed.

[0045] In step S202, controlling the fork arms 120 to suspend rising or descending when it is detected that there is an obstacle below the fork arms.

[0046] In step S203, judging whether the obstacle below the fork arms disappears, and controlling the fork arms 120 to rise or descend at a second preset speed if the obstacle disappears; and controlling the fork arms 120 to stay still and cancelling the goods picking or placing task this time if the obstacle does not disappear after a preset time.

[0047] FIG. 11 is a flowchart showing that the fork arms performs a goods picking or placing task according to one example of the present invention. As shown in FIG. 11, the process 300 of controlling the fork arms to move to perform a goods picking or placing task comprises the following steps:

[0048] In step S301, controlling the fork arms 120 to rise or descend at a second preset speed.

[0049] In step S302: triggering anti-pinch protection, cancelling the goods picking or placing task this time and controlling the fork arms 120 to move downward or upward by a preset distance when the fork arms 120 suspend rising or descending and no obstacle below the fork arms is detected.

[0050] FIG. 12 is a flowchart showing that the fork arms perform a goods picking or placing task according to one example of the present invention. As shown in FIG. 12, the process 400 of controlling the fork arms to move to perform a goods picking or placing task comprises the following steps:

[0051] In step S401, controlling the fork arms 120 to rise or descend at a second preset speed.

[0052] In step S402, triggering anti-pinch protection

and judging whether the obstacle disappears after a preset time when the fork arms 120 suspend rising or descending and no obstacle below the fork arms is detected.

[0053] In step S403, controlling the fork arms 120 to rise or descend at a second preset speed if the obstacle disappears.

[0054] In step S404, controlling the fork arms 120 to stay still and cancelling the goods picking or placing task this time if the obstacle does not disappear.

[0055] The present invention also relates to an omnidirectional automatic forklift, comprising: a vehicle body 110, a chassis (see FIGS. 13A, 13B and 13C), fork arms 120, a tray and a controller (not shown). Among them, the chassis is connected with the vehicle body 110 and configured to drive the omnidirectional automatic forklift 100 under different working conditions. FIGS. 13A, 13B and 13C respectively show a schematic diagram of a chassis according to one example of the present invention. As shown in FIG. 13A, the chassis 10 alternatively comprises four differential wheels (a differential wheel group) 11, or as shown in FIG. 13B, the chassis 10 alternatively comprises two differential wheels 11 and one steering wheel 12, or as shown in FIG. 13C, the chassis 10 alternatively comprises two differential wheels 11 and two steering wheels 12. The chassis 10 as arranged above can allow the vehicle body 110 to achieve omnidirectional movement, including advance, retreat, left lateral movement, right lateral movement, rotation around the center O of the vehicle body and curve movement. The fork arms 120 are connected with the vehicle body 110 and configured to move upward and downward in a vertical direction. The tray is placed on the fork arms 120 for carrying goods. The controller communicates with the omnidirectional automatic forklift 100 and is configured to perform the aforesaid movement control methods 100, 200, 300 and 400 on the omnidirectional automatic forklift 100.

[0056] According to one example of the present invention, the omnidirectional automatic forklift 100 further comprises lidars and 3D cameras, both of which are mounted on the vehicle body 110 and configured to detect obstacles.

[0057] According to one example of the present invention, the omnidirectional automatic forklift comprises two fork arms 120, two lidars 136, 137 and five 3D cameras (131, 132, 133, 134, 135). Among them, two lidars 136 and 137 are respectively mounted on both left and right sides of a head portion of the vehicle body 110, and five 3D cameras (131, 132, 133, 134 and 135) are respectively mounted on an upper side of a front portion of the vehicle body 110, an upper side of a rear portion of the vehicle body 110, a lower side of one of the fork arms 120 and ends of two of the fork arms 120. Specifically, referring to FIG. 2A, FIG. 2B, FIG. 3A, FIG. 3B, FIG. 4, FIG. 5A and FIG. 5B, the aforesaid drawings respectively show the positions where two laser radars 136 and 137 and five 3D cameras (131, 132, 133, 134 and 135) are mounted in the vehicle body 110, as well as the detection

ranges covered by them, and no more description will be made here.

