

**DISTANCE MEASUREMENT METHOD, APPARATUS, DEVICE,
VEHICLE, STORAGE MEDIUM, AND PROGRAM PRODUCT**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of and priority to
5 Chinese patent application No. 202510095133.X, titled “DISTANCE
MEASUREMENT METHOD, APPARATUS, DEVICE, VEHICLE, STORAGE
MEDIUM, AND PROGRAM PRODUCT”, filed with China National Intellectual
Property Administration on January 21, 2025, the content of the aforementioned
application is incorporated herein by reference in its entirety.

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TECHNICAL FIELD

[0002] The present application relates to, but is not limited to, the field of
autonomous driving, for example, to a distance measurement method, apparatus,
device, vehicle, storage medium, and program product.

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BACKGROUND

[0003] In the field of autonomous driving, a charge-coupled device (CCD)
is a detection sensor used in intelligent driving. The core functions of a vision
system constructed with a CCD include target detection and distance
20 measurement for detected targets.

SUMMARY

[0004] The following is an overview of the subject matter described in detail herein. This overview is not intended to limit the scope of the claims.

[0005] Embodiments of the present disclosure provide a distance
5 measurement method, an apparatus, a device, a vehicle, a storage medium, and a program product, which can improve the problem of low distance measurement accuracy for distant targets.

[0006] The technical solutions adopted by the embodiments of the present disclosure are as follows.

10 [0007] A distance measurement method includes:

[0008] obtaining a first distance-measurement range between one or more first targets in a first image frame and a vehicle, and a second distance-measurement range between the first target in a second image frame and the vehicle, where the first image frame and the second image frame are sequentially
15 captured by an image capture device mounted on the vehicle during travel of the vehicle;

[0009] determining a distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range;

20 [0010] determining, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, a second predicted size of a second target according to a size relationship between

the first target and the second target detected in the second image frame, and a first predicted size of the first target, where the second distance-measurement range is determined according to the first predicted size; and

[0011] determining a first target distance-measurement range between the
5 second target in the second image frame and the vehicle according to the second predicted size and detection box information of the second target in the second image frame.

[0012] With the above technical means, the second predicted size of the second target is inferred according to the first predicted size of the first target with
10 a credible distance-measurement confidence state and the size relationship between the first target and the second target, and then the first target distance-measurement range between the second target and the vehicle is inferred according to the second predicted size. In this way, since the second distance-measurement range of the first target is credible and the second distance-measurement range of the first target is determined according to the first predicted
15 size, the first predicted size can also be considered credible. Therefore, a relatively accurate second predicted size can be inferred according to the first predicted size and the size relationship between the first target and the second target, so that the first target distance-measurement range between the second target and the vehicle
20 can be inferred relatively accurately based on the second predicted size, reducing the distance measurement error of the second target.

[0013] In some embodiments, the first target includes a first traffic cone, where the second target includes a second traffic cone; where determining the

second predicted size of the second target according to the size relationship between the first target and the second target detected in the second image frame, and the first predicted size of the first target, includes:

[0014] determining, when the size relationship indicates that the first
5 traffic cone and the second traffic cone have a same size specification, the first predicted size as the second predicted size; where the first predicted size and the second predicted size correspond to a same size parameter, and the size parameter includes a height parameter and/or a width parameter.

[0015] With the above technical means, when the size relationship
10 indicates that the first traffic cone and the second traffic cone have the same size specification, the first predicted size is determined as the second predicted size. In this way, the overall distance measurement efficiency can be improved on the basis of increasing the distance-measurement confidence state of the first target distance-measurement range, and the distance measurement task can be
15 completed timely and accurately.

