VEHICLE CONTROL METHOD, APPARATUS AND VEHICLE BASED ON DETECTION OF PORT VERTICAL TRANSPORT TARGET

[0001] This application claims the priority of the Chinese patent application with application number 202410304020.1, entitled "Vehicle Control Method, Apparatus and Vehicle Based on Detection of Port Vertical Transport Target", filed with the China Patent Office on March 15, 2024, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates to the technical field of port loading and unloading, and in particular, to a vehicle control method, apparatus and vehicle based on detection of a port vertical transport target.

BACKGROUND

[0003] Among transport vehicles operating in a port, ensuring the moving and stopping of the transport vehicles in different loading and unloading operation scenarios has important technical significance, in particular, the incidence of accidents can be effectively reduced, and the safety of drivers, workers and the surrounding environment can be ensured. Particularly, in a busy port environment, accurately controlling the moving and stopping of transport vehicles can avoid collisions and injuries.

[0004] In the prior art, since during the loading and unloading operation of a spreader, whether the transport vehicle should move or stop is generally determined by driver or corresponding supervisory personnel, roughly, a loading and unloading control person informs the driver to control the transport vehicle to start or continue to

stop according to the loading and unloading process.

[0005] However, in the above implementation, the subjective judgment of the driver or supervisory personnel may have errors, and particularly in a complex loading and unloading operation environment, the judgment is easily affected by external factors, resulting in inaccurate judgment, thereby causing damage to the transport vehicle, etc.

SUMMARY

[0006] The present application provides a vehicle control method, apparatus and vehicle based on detection of a port vertical transport target, so as to solve the problems in the prior art such as dangerous operations of vehicles caused by manual intervention.

[0007] In a first aspect, an embodiment of the present application provides a method, a vehicle control method based on detection of a port vertical transport target, characterized by being applied to a vehicle, the method including:

acquiring first point cloud data of a region above the vehicle;

determining, according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, second point cloud data located in the region of interest of the spreader or the grabbed object from the first point cloud data;

determining, according to feature information of the second point cloud data, position information and grabbing state of the spreader corresponding to the second point cloud data; and

controlling a moving and stopping state of the vehicle according to the position information and the grabbing state.

[0008] In one or more embodiments, the lifting device is a device with a beam-type structure;

correspondingly, determining, according to the feature information of the second point cloud data, the position information and the grabbing state of the spreader corresponding to the second point cloud data includes:

dividing, according to normal vectors of points in the second point cloud data, the point cloud in the second point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a first number threshold, determining a mean value of the point clouds on the plane in a vertical direction as a height position of the spreader; and/or, cutting the second point cloud data along the vertical direction, and taking a vertical mean value of the point clouds in a region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than a second number threshold, as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to a point cloud density of a plane of a horizontal dimension and a first density threshold, or vertical values of point clouds of a plane of another dimension and a first value threshold;

where the position information includes the height position of the spreader; and the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0009] In one or more embodiments, the region of interest of the spreader is a region constituted by a beam of the lifting device and a lane in which the vehicle is located;

correspondingly, before determining, according to the first point cloud data and the pre-determined region of interest of the spreader in the lifting device, the second point cloud data located in the region of interest of the spreader from the first point cloud data, the method further includes:

acquiring third point cloud data of the beam;

performing fitting processing on a point cloud corresponding to a projection of normal vectors of points in the third point cloud data onto a vertical plane of the beam, to obtain a vertical plane equation of the beam; and

determining the region of interest of the spreader in the lifting device according to information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0010] In one or more embodiments, before performing the fitting processing on

the point cloud corresponding to the projection of the normal vectors of the points in the third point cloud data onto the vertical plane of the beam, to obtain the vertical plane equation of the beam, the method further includes:

projecting the normal vectors of the points in the third point cloud data onto a ground plane, to obtain two-dimensional vectors; and

filtering the two-dimensional vectors by using a preset strategy, to obtain the point cloud corresponding to the projection onto the vertical plane of the beam, where the preset strategy is filtering points corresponding to the two-dimensional vectors for which the sum of squares of data in the two-dimensional vectors is greater than a preset threshold.

[0011] In one or more embodiments, the lifting device is a device with a hoisting-type structure;

correspondingly, determining, according to the feature information of the second point cloud data, the position information and the grabbing state of the spreader corresponding to the second point cloud data includes:

performing clustering and filtering processing on the second point cloud data, to obtain fourth point cloud data;

dividing, according to normal vectors of points in the fourth point cloud data, the point cloud in the fourth point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a third number threshold, performing plane fitting, and taking a mean value of the point clouds on the fitted plane in the vertical direction as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to whether the fitted plane exists;

where the height position includes the height position of the spreader; and the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0012] In one or more embodiments, the region of interest of the grabbed object is a region formed by the spreader of the lifting device lifting with the grabbed object;

correspondingly, before determining, according to the first point cloud data

and the pre-determined region of interest of the grabbed object in the lifting device, the second point cloud data located in the region of interest of the grabbed object from the first point cloud data, the method further includes:

acquiring fifth point cloud data of the lifting device within a predicted range;

determining a center position of the lifting device based on a side door plane region and a tire region of the lifting device determined from point clouds of multiple part types obtained by clustering the fifth point cloud data; and

determining the region of interest of the grabbed object according to the center position.

[0013] In one or more embodiments, the method further includes:

determining a movement state of the spreader according to the position information and position information of a previous frame of the position information.

[0014] In a second aspect, an embodiment of the present application provides a vehicle control apparatus based on detection of a port vertical transport target, characterized by being applied to a vehicle, the apparatus including:

an acquiring module, configured for acquiring first point cloud data of a region above the vehicle;

a first determining module, configured for determining, according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, second point cloud data located in the region of interest of the spreader or the grabbed object from the first point cloud data;

a second determining module, configured for determining, according to feature information of the second point cloud data, position information and grabbing state of the spreader corresponding to the second point cloud data; and

a controlling module, configured for controlling a moving and stopping state of the vehicle according to the position information and the grabbing state.