[0058] According to one example of the present invention, the controller in the omnidirectional automatic forklift 100 is configured to determine an obstacle-avoiding zone for the omnidirectional automatic forklift 100 under different working conditions according to the detection zones of the lidars and the 3D cameras. Among them, the obstacle-avoiding zone includes a straight travel obstacle-avoiding zone when the omnidirectional automatic forklift 100 is travelling straight, a lateral movement obstacle-avoiding zone when the omnidirectional automatic forklift 100 is moving laterally and a rotation obstacle-avoiding zone when the omnidirectional automatic forklift 100 is rotating. The straight travel obstacle-avoiding zone, the lateral movement obstacle-avoiding zone and the rotation obstacle-avoiding zone are shown by the shadows in FIG. 6, FIG. 7 and FIG. 8 respectively, and no more description will be made here.

[0059] According to one example of the present invention, the controller of the omnidirectional automatic forklift 100 is configured to switch combinations of the lidars 136, 137 and the 3D cameras (131, 132, 133, 134, 135) and types of the obstacle-avoiding zones under different working conditions of the omnidirectional automatic forklift 100 so as to perform movement control of the omnidirectional automatic forklift 100.

[0060] According to one example of the present invention, the omnidirectional automatic forklift 100 further comprises a storage unit (not shown) coupled with the controller and configured to store the movement control methods 100, 200, 300 and 400 implemented by the controller.

[0061] The present invention provides a movement control method for an omnidirectional automatic forklift, and an omnidirectional automatic forklift, equips sensors such as lidars and 3D cameras for the omnidirectional automatic forklift, and integrates detection data of the sensors with the obstacle-avoiding stop logic, achieving the omnidirectional safe obstacle avoidance of the omnidirectional automatic forklift.

[0062] The contents described above are merely better examples of the present invention, and are not used to limit the present invention. Any modification, equivalent replacement, or improvement, if only falling into the spirit and principles as stated herein, should be included in the protection scope of the present invention.

[0063] Last but not least, it should be noted that the contents described above are just preferred examples of the present invention, and are not used to limit the present invention. Although the detailed description of the present invention has been provided with reference to the foregoing examples, those skilled in the art may still make modifications to the technical solution as recited in each of the foregoing examples, or conduct equivalent replacement of some technical features therein. Any modification, equivalent replacement, or improvement, if only falling into the spirit and principles as stated herein,

should be included in the protection scope of the present invention.

5 Claims

1. A movement control method for an omnidirectional automatic forklift, wherein the omnidirectional automatic forklift comprises a vehicle body and fork arms, **characterized in that** the movement control method comprises:

S101: controlling the omnidirectional automatic forklift to travel at a first preset speed;
 S102: judging, when an obstacle is detected, the obstacle and determining an effective obstacle;
 S103: calculating a distance between the effective obstacle and the omnidirectional automatic forklift, and determining an obstacle-avoiding deceleration according to the distance;
 S104: controlling the omnidirectional automatic forklift to travel at the obstacle-avoiding deceleration; and
 S105: judging whether the obstacle disappears, and returning to step S101 if the obstacle disappears.

2. The movement control method according to claim 1, **characterized in that** the step S103 comprises:

determining that the obstacle-avoiding deceleration is an emergency stop deceleration when the distance is less than an emergency obstacle-avoiding distance;
 determining that the obstacle-avoiding deceleration is a short-range obstacle-avoiding deceleration when the distance is greater than the emergency obstacle-avoiding distance and less than a short-range obstacle-avoiding distance;
 determining that the obstacle-avoiding deceleration is a long-range obstacle-avoiding deceleration when the distance is greater than the short-range obstacle-avoiding distance.

3. The movement control method according to claim 1 or 2, **characterized in that** the step S102 comprises:

determining an obstacle-avoiding zone for the omnidirectional automatic forklift under different working conditions;
 determining obstacles in the obstacle-avoiding zone;
 calculating a distance between the obstacles in the obstacle-avoiding zone and a center of the vehicle body;
 selecting an obstacle closest to the center of the vehicle body as the effective obstacle.