[0016] In some embodiments, the detection box information includes a detection box size and a detection box position; where determining the first target distance-measurement range between the second target in the second image frame and the vehicle according to the second predicted size and the detection box
20 information of the second target in the second image includes:

[0017] determining a longitudinal distance-measurement range between the second target in the second image frame and the vehicle according to an internal parameter of the image capture device, the second predicted size, and the

detection box size of the second target in the second image frame;

[0018] determining a lateral distance-measurement range between the second target in the second image frame and the vehicle according to the internal parameter, the detection box position of the second target in the second image frame, and the longitudinal distance-measurement range; and

[0019] determining the first target distance-measurement range according to the longitudinal distance-measurement range and the lateral distance-measurement range.

[0020] With the above technical means, the longitudinal distance-measurement range and the lateral distance-measurement range between the second target in the second image frame and the vehicle are respectively determined according to the internal parameter of the image capture device, and the first target distance-measurement range is determined according to the longitudinal distance-measurement range and the lateral distance-measurement range. In this way, on the basis of increasing the accuracy of the longitudinal distance-measurement value, the accuracy of the lateral distance-measurement value determined by the longitudinal distance-measurement value is increased, and the accuracy of the first target distance-measurement range is improved.

[0021] In some embodiments, the first target includes a first traffic cone, where the second target includes a second traffic cone; where determining the first target distance-measurement range according to the longitudinal distance-measurement range and the lateral distance-measurement range includes:

[0022] determining coordinates of a plurality of edge points at a bottom of the second traffic cone according to the longitudinal distance-measurement range and the lateral distance-measurement range;

[0023] determining coordinates of a center point at the bottom of the second traffic cone according to the coordinates of the plurality of edge points; and

[0024] determining the first target distance-measurement range according to the coordinates of the center point.

[0025] With the above technical means, the coordinates of the plurality of edge points at the bottom of the second traffic cone are determined according to the longitudinal distance-measurement range and the lateral distance-measurement range, the coordinates of the center point at the bottom of the second traffic cone are determined according to the coordinates of the plurality of edge points, and then the first target distance-measurement range is determined according to the coordinates of the center point. In this way, a coordinate for distance measurement between the second traffic cone and the vehicle can be determined based on the coordinates of the plurality of edge points of the second traffic cone, improving the accuracy of the distance measurement result.

[0026] In some embodiments, determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range includes:

[0027] determining a distance measurement variation corresponding to

the second image frame according to a difference between the first distance-measurement range and the second distance-measurement range; and

[0028] determining the distance-measurement confidence state of the first target according to the distance measurement variation corresponding to the second image frame and a vehicle movement distance corresponding to the second image frame, where the vehicle movement distance corresponding to the second image frame is a movement distance of the vehicle during a capture interval between the first image frame and the second image frame.

[0029] With the above technical means, the distance measurement variation corresponding to the second image frame is determined according to the difference between the first distance-measurement range and the second distance-measurement range, and the distance-measurement confidence state of the first target is determined according to the distance measurement variation corresponding to the second image frame and the vehicle movement distance corresponding to the second image frame. In this way, comprehensively considering the difference between the distance measurement ranges of the first target in different image frames and the vehicle movement distance during the capture interval of the corresponding image frames, the accuracy of determining the distance-measurement confidence state of the first target can be improved.

[0030] In some embodiments, the first image frame is a previous frame of the second image frame; where determining the distance-measurement confidence state of the first target according to the distance measurement variation corresponding to the second image frame and the vehicle movement distance

corresponding to the second image frame includes:

[0031] determining a distance measurement variation and a vehicle movement distance respectively corresponding to at least one historical image frame, where the distance measurement variation corresponding to the historical
5 image frame is determined according to a difference between a first historical distance-measurement range of the first target in the historical image frame and a second historical distance-measurement range of the first target in a previous frame of the historical image frame, and the vehicle movement distance corresponding to the historical image frame is a movement distance of the vehicle
10 during a capture interval between the historical image frame and the previous frame of the historical image frame; and

[0032] determining the distance-measurement confidence state of the first target according to distance measurement variations and vehicle movement distances respectively corresponding to a plurality of target image frames, where
15 the plurality of target image frames includes the at least one historical image frame and the second image frame.