[0015] In one or more embodiments, the lifting device is a device with a beam-type structure;

correspondingly, the second determining module is specifically configured

for:

dividing, according to normal vectors of points in the second point cloud data, the point cloud in the second point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a first number threshold, determining a mean value of the point clouds on the plane in a vertical direction as a height position of the spreader; and/or, cutting the second point cloud data along the vertical direction, and taking a vertical mean value of the point clouds in a region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than a second number threshold, as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to a point cloud density of a plane of a horizontal dimension and a first density threshold, or vertical values of point clouds of a plane of another dimension and a first value threshold;

where the position information includes the height position of the spreader; and the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0016] In one or more embodiments, the region of interest of the spreader is a region constituted by a beam of the lifting device and a lane in which the vehicle is located;

correspondingly, before determining, according to the first point cloud data and the pre-determined region of interest of the spreader in the lifting device, the second point cloud data located in the region of interest of the spreader from the first point cloud data, the second determining module is further configured for:

acquiring third point cloud data of the beam;

performing fitting processing on a point cloud corresponding to a projection of normal vectors of points in the third point cloud data onto a vertical plane of the beam, to obtain a vertical plane equation of the beam; and

determining the region of interest of the spreader in the lifting device according to information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0017] In one or more embodiments, before performing the fitting processing on the point cloud corresponding to the projection of the normal vectors of the points in the third point cloud data onto the vertical plane of the beam, to obtain the vertical plane equation of the beam, the second determining module is further configured for:

projecting the normal vectors of the points in the third point cloud data onto a ground plane, to obtain two-dimensional vectors; and

filtering the two-dimensional vectors by using a preset strategy, to obtain the point cloud corresponding to the projection onto the vertical plane of the beam, where the preset strategy is filtering points corresponding to the two-dimensional vectors for which the sum of squares of data in the two-dimensional vectors is greater than a preset threshold.

[0018] In one or more embodiments, the lifting device is a device with a hoisting-type structure;

correspondingly, the second determining module is specifically configured for:

performing clustering and filtering processing on the second point cloud data, to obtain fourth point cloud data;

dividing, according to normal vectors of points in the fourth point cloud data, the point cloud in the fourth point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a third number threshold, performing plane fitting, and taking a mean value of the point clouds on the fitted plane in the vertical direction as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to whether the fitted plane exists;

where the height position includes the height position of the spreader; and the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0019] In one or more embodiments, the region of interest of the grabbed object is a region formed by the spreader of the lifting device lifting with the grabbed object;

correspondingly, before determining, according to the first point cloud data

and the pre-determined region of interest of the grabbed object in the lifting device, the second point cloud data located in the region of interest of the grabbed object from the first point cloud data, the second determining module is further configured for:

acquiring fifth point cloud data of the lifting device within a predicted range;

determining a center position of the lifting device based on a side door plane region and a tire region of the lifting device determined from point clouds of multiple part types obtained by clustering the fifth point cloud data; and

determining the region of interest of the grabbed object according to the center position.

[0020] In one or more embodiments, the second determining module is further configured for:

determining a movement state of the spreader according to the position information and position information of a previous frame of the position information.

[0021] In a third aspect, the present application provides a vehicle, including: a processor, and a memory and a transceiver communicatively connected to the processor;

the memory stores computer-executable instructions; the transceiver is used for transceiving data; and

the processor executes the computer-executable instructions stored in the memory to implement the method according to the first aspect or any one of the manners described above.

[0022] In a fourth aspect, the present application provides a computer-readable storage medium, in which computer-executable instructions are stored, and when the computer-executable instructions are executed by a processor, the computer-executable instructions are used for implementing the method according to the first aspect or any one of the manners described above.

[0023] In the vehicle control method, apparatus and vehicle based on detection of a port vertical transport target provided by the present application, the method is applied to a vehicle. First point cloud data of a region above the vehicle is acquired, then second point cloud data located in the region of interest of the spreader or the grabbed object

is determined from the first point cloud data according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, and position information and grabbing state of the spreader corresponding to the second point cloud data are determined according to feature information of the second point cloud data, and the moving and stopping state of the vehicle is controlled according to the position information and the grabbing state. In this technical solution, the acquired point cloud data is filtered from the region of interest of the spreader or the grabbed object, to improve the efficiency of subsequent processing. Then, after feature extraction is performed based on the filtered point cloud data, corresponding processing is performed to obtain the position information and the grabbing state of the spreader, thereby more accurately realizing the determination of the starting and stopping state of the vehicle.

BRIEF DESCRIPTION OF DRAWINGS

[0024] The accompanying drawings herein are incorporated into and constitute a part of this specification, illustrate embodiments consistent with the present application, and together with the specification serve to explain the principles of the present application.

[0025] FIG. 1 is a first schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application.

[0026] FIG. 2 is a second schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application.

[0027] FIG. 3 is a third schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application.

[0028] FIG. 4 is a fourth schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present

application.

[0029] FIG. 5 is a fifth schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application.

[0030] FIG. 6A and FIG. 6B are schematic diagrams of a detection flow of the bridge crane provided by an embodiment of the present application.

[0031] FIG. 7 is a schematic diagram of a detection flow of a stacker provided by an embodiment of the present application.

[0032] FIG. 8 is a schematic structural diagram of a vehicle control apparatus based on detection of a port vertical transport target provided by an embodiment of the present application.

[0033] FIG. 9 is a schematic structural diagram of a vehicle provided by an embodiment of the present application.

[0034] Through the above drawings, the specific embodiments of the present disclosure have been shown, and a more detailed description will be given hereinafter. These drawings and textual descriptions are not intended to limit the scope of the concept of the present disclosure in any way, but rather to explain the concept of the present disclosure to those skilled in the art by referring to specific embodiments.

DESCRIPTION OF EMBODIMENTS

[0035] In order to make the objectives, technical solutions and advantages of the embodiments of the present application clearer, the technical solutions in the embodiments of the present application will be clearly and completely described below in conjunction with the drawings in the embodiments of the present application. Apparently, the described embodiments are a part of the embodiments of the present application, rather than all of the embodiments. Based on the embodiments in the present application, all other embodiments obtained by a person of ordinary skill in the art without making creative efforts fall within the scope of protection of the present application.

[0036] Before introducing the embodiments of the present application, the application background of the embodiments of the present application is first explained:

[0037] Technical terms (scenarios related to port operations) can be described as follows:

heavy-close: the spreader is holding a container and the spreader is in the air above and in front of the lane in which the vehicle is located (or an adjacent lane), and this state is the heavy-close scenario;

close-path: when the spreader does not have a container and the spreader is in the air above and in front of the lane in which the vehicle is located (or an adjacent lane) at a certain height, this state is the close-path scenario;

placing a container: the container position differs from the predicted container loading position of the trailer, and the container is placed on the baffle of the trailer, and this state is placing a container;

lifting: the container, the spreader and the trailer lock are all opened, and the spreader has a tendency to lift, and this state is the lifting state;

starting: when the spreader height is below a threshold height or the spreader is laterally within the operation lane range, this state is the operation state, and the vehicle needs to stop and wait for the operation to be completed.

[0038] Technical background can be described as follows.

[0039] Among vehicles operating in a port, ensuring the moving and stopping of vehicles in different loading and unloading operation scenarios has important technical significance, and the carried goods can be protected from damage or loss. During the process of loading and unloading containers, precise moving and stopping can ensure stable transportation of goods and avoid goods being subjected to vibration or collision.

[0040] In the prior art, since during the loading and unloading operation of a spreader, whether the transport vehicle should move or stop is generally determined by driver or corresponding supervisory personnel, roughly, a loading and unloading control person informs the driver to control the transport vehicle to start or continue to stop according to the loading and unloading process.