4. The movement control method according to claim 3, **characterized in that** the determining the obstacle in the obstacle-avoiding zone in the step S102 comprises:

calculating coordinate values of the obstacle by taking the center of the vehicle body as a coordinate origin;
calculating an equation of a straight line constituting each side of the obstacle-avoiding zone;
judging whether the obstacle is on an inner side of the straight line;
determining that the obstacle is in the obstacle-avoiding zone if the obstacle is on the inner side of the straight line.

5. The movement control method according to claim 3, **characterized in that** the obstacle-avoiding zone includes a straight travel obstacle-avoiding zone when the omnidirectional automatic forklift is travelling straight, a lateral movement obstacle-avoiding zone when the omnidirectional automatic forklift is moving laterally, and a rotation obstacle-avoiding zone when the omnidirectional automatic forklift is rotating.

6. The movement control method according to claim 1, further comprising: controlling the fork arms to move to perform a goods picking or placing task; and the omnidirectional automatic forklift further comprises a tray placed on the fork arms for carrying goods.

7. The movement control method according to claim 6, **characterized in that** the controlling the fork arms to move to perform a goods picking or placing task comprises:

controlling the fork arms to rise or descend at a second preset speed;
controlling the fork arms to suspend rising or descending when it is detected that there is an obstacle below the fork arms;
judging whether the obstacle below the fork arms disappears, and controlling the fork arms to rise or descend at a second preset speed if the obstacle disappears; and controlling the fork arms to stay still and cancelling the goods picking or placing task this time if the obstacle does not disappear after a preset time.

8. The movement control method according to claim 6, **characterized in that** the controlling the fork arms to move to perform a goods picking or placing task comprises:

controlling the fork arms to rise or descend at a second preset speed;
cancelling the goods picking or placing task this

time, and controlling the fork arms to move downward or upward by a preset distance when the fork arms suspend rising or descending and no obstacle below the fork arms is detected.

9. The movement control method according to claim 6, **characterized in that** the controlling the fork arms to move to perform a goods picking or placing task comprises:

controlling the fork arms to rise or descend at a second preset speed;
judging whether the obstacle disappears after a preset time when the fork arms suspend rising or descending and no obstacle below the fork arms is detected;
controlling the fork arms to rise or descend at a second preset speed if the obstacle disappears;
controlling the fork arms to stay still, and cancelling the goods picking or placing task this time if the obstacle does not disappear.

10. An omnidirectional automatic forklift (100), comprising:

a vehicle body (110);
a chassis (10) connected with the vehicle body (110) and configured to drive the omnidirectional automatic forklift (100) to move under different working conditions;
fork arms (120) connected with the vehicle body (110) and configured to move upward and downward in a vertical direction;
a tray placed on the fork arms (120) for carrying goods;
a controller communicating with the omnidirectional automatic forklift (100) and configured to implement on the omnidirectional automatic forklift (100) the movement control method according to any one of claims 1 to 9.

11. The omnidirectional automatic forklift (100) according to claim 10, further comprising lidars and 3D cameras, both of which are mounted on the vehicle body (110) and configured to detect an obstacle.

12. The omnidirectional automatic forklift (100) according to claim 11, further comprising two fork arms (120), two lidars (136,137) and five 3D cameras (131,132,133,134,135), wherein the two lidars (136,137) are respectively mounted on both left and right sides of a head portion of the vehicle body (110), and the five 3D cameras (131,132,133,134,135) are respectively mounted on an upper side of a front portion of the vehicle body (110), an upper side of a rear portion of the vehicle body (110), a lower side of one of the fork arms (120) and ends of two of the fork arms (120).

13. The omnidirectional automatic forklift (100) according to claim 11, **characterized in that** the controller is configured to determine an obstacle-avoiding zone for the omnidirectional automatic forklift (100) under different working conditions according to a detection zone of the lidars (136,137) and the 3D cameras (131,132,133,134,135), and wherein the obstacle-avoiding zone includes a straight travel obstacle-avoiding zone when the omnidirectional automatic forklift (100) is travelling straight, a lateral movement obstacle-avoiding zone when the omnidirectional automatic forklift (100) is moving laterally, and a rotation obstacle-avoiding zone when the omnidirectional automatic forklift (100) is rotating.
14. The omnidirectional automatic forklift (100) according to claim 13, **characterized in that** the controller is configured to switch combinations of the lidars (136,137) and the 3D cameras (131,132,133,134,135) and types of the obstacle-avoiding zones under different working conditions of the omnidirectional automatic forklift (100) so as to perform movement control of the omnidirectional automatic forklift (100).
15. The omnidirectional automatic forklift (100) according to any one of claims 10 to 14, further comprising a storage unit coupled with the controller and configured to store the movement control method implemented by the controller.