[0033] With the above technical means, the distance-measurement confidence state of the first target is determined according to the distance measurement variations and the vehicle movement distances respectively
20 corresponding to the plurality of target image frames; where the plurality of target image frames include the at least one historical image frame and the second image frame. In this way, comprehensively considering the distance measurement variation and the vehicle movement distance respectively corresponding to each

target image frame, the accuracy of determining the distance-measurement confidence state of the first target can be improved.

[0034] In some embodiments, determining the distance-measurement confidence state of the first target according to the distance measurement variations and the vehicle movement distances respectively corresponding to the plurality of target image frames includes:

[0035] determining, when the distance measurement variations and the vehicle movement distances respectively corresponding to the plurality of target image frames satisfy a target confidence condition, the distance-measurement confidence state of the first target as a first state indicating that the second distance-measurement range is credible, where the target confidence condition includes at least one of the following:

[0036] a sum of the distance measurement variations respectively corresponding to the plurality of target image frames is less than a first target-distance threshold, where the first target-distance threshold is determined according to a sum of the vehicle movement distances respectively corresponding to the plurality of target image frames;

[0037] a difference between the distance measurement variation and the vehicle movement distance respectively corresponding to each of the plurality of target image frames is less than a distance difference threshold;

[0038] where for each of the plurality of target image frames, the distance measurement variation and the vehicle movement distance respectively

corresponding to the target image frame are both positive numbers or both negative numbers.

[0039] With the above technical means, when the distance measurement variations and the vehicle movement distances respectively corresponding to the plurality of target image frames satisfy the target confidence condition, the distance-measurement confidence state of the first target is determined as the first state indicating that the second distance-measurement range is credible. In this way, on the one hand, whether the sum of the distance measurement variations respectively corresponding to each target image frame is credible can be determined according to the sum of the distance measurement variations respectively corresponding to each target image frame and the sum of the corresponding vehicle movement distances; on the other hand, whether the value of the distance measurement variation of each target image frame is credible can be determined according to the difference between the distance measurement variation corresponding to each target image frame and the corresponding vehicle movement distance; furthermore, whether the direction of the distance measurement variation of each target image frame is reasonable can be determined according to whether the positive and negative signs of the distance measurement variation corresponding to each target image frame and the corresponding vehicle movement distance are consistent. Thus, on the basis of improving the accuracy of the distance-measurement confidence state of the first target, various distance measurement scenarios and requirements are flexibly adapt to.

[0040] In some embodiments, the distance measurement method further includes:

[0041] determining, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible,
5 a third distance-measurement range between the first target in a third image frame and the vehicle according to the second distance-measurement range and a movement distance of the vehicle during a capture interval between the third image frame and the second image frame, where the second image frame and the third image frame are sequentially captured by the image capture device during
10 travel of the vehicle.

[0042] With the above technical means, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, the third distance-measurement range between the first target in the third image frame and the vehicle is determined according to the movement
15 distance of the vehicle during the capture interval between the third image frame and the second image frame, and the second distance-measurement range; and the second image frame and the third image frame are sequentially captured by the image capture device during travel of the vehicle. In this way, when the distance-measurement confidence state of the first target is credible, the workload of
20 distance measurement for the first target in the third image frame captured after the second image frame can be reduced, and the distance measurement efficiency can be improved on the basis of increasing the distance measurement accuracy of the first target.

[0043] In some embodiments, obtaining the second distance-measurement range between the first target in the second image frame and the vehicle includes:

[0044] determining the first predicted size according to an external
5 parameter of the image capture device and detection box coordinates of the first target in the second image frame; and

[0045] determining the second distance-measurement range according to
the first predicted size, a detection box size of the first target in the second image
frame, and the detection box coordinates of the first target in the second image
10 frame.