[0041] The problems existing in the prior art that need to be solved by the embodiments of the present application are as follows: in the above implementation, the subjective judgment of the driver or supervisory personnel may have errors, and particularly in a complex loading and unloading operation environment, the judgment is easily affected by external factors, resulting in inaccurate judgment, thereby causing damage to the transport vehicle, etc.

[0042] Aiming at the technical problems existing in the prior art, the inventor's concept of the present application is as follows. In actual port operations, the starting and stopping state of a vehicle is related to the position of the spreader and the grabbing state on the spreader. If the possible position of the spreader within its activity range can be acquired first, in an actual scenario, point cloud information can be acquired in real time through sensors, and filtering is performed based on the region of the above position. For the feature information of the point cloud data, the position and state of a box, a spreader, etc. can be correspondingly determined. For example, in the case of grabbing a container, the density of the captured point cloud is large or the number of point clouds is large, and the corresponding position information can also be determined according to the position on the coordinate axis, thereby avoiding possible vehicle risks.

[0043] Hereinafter, the technical solution of the present application will be described in detail through specific embodiments. It should be noted that the following specific embodiments can be combined with each other, and the same or similar concepts or processes may not be repeated in some embodiments.

[0044] It is worth noting that the application field of the method, apparatus, vehicle and storage medium involved in the present disclosure is not limited.

[0045] The execution subject of the present application is a vehicle, and specifically may be a control unit on the vehicle, etc.

[0046] FIG. 1 is a first schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application. As shown in FIG. 1, the method may include the following steps.

[0047] Step 11, acquiring first point cloud data of a region above the vehicle.

[0048] In this step, when the spreader is performing loading and unloading operations on the vehicle, the vehicle acquires first point cloud data of the region above in real time, and the first point cloud data may include point clouds of various objects that may exist.

[0049] The region above may include above and in front, directly above, above and behind, above and to the left, above and to the right, etc., of the vehicle. In actual implementation, the corresponding acquisition angle may be adjusted based on requirements.

[0050] Optionally, the manner of acquiring the first point cloud data of the region above the vehicle may be implemented by sensors such as a video camera, an image camera, a radar, etc. arranged in the region above the vehicle. Pixel data acquired by some devices may also be transformed into point cloud data and transformed to a coordinate system at a fixed position of the vehicle by means of coordinate transformation.

[0051] For example, the coordinate system may take the position of the vehicle head as the origin, the positive front direction as the positive direction of the x-axis, the left direction as the positive direction of the y-axis, and the directly above direction as the positive direction of the z-axis.

[0052] It should be understood that the vertical transport targets involved in the embodiments of the present application include, but are not limited to: a lifting device, a spreader in the lifting device, a beam, tires, a side door grabbed object (a box, a container, a package).

[0053] The lifting device is not limited to a well-type frame, a gantry crane machine, a tower crane, a construction elevator, a stacker, etc.

[0054] Step 12, determining, according to the first point cloud data and a pre-determined region of interest (Region of Interest, RoI) of a spreader or a grabbed object in a lifting device, second point cloud data located in the region of interest of the spreader or the grabbed object from the first point cloud data.

[0055] In this step, for a device with a beam-type structure, for example, a bridge

crane machine, the region of interest of the spreader is a region between the beams where the spreader moves; for a device with a hoisting-type structure, for example, a stacker, the region of interest of the grabbed object is a region corresponding to the possible lifting and lowering of the grabbed object. The two regions of interest will be described in detail in the following embodiments.

[0056] The grabbed object may be a box, a container, a package, etc.; the spreader may be a clamp, a fork, or other device having the function of grabbing a grabbed object.

[0057] Optionally, after the first point cloud data of the region above the vehicle is acquired, the first point cloud data may be filtered by using the region of interest, to obtain point cloud data located in the region of interest, denoted as second point cloud data.

[0058] It should be understood that for different lifting devices, the vehicle may determine by means of point clouds, images, etc. acquired by sensors, or may be manually determined.

[0059] Step 13, determining, according to feature information of the second point cloud data, position information and grabbing state of the spreader corresponding to the second point cloud data.

[0060] In this step, after the second point cloud data is acquired, feature extraction is performed on the second point cloud data, to obtain feature information.

[0061] The feature information for the point cloud data may describe the number, density of point clouds, and the z-value projected onto the z-axis; in some implementations, different types of objects may also be distinguished.

[0062] The number, density of point clouds, and the z-value and density projected onto the z-axis may also reflect the grabbing state, position information, etc.

[0063] Optionally, the grabbing state includes but is not limited to: whether the spreader grabs the grabbed object, whether the grabbed object, the spreader and the trailer lock are all opened; the position information includes but is not limited to: the spreader height, the spreader horizontal position (i.e., the situation of the lane in which the spreader is located, etc.).

[0064] Step 14, controlling a moving and stopping state of the vehicle according to the position information and the grabbing state.

[0065] In this step, the position of the spreader in the region above the vehicle and the grabbing state are acquired. At this time, according to the position of the spreader and the grabbing state, the moving and stopping state of the vehicle may be confirmed based on the determination conditions of scenarios such as heavy-close, close-path, placing a container, lifting, abnormal starting, etc.

[0066] The moving and stopping state includes: starting, stopping, running, braking, etc.

[0067] In a possible implementation, taking heavy-close as an example, the spreader height is detected, the spreader is holding a container, and the spreader is in the air above and in front of the lane in which the vehicle is located (or an adjacent lane), and the vehicle needs to stop and wait; taking close-path as an example, when it is detected that the spreader is not holding a container and the spreader is in the air above and in front of the lane in which the vehicle is located (or an adjacent lane) at a certain height, the vehicle needs to stop and wait; taking operation of placing a container as an example, when it is detected that the container position differs from the predicted container loading position of the trailer of the vehicle, and the container is placed on the baffle of the trailer, the vehicle needs to stop and wait and an alarm is issued; taking lifting as an example, when it is detected that the container, the spreader and the trailer lock are all opened, and the spreader has a tendency to lift, the vehicle needs to stop and wait and an alarm is issued; taking abnormal starting as an example, when the spreader height is below a threshold height or the spreader is laterally within the operation lane range, the vehicle needs to stop and wait for the operation to be completed.

[0068] Optionally, controlling the moving and stopping state may also be issuing prompt information so that a driver or a dispatcher controls the vehicle, or may also be issuing corresponding instructions to automatically control the vehicle.

[0069] For example, if the current state is heavy-close, the vehicle needs to stop and

wait, and the driver or dispatcher may be reminded by means of lighting, voice, or display to control the vehicle to be stationary.

[0070] Furthermore, the movement state of the spreader may also be determined according to the position information and position information of a previous frame of the position information.

[0071] The movement state of the spreader includes: the movement direction, speed, etc., of the spreader; the determination of the movement direction may be the direction of change between two frames of position information, and the determination of the speed may be based on the time interval.

[0072] Subsequently, the moving and stopping state of the vehicle may also be controlled based on the movement state of the spreader. If the spreader is still moving and working, the vehicle must stop and wait.

