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 202410310963.5, 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 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.

[0004] In the prior art, since during the loading and unloading operation of a spreader, whether the 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 vehicle to start or continue to stop according to the loading and unloading process.

[0005] However, the above implementation relies too much on manual intervention. Long-duration loading and unloading operations may cause fatigue and inattention of driver or supervisory personnel, which may easily lead to misjudgment of the starting and stopping of vehicles, increasing the risk of accidents.

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, 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, target position information and target grabbing state of a spreader in a lifting device from a pre-determined point cloud mapping relationship, where the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader; and

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

[0008] In one or more embodiments, determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship includes:

matching, according to the first point cloud data, point cloud data with a difference value smaller than a first preset threshold from the point cloud mapping relationship, and using the position information and the grabbing state corresponding to the point cloud data with the difference value smaller than the first preset threshold as the target position information and the target grabbing state of the spreader.

[0009] In one or more embodiments, the lifting device is a device with a beam-type structure;

correspondingly, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the method further includes:

acquiring second point cloud data located in a region of interest of the spreader in the lifting device from the first point cloud data, and using the second point cloud data as new first point cloud data; where the region of interest of the spreader is determined based on third point cloud data of a beam of the lifting device and information of a lane in which the vehicle is located.

[0010] In one or more embodiments, before acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the method further includes:

acquiring third point cloud data of the beam of the lifting device;

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 the information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0011] In one or more embodiments, after acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the method further includes:

performing clustering processing on the point clouds in the second point cloud data, to obtain different types of point clouds; and

updating the point clouds in the second point cloud data to point clouds of non-clutter point types among all the types.

[0012] In one or more embodiments, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the

method further includes:

performing clustering processing on the first point cloud data according to a positional relationship of the point clouds, to obtain different types of point clouds; and

updating the point clouds in the first point cloud data to point clouds of non-clutter point types among all the types according to the information of the lane in which the vehicle is located.

[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 an apparatus, applied to a vehicle, the apparatus including:

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

a determining module, configured for determining, according to the first point cloud data, target position information and target grabbing state of a spreader in a lifting device from a pre-determined point cloud mapping relationship, where the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader; and

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

[0015] In one or more embodiments, the determining module is specifically configured for:

matching, according to the first point cloud data, point cloud data with a difference value smaller than a first preset threshold from the point cloud mapping relationship, and using the position information and the grabbing state corresponding to the point cloud data with the difference value smaller than the first preset threshold as the target position information and the target grabbing state of the spreader.

[0016] In one or more embodiments, the lifting device is a device with a beam-type

structure;

correspondingly, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the determining module is further configured for:

acquiring second point cloud data located in a region of interest of the spreader in the lifting device from the first point cloud data, and using the second point cloud data as new first point cloud data; where the region of interest of the spreader is determined based on third point cloud data of a beam of the lifting device and information of a lane in which the vehicle is located.

[0017] In one or more embodiments, before acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the determining module is further configured for:

acquiring third point cloud data of the beam of the lifting device;

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 the information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0018] In one or more embodiments, after acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the determining module is further configured for:

performing clustering processing on the point clouds in the second point cloud data, to obtain different types of point clouds; and

updating the point clouds in the second point cloud data to point clouds of non-clutter point types among all the types.

[0019] In one or more embodiments, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader

in the lifting device from the pre-determined point cloud mapping relationship, the determining module is further configured for:

performing clustering processing on the first point cloud data according to a positional relationship of the point clouds, to obtain different types of point clouds; and

updating the point clouds in the first point cloud data to point clouds of non-clutter point types among all the types according to the information of the lane in which the vehicle is located.

[0020] In one or more embodiments, the 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 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 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 target position information and target grabbing state of a spreader in a lifting device are determined from a pre-determined point cloud mapping relationship according to the first point cloud data, where the point cloud mapping relationship records point cloud

data corresponding to different position information and different grabbing states of the spreader, and then a moving and stopping state of the vehicle is controlled according to the target position information and the target grabbing state. In this technical solution, the point cloud data of the region above is acquired by the vehicle, and then compared with the point cloud data corresponding to pre-determined possible spreader positions and grabbing states, to determine the current spreader position and grabbing state of a region above the vehicle, thereby controlling the starting and stopping of the vehicle, to avoid dangerous operations of the vehicle caused by manual intervention.