[0046] With the above technical means, the first predicted size is
determined according to the external parameter of the image capture device and
the detection box coordinates of the first target in the second image frame, and
then the second distance-measurement range is determined according to the first
15 predicted size, the detection box size of the first target in the second image frame,
and the detection box coordinates of the first target in the second image frame. In
this way, the accuracy of the obtained second distance-measurement range can be
improved.

[0047] In some embodiments, the first target includes a first traffic cone,
20 where the second target includes a second traffic cone; where determining the first
predicted size according to the external parameter of the image capture device and
the detection box coordinates of the first target in the first image frame includes:

[0048] determining a first candidate size of the first traffic cone according to the external parameter of the image capture device and detection box coordinates of the first traffic cone in the first image frame;

[0049] determining a detection box aspect ratio of the first traffic cone in
5 the second image frame;

[0050] determining a second candidate size corresponding to the detection box aspect ratio from a preset traffic-cone size set; and

[0051] determining the first predicted size according to the first candidate size and the second candidate size.

10 [0052] With the above technical means, the first candidate size of the first traffic cone is determined according to the external parameter of the image capture device and the detection box coordinates of the first traffic cone in the first image frame; the detection box aspect ratio of the first traffic cone in the second image frame is determined; then the second candidate size corresponding to the detection
15 box aspect ratio is determined from the preset traffic-cone size set, and the first predicted size is determined according to the first candidate size and the second candidate size. In this way, the rationality and accuracy of the first predicted size of the first traffic cone can be improved based on a plurality of candidate sizes.

[0053] In some embodiments, determining the first predicted size
20 according to the first candidate size and the second candidate size includes one of the following:

[0054] determining the second candidate size as the first predicted size

when a difference between the first candidate size and the second candidate size is greater than a size difference threshold; and;

[0055] determining the first candidate size as the first predicted size when a difference between the first candidate size and the second candidate size is not greater than the size difference threshold.

[0056] With the above technical means, the first predicted size is determined from the first candidate size and the second candidate size based on the size difference threshold and the magnitude relationship of the difference between the first candidate size and the second candidate size. In this way, when the difference between the first candidate size and the second candidate size is greater than the size difference threshold, the first candidate size is considered not credible, and the second candidate size in the more credible preset target size set is determined as the first predicted size; when the difference is not greater than the size difference threshold, the first candidate size is considered relatively credible; and the first candidate size, determined based on the first image frame and more suitable for the scenario, is determined as the first predicted size, which can improve the accuracy and rationality of the first predicted size.

[0057] In some embodiments, a plurality of the first targets are presented; where before determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range, the method further includes:

[0058] determining a layout type of targets in the second image frame according to distribution information of each of the targets detected in the second

image frame;

[0059] determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range includes:

- 5 [0060] determining, for each of the first targets, the distance-measurement confidence state of the first target when the layout type is dense arrangement according to the first distance-measurement range and the second distance-measurement range corresponding to the first target.

[0061] With the above technical means, the layout type of targets in the
10 second image frame is determined according to distribution information of each target detected in the second image frame; and for each first target, the distance-measurement confidence state of the first targets is determined according to the first distance-measurement range and the second distance-measurement range corresponding to the first target when the layout type is dense arrangement. In this
15 way, the distance-measurement confidence states of a plurality of first targets can be analyzed in a dense arrangement scenario of targets, so that a more accurate second predicted size can be determined based on the first predicted sizes of the plurality of first targets with credible distance measurements, thereby improving the accuracy of distance measurement for the second target.

20 [0062] In some embodiments, a difference between a distance measurement variation corresponding to a target image frame and a vehicle movement distance corresponding to the target image frame is less than a target difference threshold; where the target image frame includes the second image

frame or a historical image frame captured before the second image frame, where the distance measurement variation corresponding to the target image frame is determined according to a difference between a first historical distance-measurement range of the first target in the target image frame and a second
5 historical distance-measurement range of the first target in a previous frame of the target image frame, and the vehicle movement distance corresponding to the target image frame is a movement distance of the vehicle during a capture interval between the target image frame and the previous frame of the target image frame.