[0073] In addition, the spreader height in the next frame may also be estimated by using a least squares method based on the heights of the spreader in two frames.

[0074] In the vehicle control method based on detection of a port vertical transport target provided by the embodiment of the present application, the method is applied to a vehicle. First point cloud data of a region above the vehicle is acquired, then second point cloud data located in the region of interest of the spreader or the grabbed object is determined from the first point cloud data according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, and position information and grabbing state of the spreader corresponding to the second point cloud data are determined according to feature information of the second point cloud data, and the moving and stopping state of the vehicle is controlled according to the position information and the grabbing state. In this technical solution, the acquired point cloud data is filtered from the region of interest of the spreader or the grabbed object, to improve the efficiency of subsequent processing. Then, after feature extraction is performed based on the filtered point cloud data, corresponding processing is performed to obtain the position information and the grabbing state of the spreader, thereby more accurately realizing the determination of the starting and stopping state

of the vehicle.

[0075] I. Lifting device is a device of a beam-type structure (e.g., a gantry crane).

[0076] On the basis of the above embodiment, FIG. 2 is a second schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application. As shown in FIG. 2, step 13 may be described as follows.

[0077] Step 21, dividing, according to normal vectors of points in the second point cloud data, the point cloud in the second point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a first number threshold, determining a mean value of the point clouds on the plane in a vertical direction as a height position of the spreader; and/or, cutting the second point cloud data along the vertical direction, and taking a vertical mean value of the point clouds in a region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than a second number threshold, as the height position of the spreader.

[0078] In this step, after the second point cloud data is obtained, the point cloud in the second point cloud data is divided into point clouds of planes of different dimensions according to the normal vectors in the second point cloud data.

[0079] For example, it may be an x-y plane (ground plane), a y-z plane (vertical plane of the beam), and an x-z plane. That is, the x-direction is the extension direction of the lane in which the vehicle is located, the y-direction is the direction parallel to the beam, and the z-direction is the direction perpendicular to the vehicle/lifting device.

[0080] For first type, if the number of point clouds of the plane is greater than the first number threshold, determining the mean value of the point clouds on the plane in the vertical direction as the height position of the spreader.

[0081] The number of point clouds of each type of plane is checked. When the first number threshold is reached, plane fitting is performed by using a random sample consensus method, and the z-mean value of the point clouds of each plane can represent the spreader height calculated by this feature.

[0082] For second type, cutting the second point cloud data along the vertical direction, and taking the vertical mean value of the point clouds in the region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than the second number threshold, as the height position of the spreader.

[0083] The second point cloud data in the region of interest of the spreader is uniformly divided in the z-direction, to obtain the divided region with the largest number of point clouds. When the number of point clouds in this region exceeds the second number threshold, the z-mean value of the point clouds in this region represents the spreader height calculated by this feature.

[0084] In view of the foregoing two manners, in order to increase the accuracy of the height position of the spreader, the results of the first type of manner and the second type of manner may be compared and voted with each other, to obtain the detected height z-value of the spreader.

[0085] In addition, the position of the spreader may be obtained based on the position x of the lifting device and the information of the lane y in which the vehicle is located, to obtain the detected position (x, y) value of the spreader.

[0086] It should be understood that the thresholds involved in the embodiments of the present application may all be set by a user based on experience, and be adjusted and set by a user based on object size, density, etc.

[0087] Step 22, determining the situation of the spreader grabbing the grabbed object according to a point cloud density of a plane of a horizontal dimension and a first density threshold, or vertical values of point clouds of a plane of another dimension and a first value threshold.

[0088] The position information includes the height position of the spreader; the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0089] In this step, since the spreader has a relatively small point cloud density and number of point clouds compared with the grabbed object, after obtaining each feature plane (i.e., planes of different dimensions), when the point cloud density of the x-y

plane is greater than the first density threshold, it is considered that the spreader grabs a container; when the z-range of the point cloud of the x-z plane is greater than the first value threshold, it is considered that the spreader grabs a container; when the z-range of the point cloud of the y-z plane is greater than the first value threshold, it is considered that the spreader grabs a container.

[0090] In the vehicle control method based on detection of a port vertical transport target provided by the embodiment of the present application, the point cloud in the second point cloud data is divided into point clouds of planes of different dimensions according to the normal vectors of the points in the second point cloud data, and if the number of point clouds of the plane is greater than the first number threshold, the mean value of the point clouds on the plane in the vertical direction is determined as the height position of the spreader; and/or, the second point cloud data is cut along the vertical direction, and the vertical mean value of the point clouds in the region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than the second number threshold, is taken as the height position of the spreader, and the situation of the spreader grabbing the grabbed object is determined according to the point cloud density of the plane of the horizontal dimension and the first density threshold, or the vertical values of the point clouds of the plane of another dimension and the first value threshold. The position information includes the height position of the spreader; the grabbing state includes the situation of the spreader grabbing the grabbed object. In this technical solution, since the number of point clouds, the point cloud density, and the vertical values of the point clouds of the spreader and the grabbed object on planes of different dimensions are different, the spreader height and the situation of the spreader grabbing the grabbed object can be accurately determined based on the numerical magnitudes of the number of point clouds and the point cloud density.

[0091] On the basis of the above embodiment, FIG. 3 is a third schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application. As shown in FIG. 3, the manner

of determining the region of interest of the spreader may be described as follows.

[0092] Step 31, acquiring third point cloud data of the beam.

[0093] In this step, the vehicle acquires point cloud data of a beam (e.g., two beams) in the lifting device, denoted as third point cloud data.

[0094] In an implementation, the region of interest of the beam is determined according to information such as the position of the beam in the lifting device, the size of the beam, and the approximate position of the crane determined by other methods (meter-level precision is sufficient), and each beam has a region of interest; the point cloud is filtered by using these two regions of interest, to respectively obtain point clouds falling in different beam regions, i.e., the third point cloud data.

[0095] Before the following steps, the normal vectors of the points in the third point cloud data may also be projected onto the ground plane, to obtain two-dimensional vectors; the two-dimensional vectors are filtered by using a preset strategy, to obtain the point cloud corresponding to the projection onto the vertical plane of the beam, where the preset strategy is filtering points corresponding to the two-dimensional vectors for which the sum of squares of data in the two-dimensional vectors is greater than a preset threshold.

[0096] That is, the preset strategy may be: filtering the $n_x^2 + n_y^2 > T$ points.

[0097] In this implementation, normal vectors (n_x, n_y, n_z) of each point are estimated for the point cloud data of the beam region, $n_x^2 + n_y^2 + n_z^2 = 1$; then the normal vectors are projected onto the x-y plane (ground plane), to obtain two-dimensional vectors (n_x, n_y), and the relationship $n_x^2 + n_y^2 > T$ is used to filter out points in the point cloud whose normal vectors are approximately parallel to the x-y plane, i.e., points falling on the vertical plane of the beam, i.e., points on the y-z plane.