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 schematic diagram of a detection flow of the bridge crane provided by an embodiment of the present application.

[0029] FIG. 5 is a schematic diagram of a detection flow of a stacker provided by an embodiment of the present application.

[0030] FIG. 6 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.

[0031] FIG. 7 is a schematic structural diagram of a vehicle provided by an embodiment of the present application.

[0032] 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

[0033] 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.

[0034] Before introducing the embodiments of the present application, the technical terms and the application background of the embodiments of the present application is first explained:

[0035] 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.

[0036] Technical background can be described as follows:

[0037] 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.

[0038] In the prior art, since during the loading and unloading operation of a spreader, whether the 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 vehicle to start or continue to stop according to the loading and unloading process.

[0039] The problems existing in the prior art that need to be solved by the embodiments of the present application are: the above implementation relies too much on manual intervention, and long-duration loading and unloading operations may cause fatigue and inattention of driver or supervisory personnel, which may easily lead to misjudgment of the starting and stopping of vehicles, increasing the risk of accidents.

[0040] 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 point cloud information respectively corresponding to the

possible position of the spreader within its activity range and the grabbing state can be acquired first, in an actual scenario, the point cloud information within the activity range of the spreader can be collected in real time through sensors, and then matched, information such as the current position and grabbing state of the spreader can be accurately determined. Then, based on the matched information, the vehicle can be informed whether it should continue to wait or start to leave, as well as stop, etc., thereby avoiding possible vehicle risks.

[0041] 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.

[0042] It is worth noting that the application field of the method, apparatus, vehicle and storage medium involved in the present disclosure is not limited, and can be applied to various scenarios such as the loading and unloading of the spreader, which is not limited to port scenarios.

[0043] The execution subject of the present application is a vehicle, and specifically may be a control unit on the vehicle, etc.

[0044] 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.

[0045] Step 11, acquiring first point cloud data of a region above the vehicle.

[0046] 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.

[0047] 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.

[0048] 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 sensors 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.

[0049] 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.

[0050] 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).

[0051] The lifting device is not limited to a well-type frame, a gantry crane machine, a tower crane, a construction elevator, a stacker, etc.

[0052] Step 12, determining, according to the first point cloud data, target position information and target grabbing state of a spreader in a lifting device from a pre-determined point cloud mapping relationship.

[0053] Among them, the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader.

[0054] In this step, the corresponding point cloud data are inconsistent for different positions and different grabbing states.

[0055] 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.).

[0056] Optionally, the implementation of acquiring the point cloud data in the point cloud mapping relationship may be: acquiring by using the above sensors, and filtering the acquired point cloud data by using the Region of Interest (RoI) involved by the spreader, retaining only the point cloud data located in the region of interest as the point cloud data in the point cloud mapping relationship.

[0057] The manner of acquiring the region of interest is given by the following embodiments, and is not repeated here.

[0058] It should be understood that when actually acquiring the point cloud data in the point cloud mapping relationship, the corresponding position information and grabbing state of the spreader are recorded.

[0059] For example, the grabbed object may be a box, a container, a package, etc.; the spreader may be a fixture, a shovel, or other devices having the function of grabbing a grabbed object.

[0060] It should be understood that the acquisition of the point cloud data is implemented based on a fixed coordinate system of the vehicle, and is consistent when acquiring the point cloud mapping relationship and the first point cloud data.

[0061] Optionally, one implementation of step 12 is: matching, according to the first point cloud data, point cloud data with a difference value smaller than a first preset threshold from the point cloud mapping relationship, and using the position information and the grabbing state corresponding to the point cloud data with the difference value smaller than the first preset threshold as the target position information and the target grabbing state of the spreader.

[0062] Under this implementation, a possible implementation may be described as follows.