[0063] With the above technical means, the difference between the
10 distance measurement variation corresponding to the target image frame and the vehicle movement distance corresponding to the target image frame is less than the target difference threshold, which indicates that the distance measurement for each of the first targets is more credible. Therefore, a more accurate second predicted size can be determined based on the first predicted sizes of the plurality
15 of first targets with more credible distance measurements, so as to improve the accuracy of distance measurement for the second target.

[0064] In some embodiments, the distance measurement method further includes:

[0065] obtaining a third image frame when the distance-measurement
20 confidence state of the first target indicates that the second distance-measurement range is not credible;

[0066] determining, when third distance-measurement ranges between a plurality of third targets in the third image frame and the vehicle are less than a

target distance threshold, third predicted sizes of the plurality of third targets; and

[0067] determining a second target distance-measurement range between
a fourth target in the third image frame and the vehicle according to the third
predicted sizes and detection box information of the fourth target in the third
5 image frame.

[0068] With the above technical means, when the distance-measurement
confidence state of the first target indicates that the second distance-measurement
range is not credible, the third image frame is obtained; when the third distance-
measurement ranges between the plurality of third targets in the third image frame
10 and the vehicle are less than the target distance threshold, the third predicted sizes
of the plurality of third targets are determined; and the second target distance-
measurement range between the fourth target in the third image frame and the
vehicle is determined according to the third predicted sizes and the detection box
information of the fourth target in the third image frame. In this way, predicting
15 the fourth target based on the third targets close to the vehicle can improve the
accuracy of distance measurement for the fourth target when the first target is not
credible.

[0069] In some embodiments, the distance measurement method further
includes:

20 [0070] determining a relative positional relationship of the second target
with respect to a lane line point in the second image frame, and a lane distance-
measurement range between the lane line point in the second image frame and the
vehicle; and

[0071] updating the first target distance-measurement range according to the relative positional relationship and the lane distance-measurement range.

[0072] With the above technical means, the relative positional relationship of the second target with respect to the lane line point in the second
5 image frame, and the lane distance-measurement range between the lane line point in the second image frame and the vehicle are determined; then the first target distance-measurement range is updated according to the relative positional relationship and the lane distance-measurement range. In this way, based on the position of the lane line point in the second image frame, the distance
10 measurement error of the second target can be reduced, and the authenticity and accuracy of the first target distance-measurement range can be improved.

[0073] A distance measurement apparatus includes:

[0074] a first acquisition station, configured to obtain a first distance-measurement range between a first target in a first image frame and a vehicle, and
15 a second distance-measurement range between the first target in a second image frame and the vehicle, where the first image frame and the second image frame are sequentially captured by an image capture device mounted on the vehicle during travel of the vehicle;

[0075] a first determination station, configured to determine a distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range;

[0076] a second determination station, configured to, when the distance-

measurement confidence state of the first target indicates that the second distance-measurement range is credible, determine a second predicted size of a second target according to a size relationship between the first target and the second target detected in the second image frame, and a first predicted size of the first target, where the second distance-measurement range is determined according to the first predicted size; and

[0077] a third determination station, configured to determine a first target distance-measurement range between the second target in the second image frame and the vehicle according to the second predicted size and detection box information of the second target in the second image frame.

[0078] With the above technical means, the second predicted size of the second target is inferred according to the first predicted size of the first target with a credible distance-measurement confidence state and the size relationship between the first target and the second target, and then the first target distance-measurement range between the second target and the vehicle is inferred according to the second predicted size. In this way, since the second distance-measurement range of the first target is credible and the second distance-measurement range of the first target is determined according to the first predicted size, the first predicted size can also be considered credible. Therefore, a relatively accurate second predicted size can be inferred according to the first predicted size and the size relationship between the first target and the second target, so that the first target distance-measurement range between the second target and the vehicle can be inferred relatively accurately based on the second predicted size, reducing

the distance measurement error of the second target.