[0098] Among them, T is a preset threshold, such as 0.99.

[0099] Step 32, performing fitting processing on a point cloud corresponding to a projection of normal vectors of points in the third point cloud data onto a vertical plane of the beam, to obtain a vertical plane equation of the beam.

[0100] A random sample consensus (RANSAC) method is used to perform plane fitting on the points falling on the vertical plane of the beam, which can effectively eliminate the influence of clutter points on fitting. The fitted vertical plane equation of the beam is ax+by+cz+d=0.

[0101] It should be understood that each vertical plane equation of the beam corresponds to a respective vertical plane equation.

[0102] Step 33, determining the region of interest of the spreader in the lifting device according to information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0103] In this implementation, the precise position of the crane (e.g., within 10 cm precision) is obtained from the vertical plane equation of the beam, and the region of interest of the spreader of the lifting device is determined in combination with information of the lane in which the vehicle is located.

[0104] In the vehicle control method based on detection of a port vertical transport target provided by the embodiment of the present application, third point cloud data of the beam is acquired, fitting processing is performed on the point cloud corresponding to the projection of the normal vectors of the points in the third point cloud data onto the vertical plane of the beam, to obtain the vertical plane equation of the beam, and the region of interest of the spreader in the lifting device is determined according to information of the lane in which the vehicle is located and the vertical plane equation of the beam. In this technical solution, the region where the spreader may appear is determined by the lane and the beam, so that the subsequently acquired point cloud is filtered, thereby improving the efficiency and accuracy of subsequent processing.

[0105] II. Lifting device is a device of a lifting-type structure (e.g., a stacker):

[0106] Based on the above embodiments, FIG. 4 is a fourth schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application. As shown in FIG. 4, step 13 may include the follow steps.

[0107] Step 41, performing clustering and filtering processing on the second point

cloud data, to obtain fourth point cloud data.

[0108] In this step, after the second point cloud data is obtained, the point cloud is first clustered using the k-means method, and then, according to information of the lane in which the vehicle is located and the number of point clouds of various types, non-clutter point cloud types are retained, thereby obtaining the fourth point cloud data.

[0109] Step 42, dividing, according to normal vectors of points in the fourth point cloud data, the point cloud in the fourth point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a third number threshold, performing plane fitting, and taking a mean value of the point clouds on the fitted plane in the vertical direction as the height position of the spreader.

[0110] In this step, through the directions of the normal vectors, the point cloud in the fourth point cloud data is divided into point clouds of three types of planes (different dimensions): x-y plane, x-z plane, and y-z plane.

[0111] Furthermore, the number of point clouds of each dimensional plane is checked, respectively. When the third number threshold is reached, a random sample consensus method is used for plane fitting, and the z-mean value of the point cloud of the obtained plane can represent the spreader height calculated by this feature.

[0112] In an implementation, a spreader height is calculated for each plane, and then mutual comparison and voting are performed, to obtain a detected height z value of the grabbed object.

[0113] Step 43, determining the situation of the spreader grabbing the grabbed object according to whether the fitted plane exists.

[0114] Among them, if any fitted plane is detected, the spreader has grabbed the grabbed object; if no fitted plane is detected, the spreader has not grabbed the grabbed object.

[0115] Among them, the height position includes the height position of the spreader; the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0116] In the vehicle control method based on detection of a port vertical transport target provided by the embodiment of the present application, clustering and filtering

processing is performed on the second point cloud data, fourth point cloud data is obtained; the point cloud in the fourth point cloud data is divided into point clouds of planes of different dimensions according to the normal vectors of the points in the fourth point cloud data, and if the number of point clouds of the plane is greater than the third number threshold, plane fitting is performed, and the mean value of the point clouds on the fitted plane in the vertical direction is taken as the height position of the spreader; and the situation of the spreader grabbing the grabbed object is determined according to whether the fitted plane exists, where when the type represents the spreader, the height position of the object corresponding to the type includes the height position of the spreader, and the grabbing state includes the situation of the spreader grabbing the grabbed object. In this technical solution, clustering is performed on the point cloud data, and for each type, the spreader height and the situation of the spreader grabbing the grabbed object are determined by using the point clouds of planes of different dimensions.

[0117] Based on the above embodiments, FIG. 5 is a fifth schematic flowchart of a vehicle control method based on detection of a port vertical transport target provided by an embodiment of the present application. As shown in FIG. 5, the manner of determining the region of interest of the grabbed object may be described as follows.

[0118] Step 51, acquiring fifth point cloud data of the lifting device within a predicted range.

[0119] Among them, the predicted range may be the range where the grabbing tool of the device of the lifting-type structure and the grabbed object may appear, and may also refer to a range within a certain angle.

[0120] Point cloud information within the predicted range is acquired, and then any fixed point on the vehicle itself is used as the origin of a coordinate system, to obtain the fifth point cloud data after coordinate transformation.

[0121] Step 52, determining a center position of the lifting device based on a side door plane region and a tire region of the lifting device determined from point clouds of multiple part types obtained by clustering the fifth point cloud data.

[0122] In this step, based on the positional relationship of the point cloud, the k-means method is used to cluster the fifth point cloud data, to obtain multiple types of point clouds.

[0123] In addition, after clustering, non-clutter point cloud types may be retained according to information of the lane in which the vehicle is located and the quantities of various types of point clouds.

[0124] Furthermore, corresponding regions of interest are determined through the ranges of various types of point clouds. A random sample consensus method is used on the point cloud of the region of interest to calculate the side door plane of the lifting device, and the region of interest of the tire is determined by using the plane position, and a random sample consensus method is used on the point cloud in the region of interest to calculate the tire plane (this is because the point cloud features of the tire and the side door are relatively obvious and convenient for determination).

[0125] Afterwards, the center position of the lifting device is obtained through mutual verification of the side door plane and the tire plane.

[0126] In addition, based on the center position, the position (x, y) value of the grabbed object can be obtained through transformation.

[0127] Step 53, determining the region of interest of the grabbed object according to the center position.

[0128] In this step, the region of interest of the grabbed object (such as a container) is determined based on the center position of the lifting device, and the normal vector of each point is estimated for the point cloud of the region of interest, (n_x, n_y, n_z), $n_x^2 + n_y^2 + n_z^2 = 1$. Through the directions of the normal vectors, the points are divided into three types: x-y plane, x-z plane, and y-z plane.

[0129] That is, the x-y plane (horizontal ground plane), the y-z plane (left-right, vertical plane of the vehicle), and the x-z plane (front-back, vertical plane of the vehicle).

[0130] In the vehicle control method based on detection of a port vertical transport target provided by the embodiment of the present application, fifth point cloud data of

the lifting device within the predicted range is acquired; based on the side door plane region and the tire region of the lifting device determined from point clouds of multiple part types obtained by clustering the fifth point cloud data, the center position of the lifting device is determined; and the region of interest of the grabbed object is determined according to the center position. In this technical solution, the region where the grabbed object may appear is determined through the side door plane region and the tire region of the lifting device, so that subsequently acquired point cloud data is filtered, thereby improving the efficiency and accuracy of subsequent processing.