[0063] First: initially aligning the first point cloud data and the point cloud data in the point cloud mapping relationship, usually using some initial estimation methods (such as feature matching, nearest neighbor search, etc.) to obtain a rough transformation matrix; secondly: using an Iterative Closest Point (ICP) iterative algorithm for iterative optimization, to further improve the alignment effect of the point

clouds, and the ICP algorithm gradually adjusts the relative position and posture of the point clouds by finding the minimum square error between corresponding point pairs until the best alignment effect is achieved; then: calculating the difference value, after each ICP iteration, calculating the difference value between the first point cloud data and the point cloud data in the mapping relationship, where common difference value calculation methods include average distance, least squares method, or Hausdorff distance, etc., for evaluating the similarity of two groups of point clouds; finally, according to application requirements, setting an appropriate difference value threshold (e.g., a first preset threshold) to judge the matching result. By setting the threshold, the difference value can be compared with the threshold, and the point cloud data with the difference value within the threshold is regarded as successfully matched point cloud data.

[0064] In other implementations, since point cloud data needs to be acquired in real time, that is, different frames correspond to different first point cloud data, in order to improve efficiency, the matching result of the previous frame can be used as the initial matching point, and the point cloud data before or after the point cloud data corresponding to the matching result of the previous frame (the specific selection may be arbitrary or determined based on the previous movement state of the spreader) is used as the matching target for matching the first point cloud data, so that the target position information and the target grabbing state of the spreader in the lifting device can be quickly determined.

[0065] In this implementation, the point cloud mapping relationship may be stored in a tree-type comparison point cloud set manner. For example, a certain spreader height range is set, and the spreader within 1-3m is one branch; 3-5m is another branch, and each branch is provided with point cloud data corresponding to different spreader heights within 1-3m; in addition, the situation of the distance (e.g., horizontal distance) between the lifting device and the vehicle can also be added, to improve matching efficiency.

[0066] Step 13: controlling a moving and stopping state of the vehicle according to

the target position information and the target grabbing state.

[0067] 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.

[0068] The moving and stopping state includes: starting, stopping, running, braking, etc.

[0069] 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.

[0070] 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.

[0071] 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.

[0072] 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.

[0073] 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.

[0074] 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.

[0075] 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.

[0076] In the vehicle control method based on detection of a port vertical transport target provided by the embodiments of the present application, applied to a vehicle. First point cloud data of a region above the vehicle is acquired, then target position information and target grabbing state of a spreader in a lifting device are determined from a pre-determined point cloud mapping relationship according to the first point cloud data, where the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader, and then a moving and stopping state of the vehicle is controlled according to the target position information and the target grabbing state. In this technical solution, the point cloud data of the region above is acquired by the vehicle, and then compared with the point cloud data corresponding to pre-determined possible spreader positions and grabbing states, to determine the current spreader position and grabbing state of a region above the vehicle, thereby controlling the starting and stopping of the vehicle, to avoid dangerous operations of the vehicle caused by manual intervention.

[0077] Based on the above embodiments, the lifting device is a device with a beam-type structure. 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, before step 12, the method may further include the following steps.

[0078] Step 21, acquiring second point cloud data located in a region of interest of the spreader in the lifting device from the first point cloud data, and using the second point cloud data as new first point cloud data.

[0079] Among them, the region of interest of the spreader is determined based on third point cloud data of a beam of the lifting device and information of a lane in which the vehicle is located.

[0080] In this step, in order to ensure the matching efficiency and accuracy described above, the first point cloud data may be updated, that is, retaining the point cloud data (i.e., the second point cloud data) in the first point cloud data that is located in the movable region of the spreader (i.e., the region of interest of the spreader).

[0081] Optionally, the manner of determining the region of interest of the spreader in the lifting device is described as flows.

[0082] Step 1, acquiring third point cloud data of the beam of the lifting device.

[0083] In this implementation, the vehicle acquires point cloud data of a beam (e.g., two beams) in the lifting device, denoted as third point cloud data.

[0084] 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.

[0085] Step 2, 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.

[0086] In this step, the normal vectors (n_x, n_y, n_z) of each point are estimated for the third point cloud data, $n_x^2 + n_y^2 + n_z^2 = 1$.

[0087] Taking the z-direction as the extension direction of the lane where the vehicle is located, the y-direction as the direction parallel to the beam, and the z-direction as the direction perpendicular to the vehicle/lifting device.

[0088] 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 set threshold, such as 0.99.

[0089] Subsequently, 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.