[0079] An electronic device includes a processor and a memory storing computer instructions executable on the processor, where the processor is configured to implement the above distance measurement method when executing
5 the computer instructions.

[0080] A vehicle includes the above electronic device.

[0081] A computer-readable storage medium stores computer instructions executable by a processor to implement the above distance measurement method.

[0082] A computer program product includes computer instructions that,
10 when executed by a processor, implement part or all of the steps of the above distance measurement method.

[0083] Beneficial effects of embodiments of the present disclosure:

[0084] a relatively accurate second predicted size can be inferred based on the credible first predicted size and the size relationship between the first target
15 and the second target, so that the first target distance-measurement range between the second target and the vehicle can be inferred relatively accurately based on the second predicted size, reducing the distance measurement error of the second target;

[0085] when the first target includes a first traffic cone, the second target
20 includes a second traffic cone, and the size relationship indicates that the first traffic cone and the second traffic cone have the same size specification, the first predicted size is determined as the second predicted size. In this way, the overall

distance measurement efficiency can be improved on the basis of increasing the distance-measurement confidence state of the first target distance-measurement range, and the distance measurement task can be completed timely and accurately;

[0086] on the basis of increasing the accuracy of the longitudinal distance-measurement value, the accuracy of the lateral distance-measurement value determined by the longitudinal distance-measurement value is increased, and the accuracy of the first target distance-measurement range is improved;

[0087] when the first target includes a first traffic cone and the second target includes a second traffic cone, a coordinate for distance measurement between the second traffic cone and the vehicle can be determined based on coordinates of a plurality of edge points of the second traffic cone, improving the accuracy of the distance measurement result;

[0088] comprehensively considering the difference between the distance measurement ranges of the first target in different image frames and the vehicle movement distance during the capture interval of the corresponding image frames, the accuracy of determining the distance-measurement confidence state of the first target can be improved;

[0089] on the basis of improving the accuracy of the distance-measurement confidence state of the first target, various distance measurement scenarios and requirements are flexibly adapt to;

[0090] when the distance-measurement confidence state of the first target is credible, the workload of distance measurement for the first target in the third

image frame captured after the second image frame can be reduced, and the distance measurement efficiency can be improved on the basis of increasing the distance measurement accuracy of the first target;

[0091] when the first target includes a first traffic cone and the second
5 target includes a second traffic cone, the rationality and accuracy of the first predicted size of the first traffic cone can be improved based on a plurality of candidate sizes;

[0092] when the difference between the first candidate size and the second
candidate size is greater than the size difference threshold, the second candidate
10 size in the preset target size set is determined as the first predicted size; when the difference is not greater than the size difference threshold, the first candidate size, determined based on the first image frame and more adapted to the scenario, is determined as the first predicted size, which can improve the accuracy and rationality of the first predicted size;

[0093] in a dense arrangement scenario of targets, the distance-
measurement confidence states of a plurality of first targets are analyzed, so that
a more accurate second predicted size can be determined based on the first
predicted sizes of the plurality of first targets with credible distance
measurements, thereby improving the accuracy of distance measurement for the
20 second target;

[0094] a more accurate second predicted size can be determined based on
the first predicted sizes of the plurality of first targets with more credible distance
measurements, so as to improve the accuracy of distance measurement for the

second target;

[0095] when the first target is not credible, predicting the fourth target based on the third targets close to the vehicle can improve the accuracy of distance measurement for the fourth target;

5 [0096] based on the position of the lane line point in the second image frame, the distance measurement error of the second target can be reduced, and the authenticity and accuracy of the first target distance-measurement range can be improved.