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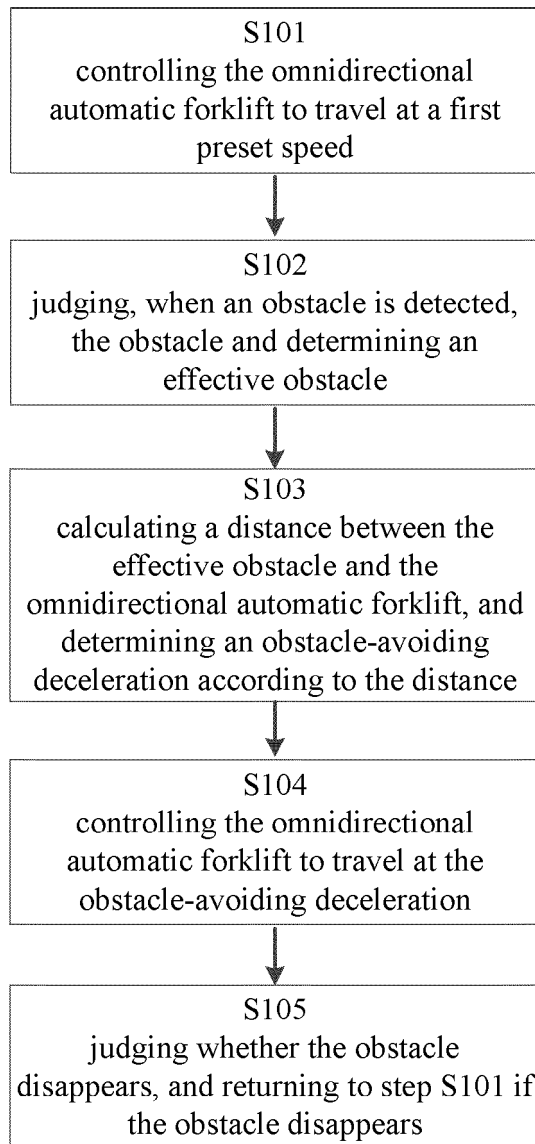