[0090] It should be understood that each vertical plane equation of the beam corresponds to a respective vertical plane equation.

[0091] Step 3, determining the region of interest of the spreader in the lifting device according to the information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0092] 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.

[0093] Subsequently, based on the region of interest, the second point cloud data corresponding to the first point cloud data is determined.

[0094] Optionally, in step 21, after acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the method further includes: performing clustering processing on the point clouds in the second point cloud data, to obtain different types of point clouds, and then updating the point clouds in the second point cloud data to point clouds of non-clutter point types among all the types.

[0095] In order to ensure the authenticity and validity of the second point cloud data in the region of interest, the second point cloud data may be subjected to clustering processing by the means of clustering (for example, distance may be used as the clustering judgment condition). Point clouds whose number after clustering is smaller than a certain threshold (for example, and these point clouds are relatively far away) are regarded as point clouds with clutter point types, and then these point clouds are removed, and other point clouds are retained, i.e., the updated point clouds in the second point cloud data are obtained.

[0096] For example, these clutter points may be rainwater in the air collected by sensors. In order not to affect the matching effect, the above manner may be adopted; where the setting of the threshold in this implementation is related to the number of collected point clouds of the spreader and the grabbed object. Generally speaking, the number of point clouds of the spreader and the grabbed object is much larger than the number of point clouds corresponding to rainwater.

[0097] 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.

[0098] In the vehicle control method based on detection of a port vertical transport target provided by the embodiments of the present application, second point cloud data located in a region of interest of the spreader in the lifting device is acquired from the first point cloud data, and the second point cloud data is used as new first point cloud data, where the region of interest of the spreader is determined based on third point cloud data of a beam of the lifting device and information of the lane in which the vehicle is located. In this technical solution, point cloud data not in the region of interest of the spreader is filtered out, to increase the accuracy of matching using the point cloud mapping relationship and increase the matching efficiency.

[0099] Based on the above embodiments, 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, before step 12, the

method may further include the following steps (this implementation may be applied to any lifting device).

[0100] Step 31, performing clustering processing on the first point cloud data according to a positional relationship of the point clouds, to obtain different types of point clouds.

[0101] In this step, in order to ensure the authenticity and validity of the first point cloud data, the first point cloud data may be subjected to clustering processing by the means of clustering using the positional relationship of the point clouds (such as distance metric, density clustering, etc.) as the clustering judgment condition, to obtain different types of point clouds.

[0102] Step 32, updating the point clouds in the first point cloud data to point clouds of non-clutter point types among all the types according to the information of the lane in which the vehicle is located.

[0103] In this step, when determining the target position information and the target grabbing state of the spreader, it can be considered that only the point cloud information within the relevant lanes related to the vehicle needs to be determined. Based on the lane information, point clouds of non-clutter point types within the predicted position range are retained.

[0104] The number of point clouds of the clutter point type is relatively small. At this time, these point clouds are removed, and other point clouds are retained, i.e., the updated point clouds in the first point cloud data are obtained.

[0105] For example, these clutter points may be rainwater in the air collected by sensors. In order not to affect the matching effect, the above manner may be adopted; where the setting of the threshold in this implementation is related to the number of collected point clouds of the spreader and the grabbed object. Generally speaking, the number of point clouds of the spreader and the grabbed object is much larger than the number of point clouds corresponding to rainwater.

[0106] In the vehicle control method based on detection of a port vertical transport target provided by the embodiments of the present application, clustering processing is

performed on the first point cloud data according to a positional relationship of the point clouds, to obtain different types of point clouds, and the point clouds in the first point cloud data are updated to point clouds of non-clutter point types among all the types according to the information of the lane in which the vehicle is located. In this technical solution, point clouds of non-clutter point types are filtered out to increase the accuracy of matching using the point cloud mapping relationship and increase the matching efficiency.

[0107] 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.

[0108] FIG. 4 is a schematic diagram of a detection flow of the bridge crane provided by an embodiment of the present application. As shown in FIG. 4, the schematic diagram includes the following steps.

[0109] Step 41, installing sensors, usually cameras and/or laser radars, where the installation position and angle need to cover the region above the vehicle body.

[0110] Step 42, 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.