[0131] The following are examples of two specific implementation manners provided by the embodiments of the present application, exemplified by a bridge crane and a stacker, respectively.

[0132] FIG. 6A and FIG. 6B are schematic diagrams of a detection flow of the bridge crane provided by an embodiment of the present application. As shown in FIG. 6A and FIG. 6B, the schematic diagrams include the following steps.

[0133] Step 611, installing sensors, usually cameras or laser radars, where the installation position and angle need to cover the region above the vehicle body.

[0134] Step 612, coordinate transformation, transforming the sensor data into a coordinate system fixed to the own vehicle, where the front of the own vehicle is the positive direction of the x-axis of the coordinate system, the left side of the own vehicle is the positive direction of the y-axis, and the directly above of the own vehicle is the positive direction of the z-axis.

[0135] Step 613, determining the region of interest (RoI) of the beam of the crane according to information such as the position of the beam in the crane, the size of the beam, and the approximate position of the crane determined by other methods (meter-level precision is sufficient), and each of two beams has a region of interest. The point cloud is filtered by using these two regions of interest, to respectively obtain point clouds falling in different beam regions.

[0136] Step 614, estimating normal vectors (n_x, n_y, n_z) of each point for the point cloud of the beam region, $n_x^2 + n_y^2 + n_z^2 = 1$. Then the normal vectors are projected

onto the x-y plane (ground plane), to obtain two-dimensional vectors (n_x, n_y), and the relationship $n_x^2 + n_y^2 > T$ is used to filter out points in the point cloud whose normal vectors are approximately parallel to the x-y plane, i.e., points falling on the vertical plane of the beam. Among them, T is a preset threshold, such as 0.99.

[0137] Step 615, performing plane fitting on the points falling on the vertical plane of the beam obtained in step 614 by using a random sample consensus (RANSAC) method, which can effectively eliminate the influence of clutter points on fitting. The fitted vertical plane equation of the beam ax+by+cz+d=0 is obtained, and the interior points in the fitting process, that is, the points finally used for determining the vertical plane equation in the fitting process, are also obtained.

[0138] Step 616, obtaining the precise position of the crane (with a precision within 10 centimeters) through the two vertical plane equations of the beam in step 615, and determining the region of interest (RoI) of the spreader of the crane in combination with information of the lane in which the vehicle is located, to obtain the point cloud of the region of interest of the spreader.

[0139] Step 617, estimating the normal vector of each point for the point cloud of the beam region, $(n_x, n_y, n_z), n_x^2 + n_y^2 + n_z^2 = 1$. Through the directions of the normal vectors, the points are divided into three types: x-y plane, x-z plane, and y-z plane.

[0140] Step 618, checking the number of point clouds of each type of plane, respectively. When the number threshold is reached, a random sample consensus (RANSAC) method is used for plane fitting, and the z-mean value of the point clouds of each plane can represent the spreader height calculated by this feature.

[0141] Step 619, uniformly dividing the region of interest (RoI) of the spreader of the crane in the z direction, to obtain the divided region with the largest number of point clouds. When the number of point clouds in this region exceeds the threshold, the z-mean value of the point clouds in this region represents the spreader height calculated by this feature.

[0142] Step 620, comparing and voting the spreader height calculated by the

respective features obtained in step 618 and step 619 with each other, to obtain the detected height z value of the spreader.

[0143] Step 621, obtaining the detected position (x, y) values of the spreader according to the crane position x obtained in step 616 and the information of the lane y in which the vehicle is located.

[0144] Step 622, according to the respective feature planes obtained in step 618, when the point cloud density of the x-y plane is greater than the threshold, it is considered that the spreader grabs a container; when the z-range of the point cloud of the x-z plane is greater than the threshold, it is considered that the spreader grabs a container; when the z-range of the point cloud of the y-z plane is greater than the threshold, it is considered that the spreader grabs a container.

[0145] Step 623, comparing and voting the results of whether the spreader grabs a container obtained from the respective features in step 620 with each other, to obtain the container-grabbing state of the spreader.

[0146] Step 624, estimating the spreader height of the next frame by using a least squares method based on the currently calculated spreader height and the spreader heights of the historically stored n frames, to obtain the current spreader speed and direction.

[0147] FIG. 7 is a schematic diagram of a detection flow of a stacker provided by an embodiment of the present application. As shown in FIG. 7, the schematic diagram includes the following steps.

[0148] Step 711, installing sensors, usually cameras or laser radars, where the installation position and angle need to cover the region above the vehicle body.

[0149] Step 712, coordinate transformation, transforming the sensor data into a coordinate system fixed to the own vehicle, where the front of the own vehicle is the positive direction of the x-axis of the coordinate system, the left side of the own vehicle is the positive direction of the y-axis, and the directly above of the own vehicle is the positive direction of the z-axis.

[0150] Step 713, clustering the point cloud by using the k-means method based on

the positional relationship of the point cloud, and retaining non-clutter point cloud types within the predicted position range according to the lane in which the vehicle is located and the number of point clouds of various types.

[0151] Step 714, determining regions of interest through the ranges of various types of point clouds, and calculating the side door plane of the stacker by using a random sample consensus (RANSAC) method on the point cloud of the region of interest.

[0152] Step 715, determining the region of interest of the tire according to the plane position in step 714, and calculating the tire plane by using a random sample consensus (RANSAC) method on the point cloud in the region of interest.

[0153] Step 716, mutually verifying the side door plane and the tire plane according to step 714 and step 715, to obtain the center position of the stacker.

[0154] Step 717, determining the region of interest of the container of the stacker according to the center position of the stacker in step 716, and estimating the normal vector of each point for the point cloud of the region of interest, $(n_x, n_y, n_z), n_x^2 + n_y^2 + n_z^2 = 1$. Through the directions of the normal vectors, the points are divided into three types: x-y plane, x-z plane, and y-z plane.

[0155] Step 718, checking the number of point clouds of each type of plane, respectively. When the number threshold is reached, a random sample consensus (RANSAC) method is used for plane fitting, and the z-mean value of the point cloud of each plane can represent the spreader height calculated by this feature.

[0156] Step 719, obtaining the container-grabbing state of the stacker according to whether the three types of planes exist in step 718.

[0157] Step 720, comparing and voting the spreader heights calculated by the respective features in step 718 with each other, to obtain the detected height z value of the container of the stacker.

[0158] Step 721, transforming according to the center position of the stacker in step 716 to obtain the container position (x, y) value of the stacker.

[0159] Step 722, estimating the spreader height of the next frame by using a least squares method based on the currently calculated container height of the stacker and

the spreader heights of the historically stored n frames, to obtain the current container speed and direction of the stacker.