FIG. 1

100

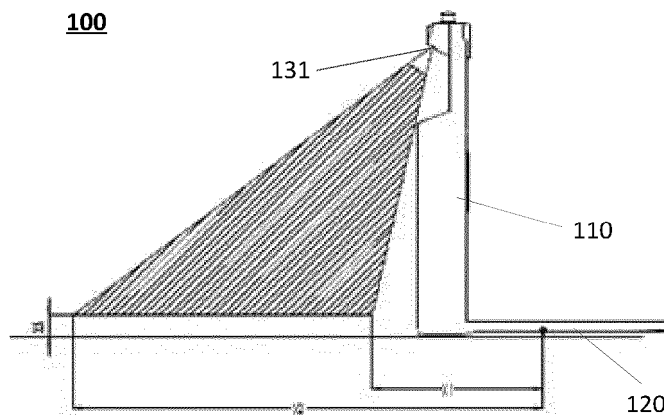


FIG. 2A

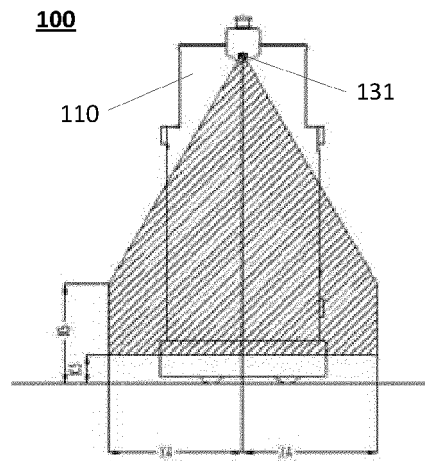


FIG.2B

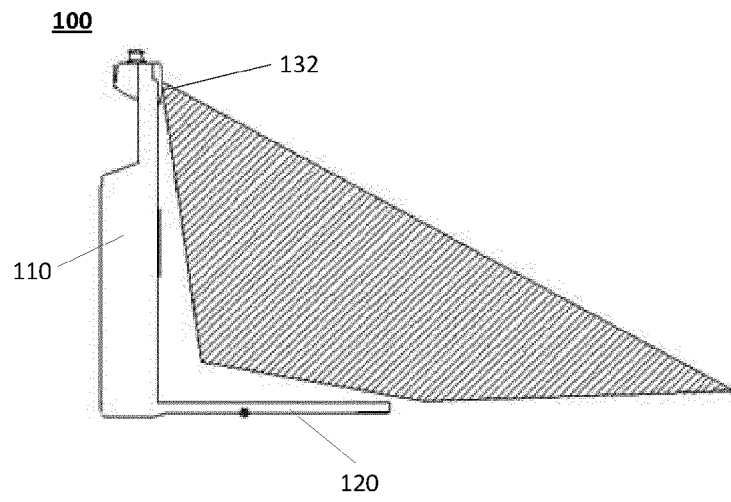


FIG.3A

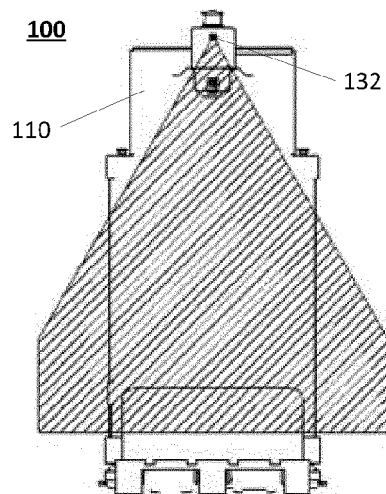


FIG.3B

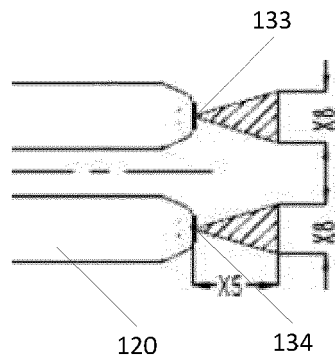


FIG.4

100

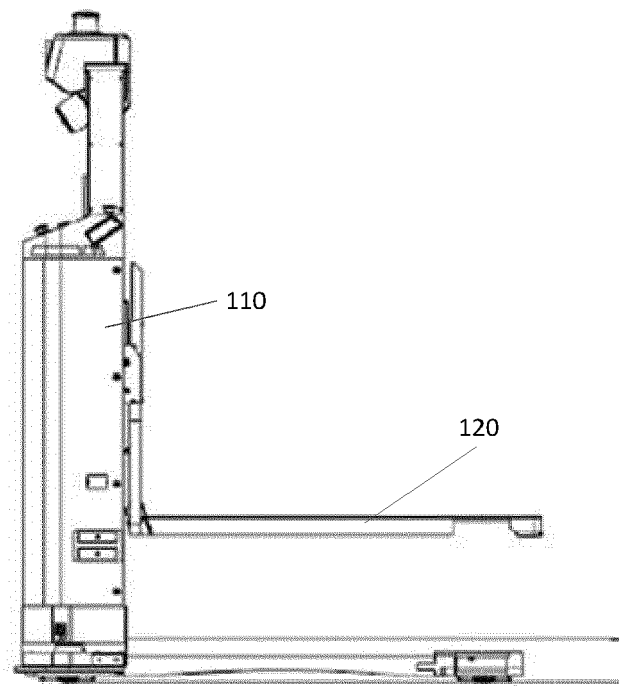


FIG5A

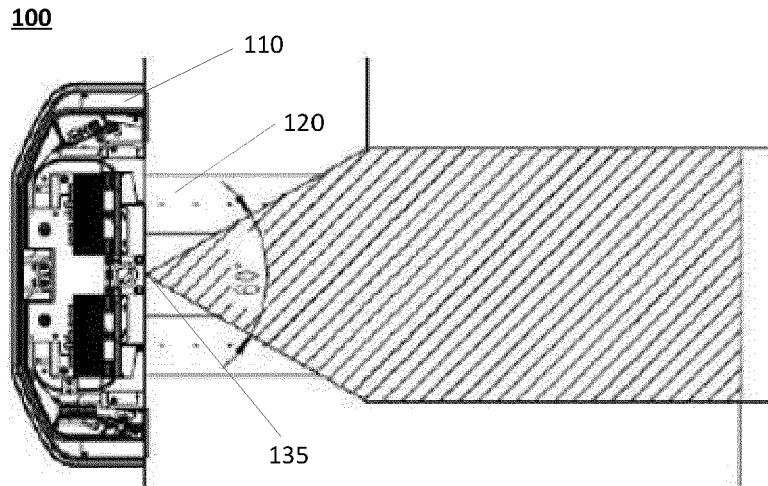


FIG. 5B

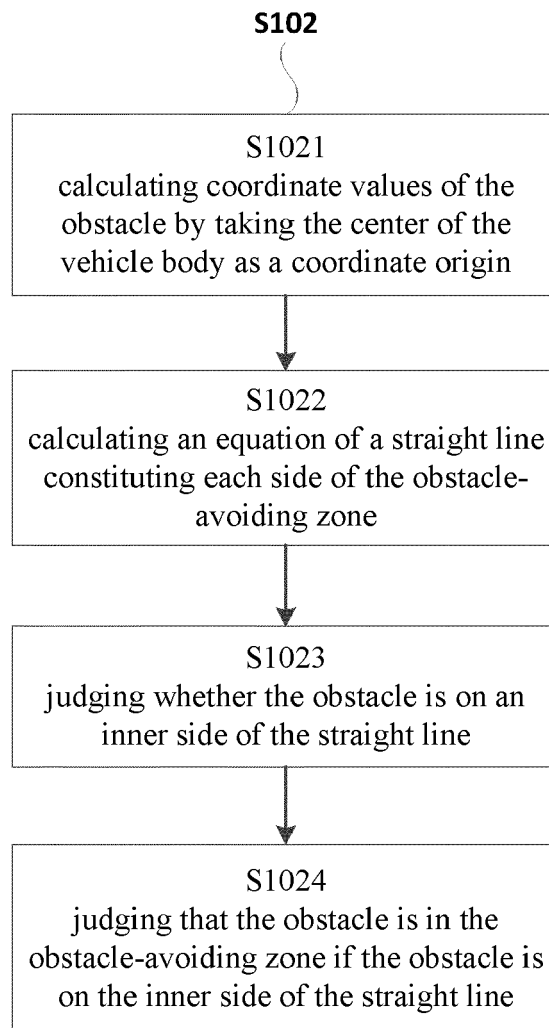


FIG. 6

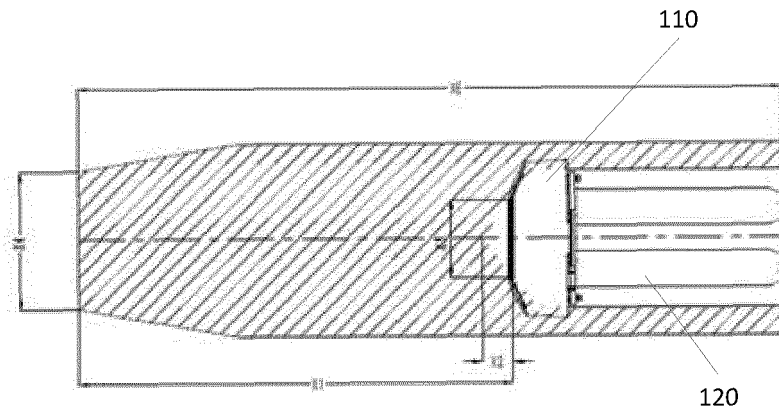