[0111] Step 43, acquiring point cloud data of the spreader relative to each position (x, y, z) of the vehicle and whether the spreader grabs a container, and recording the spreader position value and the spreader container-grabbing state value corresponding to each point cloud set; storing the point cloud sets in a tree-type topology according to the true value condition as a comparison point cloud set (i.e., a point cloud mapping relationship).

[0112] Step 44: 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.

[0113] Step 45, 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 (parallel ground), 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.

[0114] Step 46, performing plane fitting on the points falling on the vertical plane of the beam obtained in step 44 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.

[0115] Step 47, obtaining the precise position of the crane (with a precision within 10 centimeters) through the two vertical plane equations of the beam in step 45, and determining the region of interest (RoI) of the spreader 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;

[0116] Step 48, clustering the point cloud by using the k-means method for the point cloud of the region of interest of the spreader, 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;

[0117] Step 49, performing point cloud matching between the point cloud in step 48 and the comparison point cloud set in step 43, using the previous frame matching result as the starting matching point, extracting the comparison point cloud group from the tree-type comparison point cloud set according to a set threshold, using the ICP

method to obtain each difference value between the detected point cloud and the comparison point cloud group, obtaining the matching result based on the magnitude of the difference value and the preset threshold, and obtaining the detected position (x, y, z) and container-grabbing state of the spreader based on the matching result;

[0118] Step 50, 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.

[0119] FIG. 5 is a schematic diagram of a detection flow of a stacker provided by an embodiment of the present application. As shown in FIG. 5, the schematic diagram includes the following steps.

[0120] Step 51, installing sensors, usually cameras or laser radars, where the installation position and angle need to cover the region above the vehicle body.

[0121] Step 52, 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.

[0122] Step 53, collecting point cloud data of the spreader relative to each position (x, y, z) of the vehicle and whether the spreader grabs a container, and recording the spreader position value and the spreader container-grabbing state value corresponding to each point cloud set; storing the point cloud sets in a tree-type topology according to the true value condition as a comparison point cloud set.

[0123] Step 54, 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.

[0124] Step 55, performing point cloud matching between the point cloud in step 54 and the comparison point cloud set in step 53, using the previous frame matching

result as the starting matching point, extracting the comparison point cloud group from the tree-type comparison point cloud set according to a set threshold, using the ICP method to obtain each difference value between the detected point cloud and the comparison point cloud group, obtaining the matching result based on the magnitude of the difference value and the preset threshold, and obtaining the detected position (x, y, z) and container-grabbing state of the spreader based on the matching result.

[0125] Step 56, 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.

[0126] The technical solutions and technical effects of the embodiments shown in FIG. 4 and FIG. 5 are similar to those of the above embodiments, and are not described in detail herein.

[0127] 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.

[0128] FIG. 6 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. 6, the apparatus is applied to a vehicle and includes:

an acquiring module 61, configured for acquiring first point cloud data of a region above the vehicle;

a determining module 62, configured for determining, according to the first point cloud data, target position information and target grabbing state of a spreader in a lifting device from a pre-determined point cloud mapping relationship, where the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader; and

a controlling module 63, configured for controlling a moving and stopping state of the vehicle according to the target position information and the target grabbing

state.

[0129] In one or more embodiments, the determining module 62 is specifically configured for:

matching, according to the first point cloud data, point cloud data with a difference value smaller than a first preset threshold from the point cloud mapping relationship, and using the position information and the grabbing state corresponding to the point cloud data with the difference value smaller than the first preset threshold as the target position information and the target grabbing state of the spreader.

[0130] In one or more embodiments, the lifting device is a device with a beam-type structure;

correspondingly, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the determining module 62 is further configured for:

acquiring second point cloud data located in a region of interest of the spreader in the lifting device from the first point cloud data, and using the second point cloud data as new first point cloud data; where the region of interest of the spreader is determined based on third point cloud data of a beam of the lifting device and information of a lane in which the vehicle is located.

[0131] In one or more embodiments, before acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the determining module 62 is further configured for:

acquiring third point cloud data of the beam of the lifting device;

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 the information of the lane in which the vehicle is located and the vertical plane equation of the beam.