[0097] Other aspects can be understood upon reading and understanding
10 the accompanying drawings and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0098] FIG. 1A is a schematic flowchart for implementing a distance measurement method provided by embodiments of the present disclosure;

15 [0099] FIG. 1B is a schematic structural diagram of an external parameter grid provided by embodiments of the present disclosure;

[0100] FIG. 1C is a schematic structural diagram of a vehicle coordinate system provided by embodiments of the present disclosure;

[0101] FIG. 1D is a schematic diagram of bounding box coordinates of a
20 target provided by embodiments of the present disclosure;

[0102] FIG. 1E is a schematic diagram of the principle of pinhole imaging

for distance measurement provided by embodiments of the present disclosure;

[0103] FIG. 1F is a schematic structural diagram of edge points at the bottom of a traffic cone provided by embodiments of the present disclosure;

[0104] FIG. 1G is a schematic scenario diagram of a positional
5 relationship between a lane line and a target provided by embodiments of the present disclosure;

[0105] FIG. 1H is a schematic coordinate diagram of a positional relationship between a lane line and a target provided by embodiments of the present disclosure;

10 [0106] FIG. 2 is a schematic flowchart for implementing a traffic cone distance-measurement method provided by embodiments of the present disclosure;

[0107] FIG. 3 is a schematic structural diagram of a distance measurement apparatus provided by embodiments of the present disclosure;

15 [0108] FIG. 4 is a schematic structural diagram of an electronic device provided by embodiments of the present disclosure.

DETAILED DESCRIPTION

[0109] Hereinafter, embodiments of the present application will be
20 described with reference to the accompanying drawings and embodiments. Those skilled in the art can readily understand other advantages and effects of the present

application from the disclosure in the present specification. The present application may be implemented or applied in other different embodiments, and various modifications or changes may be made to the details in the present specification based on different viewpoints and applications without departing
5 from the embodiments of the present disclosure. The embodiments are merely illustrative of the present application and are not intended to limit the scope of protection thereof.

[0110] The diagrams provided in the following embodiments are merely schematic illustrations of the basic concept of the present application, so the
10 diagrams only show the components related to the present application instead of being drawn according to the number, shape and size of the components in actual implementation. The form, number and proportion of each component in actual implementation may be arbitrarily changed, and the layout form of the components may also be more complex.

15 [0111] In the process of implementing the embodiments of the present disclosure, it has been found that in intelligent driving, for distant targets, the jitter of distance measurement calculation errors is usually large due to vehicle bouncing during travel, target occlusion, or a small calculation range of calibrated external parameters for distant objects, resulting in relatively unreliable distance
20 measurement results.

[0112] When an autonomous driving vehicle measures the longitudinal distance of a traffic cone using monocular vision, it often relies on pre-calibration and measurement using external parameters of the vision system. This

measurement approach is relatively accurate when the distance between the traffic cone and the vehicle is short. However, when the traffic cone is far from the vehicle, due to systematic errors such as road bumps, the distance measurement accuracy of this approach cannot fully meet the requirements of practical application scenarios.

[0113] Monocular vision distance-measurement involves performing continuous multi-frame measurements first, then optimizing the distance measurement accuracy to a certain extent using a specific filter, and finally obtaining the distance measurement result. The distance measurement result of this approach is relatively reliable when the display state of nearby targets is clear and stable. For distant targets, however, due to target bouncing or occlusion, and a small calculation range of calibrated external parameters for distant objects, the calculation error jitter is large, which is not conducive to measurement convergence, thus resulting in relatively unreliable distance measurement results.

[0114] On this basis, embodiments of the present disclosure propose a distance measurement method, which may be executed by an electronic device. The electronic device may refer to a device with data processing capabilities such as a server, a laptop computer, a tablet computer, a desktop computer, a smart television, a set-top box, and a mobile device (e.g., a mobile phone, a portable video player, a personal digital assistant, a dedicated messaging device, a portable game console). As shown in FIG. 1A, the distance measurement method includes the following steps S11 to S14.