FIG. 7

100

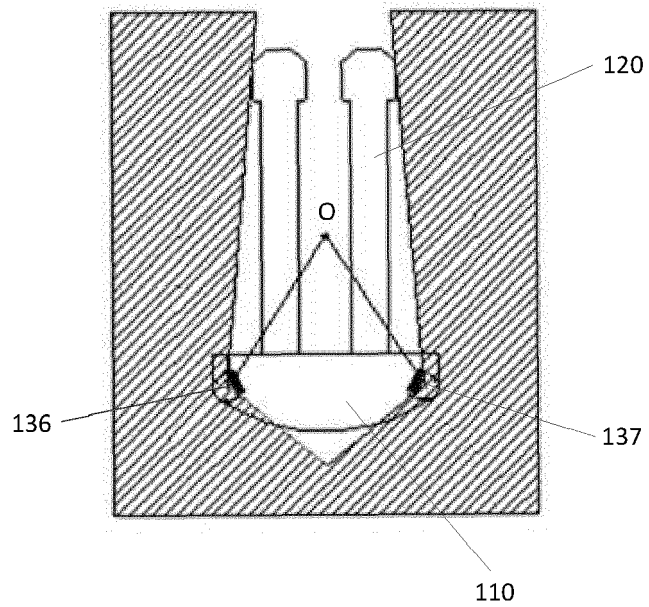


FIG.8

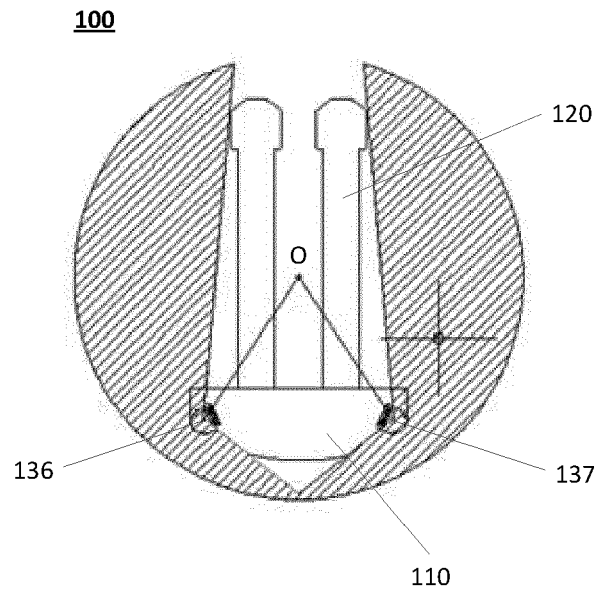


FIG. 9

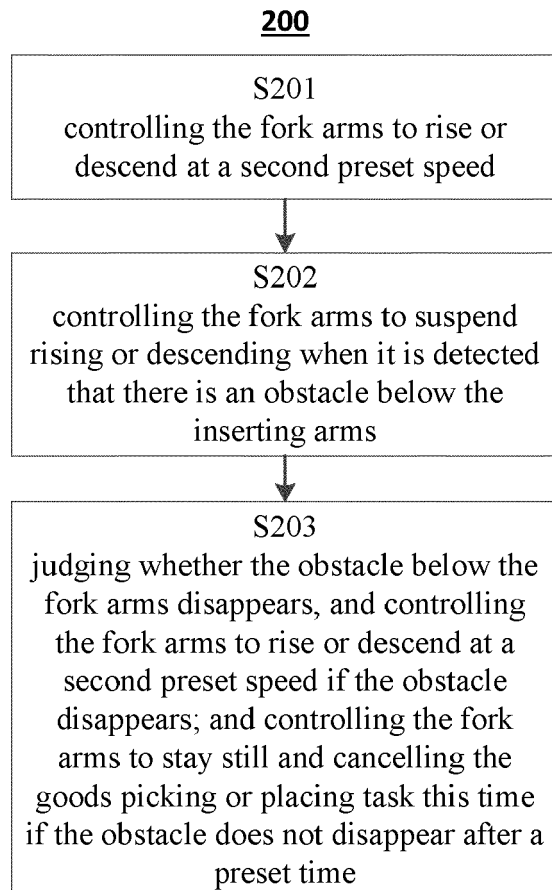


FIG. 10

300

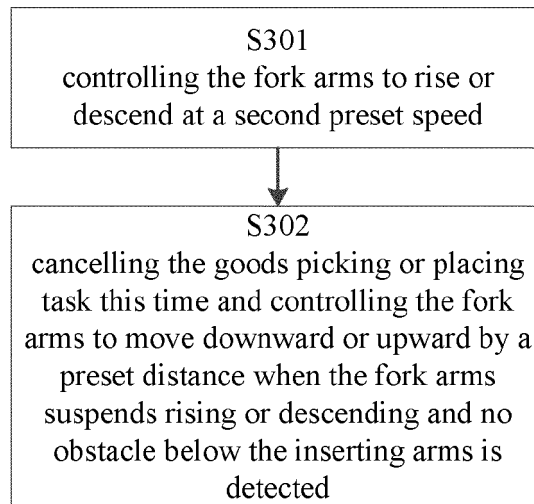


FIG. 11

400

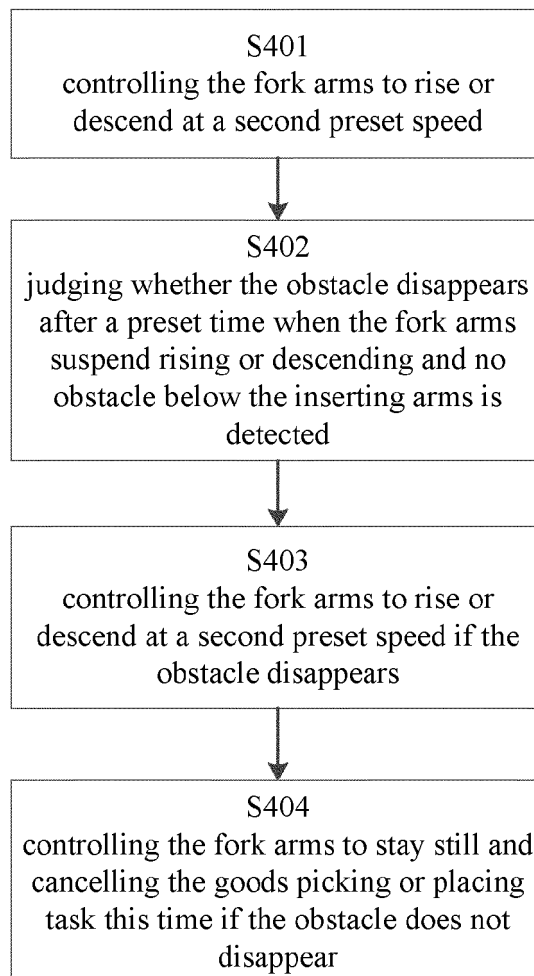


FIG. 12

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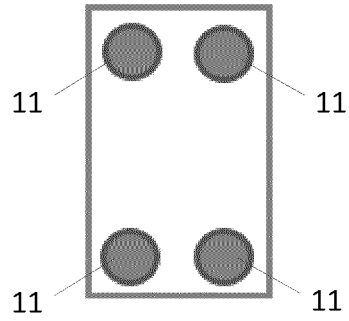


FIG.13A

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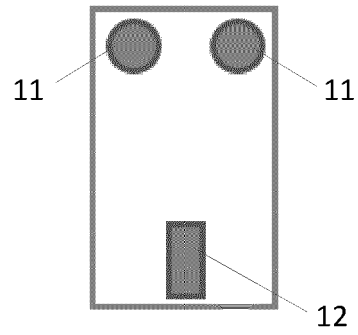


FIG.13B

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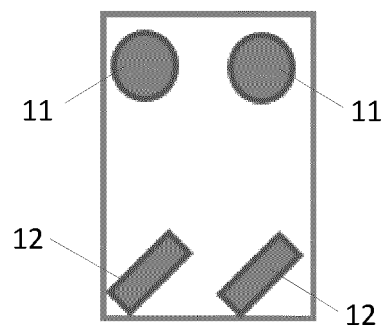


FIG. 13C



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 4733

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/057049 A1 (STEWART ALAN [NZ] ET AL) 1 March 2018 (2018-03-01) * figures 1-12 *	1-15	INV. B66F9/075 B66F9/06 B66F17/00
X	US 2021/087031 A1 (LUNSCHER NOLAN [CA] ET AL) 25 March 2021 (2021-03-25) * paragraph [0117] * * paragraph [0119]; figures 1-12 *	1, 2, 6-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B66F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		19 August 2022	Severens, Gert
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 22 16 4733

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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19-08-2022

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