[0132] In one or more embodiments, after acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the determining module 62 is further configured for:

performing clustering processing on the point clouds in the second point cloud data, to obtain different types of point clouds; and

updating the point clouds in the second point cloud data to point clouds of non-clutter point types among all the types.

[0133] In one or more embodiments, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the determining module 62 is further configured for:

performing clustering processing on the first point cloud data according to a positional relationship of the point clouds, to obtain different types of point clouds; and

updating the point clouds in the first point cloud data to point clouds of non-clutter point types among all the types according to the information of the lane in which the vehicle is located.

[0134] In one or more embodiments, the determining module 62 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.

[0135] 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.

[0136] 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.

[0137] FIG. 7 is a schematic structural diagram of a vehicle provided by an embodiment of the present application. As shown in FIG. 7, the vehicle may include: a processor 71, a memory 72, and computer program instructions stored in the memory 72 and executable on the processor 71, where when the processor 71 executes the computer program instructions, the method provided in any one of the preceding embodiments is implemented.

[0138] Optionally, the above various devices of the vehicle may be connected through a system bus.

[0139] The memory 72 may be a separate storage unit, or may be a storage unit integrated in the processor 71. The number of processors 71 is one or more.

[0140] It should be understood that the processor 71 may be a central processing unit (CPU), and may also be other general-purpose processors 71, a digital signal processor (DSP) 71, an application specific integrated circuit (ASIC), etc. The general-purpose processor 71 may be a microprocessor 71 or the processor 71 may also be any conventional processor 71 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 71, or executed by a combination of hardware and software modules in the processor 71.

[0141] 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 72 may include a random access memory (RAM) 72, and may also include a non-volatile memory (NVM) 72, such as at least one disk memory 72.

[0142] 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 72. When the program is executed, it executes the steps including the above method embodiments; and the aforementioned memory 72 (storage medium) includes: a read-only memory (ROM) 72, a RAM, a flash memory 72, a hard disk, a solid-state hard disk, a magnetic tape, a floppy disk, an optical disc, and any combination thereof.

[0143] 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.

[0144] 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.

[0145] 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.

[0146] 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.

[0147] 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.

[0148] 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 vertical transport target in a port, 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, target position information and target grabbing state of a spreader in a lifting device from a pre-determined point cloud mapping relationship, wherein the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader; and

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

2. The method according to claim 1, wherein determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship comprises:

matching, according to the first point cloud data, point cloud data with a difference value smaller than a first preset threshold from the point cloud mapping relationship, and using the position information and the grabbing state corresponding to the point cloud data with the difference value smaller than the first preset threshold as the target position information and the target grabbing state of the spreader.

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

correspondingly, before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the method further comprises:

acquiring second point cloud data located in a region of interest of the spreader in the lifting device from the first point cloud data, and using the second point cloud data

as new first point cloud data, wherein the region of interest of the spreader is determined based on third point cloud data of a beam of the lifting device and information of a lane in which the vehicle is located.

4. The method according to claim 3, wherein before acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the method further comprises:

acquiring third point cloud data of the beam of the lifting device;

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 the information of the lane in which the vehicle is located and the vertical plane equation of the beam.

5. The method according to claim 3, wherein after acquiring the second point cloud data located in the region of interest of the spreader in the lifting device from the first point cloud data, the method further comprises:

performing clustering processing on the point clouds in the second point cloud data, to obtain different types of point clouds; and

updating the point clouds in the second point cloud data to point clouds of non-clutter point types among all the types.

6. The method according to claim 1 or 2, wherein before determining, according to the first point cloud data, the target position information and the target grabbing state of the spreader in the lifting device from the pre-determined point cloud mapping relationship, the method further comprises:

performing clustering processing on the first point cloud data according to a positional relationship of the point clouds, to obtain different types of point clouds; and

updating the point clouds in the first point cloud data to point clouds of non-clutter point types among all the types according to the information of the lane in which the vehicle is located.

7. The method according to claim 1 or 2, 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 vertical transport target in a port, 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 determining module, configured for determining, according to the first point cloud data, target position information and target grabbing state of a spreader in a lifting device from a pre-determined point cloud mapping relationship, wherein the point cloud mapping relationship records point cloud data corresponding to different position information and different grabbing states of the spreader; and

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