[0160] The technical solutions and technical effects of the embodiments shown in FIG. 6A and FIG. 6B and FIG. 7 are similar to those of the above embodiments, and are not described in detail herein.

[0161] The following are apparatus embodiments of the present application, which can be used to execute the method embodiments of the present application. For details not disclosed in the apparatus embodiments of the present application, please refer to the method embodiments of the present application.

[0162] FIG. 8 is a schematic structural diagram of a vehicle control apparatus based on detection of a port vertical transport target provided by an embodiment of the present application. As shown in FIG. 8, the apparatus is applied to a vehicle and includes:

an acquiring module 81, configured for acquiring first point cloud data of a region above the vehicle;

a first determining module 82, configured for determining, according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, second point cloud data located in the region of interest of the spreader or the grabbed object from the first point cloud data;

a second determining module 83, configured for determining, according to feature information of the second point cloud data, position information and grabbing state of the spreader corresponding to the second point cloud data;

a controlling module 84, configured for controlling a moving and stopping state of the vehicle according to the position information and the grabbing state.

[0163] In one or more embodiments, the lifting device is a device with a beam-type structure;

correspondingly, the second determining module 83 is specifically configured for:

dividing, according to normal vectors of points in the second point cloud data, the point cloud in the second point cloud data into point clouds of planes of

different dimensions, and if the number of point clouds of the plane is greater than a first number threshold, determining a mean value of the point clouds on the plane in a vertical direction as a height position of the spreader; and/or, cutting the second point cloud data along the vertical direction, and taking a vertical mean value of the point clouds in a region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than a second number threshold, as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to a point cloud density of a plane of a horizontal dimension and a first density threshold, or vertical values of point clouds of a plane of another dimension and a first value threshold;

where the position information includes the height position of the spreader; and the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0164] In one or more embodiments, the region of interest of the spreader is a region constituted by a beam of the lifting device and a lane in which the vehicle is located;

correspondingly, before determining, according to the first point cloud data and the pre-determined region of interest of the spreader in the lifting device, the second point cloud data located in the region of interest of the spreader from the first point cloud data, the second determining module 83 is further configured for:

acquiring third point cloud data of the beam;

performing fitting processing on a point cloud corresponding to a projection of normal vectors of points in the third point cloud data onto a vertical plane of the beam, to obtain a vertical plane equation of the beam; and

determining the region of interest of the spreader in the lifting device according to information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0165] In one or more embodiments, before performing the fitting processing on the point cloud corresponding to the projection of the normal vectors of the points in the third point cloud data onto the vertical plane of the beam, to obtain the vertical plane

equation of the beam, the second determining module 83 is further configured for:

projecting the normal vectors of the points in the third point cloud data onto a ground plane, to obtain two-dimensional vectors; and

filtering the two-dimensional vectors by using a preset strategy, to obtain the point cloud corresponding to the projection onto the vertical plane of the beam, where the preset strategy is filtering points corresponding to the two-dimensional vectors for which the sum of squares of data in the two-dimensional vectors is greater than a preset threshold.

[0166] In one or more embodiments, the lifting device is a device with a hoisting-type structure;

correspondingly, the second determining module 83 is specifically configured for:

performing clustering and filtering processing on the second point cloud data, to obtain fourth point cloud data;

dividing, according to normal vectors of points in the fourth point cloud data, the point cloud in the fourth point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a third number threshold, performing plane fitting, and taking a mean value of the point clouds on the fitted plane in the vertical direction as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to whether the fitted plane exists;

where the height position includes the height position of the spreader; and the grabbing state includes the situation of the spreader grabbing the grabbed object.

[0167] In one or more embodiments, the region of interest of the grabbed object is a region formed by the spreader of the lifting device lifting with the grabbed object;

correspondingly, before determining, according to the first point cloud data and the pre-determined region of interest of the grabbed object in the lifting device, the second point cloud data located in the region of interest of the grabbed object from the first point cloud data, the second determining module 83 is further configured for:

acquiring fifth point cloud data of the lifting device within a predicted range;

determining a center position of the lifting device based on a side door plane region and a tire region of the lifting device determined from point clouds of multiple part types obtained by clustering the fifth point cloud data; and

determining the region of interest of the grabbed object according to the center position.

[0168] In one or more embodiments, the second determining module 83 is further configured for:

determining a movement state of the spreader according to the position information and position information of a previous frame of the position information.

[0169] The apparatus provided in the embodiment of the present application can be used to execute the method in any one of the above embodiments, and its implementation principles and technical effects are similar, which will not be described in detail herein.

[0170] It should be noted that it should be understood that the division of the various modules of the above apparatus is only a division of logical functions, and in actual implementation, they may be wholly or partially integrated into one physical entity, or may be physically separated. Moreover, these modules may all be implemented in the form of software called by processing elements; or may all be implemented in the form of hardware; or some modules may be implemented in the form of software called by processing elements, and some modules may be implemented in the form of hardware. In addition, these modules may all or partially be integrated together, or may be implemented independently. The processing element described herein may be an integrated circuit with signal processing capability. During the implementation process, each step of the above method or each of the above modules may be completed by an integrated logic circuit of hardware in a processor element or instructions in the form of software.

[0171] FIG. 9 is a schematic structural diagram of a vehicle provided by an embodiment of the present application. As shown in FIG. 9, the vehicle may include: a

processor 91, a memory 92, and computer program instructions stored in the memory 92 and executable on the processor 91, where when the processor 91 executes the computer program instructions, the method provided in any one of the preceding embodiments is implemented.

[0172] Optionally, the above various devices of the vehicle may be connected through a system bus.

[0173] The memory 92 may be a separate storage unit, or may be a storage unit integrated in the processor 91. The number of processors 91 is one or more.

[0174] It should be understood that the processor 91 may be a central processing unit (CPU), and may also be other general-purpose processors 91, a digital signal processor (DSP) 91, an application specific integrated circuit (ASIC), etc. The general-purpose processor 91 may be a microprocessor 91 or the processor 91 may also be any conventional processor 91 or the like. The steps of the method disclosed in combination with the present application may be directly embodied as being executed by a hardware processor 91, or executed by a combination of hardware and software modules in the processor 91.

[0175] The system bus may be a peripheral component interconnect (PCI) bus or an extended industry standard architecture (EISA) bus, or the like. The system bus may be divided into an address bus, a data bus, a control bus, and the like. For ease of representation, only one thick line is used in the figure, but it does not mean that there is only one bus or one type of bus. The memory 92 may include a random access memory (RAM) 92, and may also include a non-volatile memory (NVM) 92, such as at least one disk memory 92.

[0176] All or part of the steps of implementing the above method embodiments may be completed by program instructions related to hardware. The aforementioned program may be stored in a readable memory 92. When the program is executed, it executes the steps including the above method embodiments; and the aforementioned memory 92 (storage medium) includes: a read-only memory (ROM) 92, a RAM, a flash memory 92, a hard disk, a solid-state hard disk, a magnetic tape, a floppy disk, an optical

disc, and any combination thereof.

[0177] The vehicle provided in the embodiment of the present application can be used to execute the method provided in any one of the above method embodiments, and its implementation principles and technical effects are similar, which will not be described in detail herein.

[0178] An embodiment of the present application provides a computer-readable storage medium, in which computer instructions are stored. When the computer instructions are run on a computer, the computer is caused to execute the above method.

[0179] The above-mentioned computer-readable storage medium may be implemented by any type of volatile or non-volatile storage device or a combination thereof, such as static random access memory, electrically erasable programmable read-only memory, erasable programmable read-only memory, programmable read-only memory, read-only memory, magnetic memory, flash memory, magnetic disk, or optical disk. The readable storage medium may be any available medium that can be accessed by a general-purpose or special-purpose computer.

[0180] Optionally, the readable storage medium is coupled to the processor, so that the processor can read information from the readable storage medium and write information to the readable storage medium. Of course, the readable storage medium may also be a component of the processor. The processor and the readable storage medium may be located in an application specific integrated circuit (ASIC). Of course, the processor and the readable storage medium may also exist as discrete components in a device.

[0181] An embodiment of the present application further provides a computer program product, including a computer program, where the computer program is stored in a computer-readable storage medium, and at least one processor can read the computer program from the computer-readable storage medium, and when the at least one processor executes the computer program, the above method can be implemented.

[0182] It should be understood that the present disclosure is not limited to the precise structures described above and illustrated in the accompanying drawings, and

various modifications and changes can be made without departing from the scope thereof. The scope of the present disclosure is only limited by the appended claims.

CLAIMS

1. A vehicle control method based on detection of a port vertical transport target, applied to a vehicle, wherein the method comprises:

acquiring first point cloud data of a region above the vehicle;

determining, according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, second point cloud data located in the region of interest of the spreader or the grabbed object from the first point cloud data;

determining, according to feature information of the second point cloud data, position information and grabbing state of the spreader corresponding to the second point cloud data; and

controlling a moving and stopping state of the vehicle according to the position information and the grabbing state.

2. The method according to claim 1, wherein the lifting device is a device with a beam-type structure;

correspondingly, determining, according to the feature information of the second point cloud data, the position information and the grabbing state of the spreader corresponding to the second point cloud data comprises:

dividing, according to normal vectors of points in the second point cloud data, the point cloud in the second point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a first number threshold, determining a mean value of the point clouds on the plane in a vertical direction as a height position of the spreader; and/or, cutting the second point cloud data along the vertical direction, and taking a vertical mean value of the point clouds in a region in which the cut is located, in which the number of the cut point clouds is largest and the number of the cut point clouds is greater than a second number threshold, as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to

a point cloud density of a plane of a horizontal dimension and a first density threshold, or vertical values of point clouds of a plane of another dimension and a first value threshold;

wherein the position information comprises the height position of the spreader; and the grabbing state comprises the situation of the spreader grabbing the grabbed object.

3. The method according to claim 2, wherein the region of interest of the spreader is a region constituted by a beam of the lifting device and a lane in which the vehicle is located;

correspondingly, before determining, according to the first point cloud data and the pre-determined region of interest of the spreader in the lifting device, the second point cloud data located in the region of interest of the spreader from the first point cloud data, the method further comprises:

acquiring third point cloud data of the beam;

performing fitting processing on a point cloud corresponding to a projection of normal vectors of points in the third point cloud data onto a vertical plane of the beam, to obtain a vertical plane equation of the beam; and

determining the region of interest of the spreader in the lifting device according to information of the lane in which the vehicle is located and the vertical plane equation of the beam.

4. The method according to claim 3, wherein before performing the fitting processing on the point cloud corresponding to the projection of the normal vectors of the points in the third point cloud data onto the vertical plane of the beam, to obtain the vertical plane equation of the beam, the method further comprises:

projecting the normal vectors of the points in the third point cloud data onto a ground plane, to obtain two-dimensional vectors; and

filtering the two-dimensional vectors by using a preset strategy, to obtain the point cloud corresponding to the projection onto the vertical plane of the beam, wherein the preset strategy is filtering points corresponding to the two-dimensional vectors for

which the sum of squares of data in the two-dimensional vectors is greater than a preset threshold.

5. The method according to claim 1, wherein the lifting device is a device with a hoisting-type structure;

correspondingly, determining, according to the feature information of the second point cloud data, the position information and the grabbing state of the spreader corresponding to the second point cloud data comprises:

performing clustering and filtering processing on the second point cloud data, to obtain fourth point cloud data;

dividing, according to normal vectors of points in the fourth point cloud data, the point cloud in the fourth point cloud data into point clouds of planes of different dimensions, and if the number of point clouds of the plane is greater than a third number threshold, performing plane fitting, and taking a mean value of the point clouds on the fitted plane in the vertical direction as the height position of the spreader; and

determining the situation of the spreader grabbing the grabbed object according to whether the fitted plane exists;

wherein the height position comprises the height position of the spreader; and the grabbing state comprises the situation of the spreader grabbing the grabbed object.

6. The method according to claim 5, wherein the region of interest of the grabbed object is a region formed by the spreader of the lifting device lifting with the grabbed object;

correspondingly, before determining, according to the first point cloud data and the pre-determined region of interest of the grabbed object in the lifting device, the second point cloud data located in the region of interest of the grabbed object from the first point cloud data, the method further comprises:

acquiring fifth point cloud data of the lifting device within a predicted range;

determining a center position of the lifting device based on a side door plane region and a tire region of the lifting device determined from point clouds of multiple part types obtained by clustering the fifth point cloud data; and

determining the region of interest of the grabbed object according to the center position.

7. The method according to any one of claims 1 to 6, wherein the method further comprises:

determining a movement state of the spreader according to the position information and position information of a previous frame of the position information.

8. A vehicle control apparatus based on detection of a port vertical transport target, applied to a vehicle, wherein the apparatus comprises:

an acquiring module, configured for acquiring first point cloud data of a region above the vehicle;

a first determining module, configured for determining, according to the first point cloud data and a pre-determined region of interest of a spreader or a grabbed object in a lifting device, second point cloud data located in the region of interest of the spreader or the grabbed object from the first point cloud data;

a second determining module, configured for determining, according to feature information of the second point cloud data, position information and grabbing state of the spreader corresponding to the second point cloud data; and

a controlling module, configured for controlling a moving and stopping state of the vehicle according to the position information and the grabbing state.

9. A vehicle, comprising: a processor, and a memory communicatively connected to the processor;

the memory stores computer-executable instructions; and

the processor executes the computer-executable instructions stored in the memory to implement the method according to any one of claims 1 to 7.

10. A computer-readable storage medium, wherein the computer-readable storage medium stores computer-executable instructions, and when the computer-executable instructions are executed by a processor, they are used to implement the method according to any one of claims 1 to 7.