[0115] Step S11: Obtaining a first distance-measurement range between a first target in a first image frame and a vehicle, and a second distance-measurement range between the first target in a second image frame and the vehicle. The first image frame and the second image frame are sequentially
5 captured by an image capture device mounted on the vehicle during travel of the vehicle.

[0116] Here, the image capture device may be a device capable of capturing information to generate images, such as at least one of a camera, an infrared camera, a thermal imager, and a depth camera.

10 [0117] The capture moment of the first image frame is earlier than that of the second image frame.

[0118] The first target is a target detectable in both the first image frame and the second image frame, and may include static objects in the scene where the vehicle is located. For example, the target may include, but is not limited to,
15 obstacles, greening facilities, roadside facilities, etc. The obstacles may include, but are not limited to, traffic cones, water barriers, crash barrels, speed bumps, buildings, etc.

[0119] In some embodiments, the first target may include a first obstacle, and the second target may include a second obstacle.

20 [0120] For example, the first target may include a first traffic cone, and the second target may include a second traffic cone.

[0121] The distance measurement range may include a lateral distance and a longitudinal distance between the target and the vehicle determined through calculation.

[0122] In some embodiments, the first distance-measurement range
5 between the first target in the first image frame and the vehicle, and the second distance-measurement range between the first target in the second image frame and the vehicle may be obtained by acquiring prior parameters, and internal parameters and external parameters of the vision system.

[0123] The prior parameters may include common sizes of targets, for
10 example, but are not limited to, the aspect ratio of a traffic cone, the width and height of a water barrier, the length of a speed bump, the height of a building, etc. The vision system includes the image capture device mounted on the vehicle. The internal parameters of the vision system may include parameters of the image capture device, for example, but are not limited to, focal length, principal point
15 coordinates, distortion coefficients, etc. The external parameters of the vision system may be parameters representing the pose information of the image capture device, such as a rotation matrix, a translation vector, etc.

[0124] In some embodiments, internal parameters and external
parameters of the vehicle may be calibrated in advance. The first distance-
20 measurement range between the first target in the first image frame and the vehicle, and the second distance-measurement range between the first target in the second image frame and the vehicle may be obtained based on the calibrated internal parameters and external parameters. In this way, the acquired calibrated

internal parameters can correct distorted images or points to reduce errors. The acquired calibrated external parameters can calculate the display of the grid in the image frame, improving the accuracy of calculating the position information of the target object in the image frame and enhancing the display effect.

5 [0125] As shown in FIG. 1B, a grid 11 calculated using external parameters is displayed in an image frame 10. In this way, the position information of the target object in the image frame 10, such as the lateral or longitudinal distance to the vehicle, can be obtained more accurately based on the grid 11.

10 [0126] In some embodiments, a vehicle coordinate system may be constructed, and the distance measurement range between the first target and the vehicle may be determined based on the coordinates of the first target in the vehicle coordinate system.

15 [0127] Exemplarily, as shown in FIG. 1C, a Vehicle Coordinate System (VCS) of the vehicle may be constructed, with the projection point O of the center of the rear axle of the vehicle on the ground as the origin of the coordinate system. The positive directions of the x-axis, y-axis, and z-axis of the coordinate system point forward, leftward, and upward of the vehicle, respectively.

20 [0128] Step S12: Determining a distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range.

 [0129] Here, the distance-measurement confidence state may represent the confidence level of the first target distance-measurement range.

[0130] In some embodiments, the distance-measurement confidence state of the first target may be determined according to a difference between the first distance-measurement range and the second distance-measurement range.

[0131] For example, when the difference between the first distance-measurement range and the second distance-measurement range is greater than a preset difference threshold, the distance-measurement confidence state of the first target may be determined to be not credible.

[0132] In some embodiments, the distance-measurement confidence state of the first target may be determined according to the difference between the first distance-measurement range and the second distance-measurement range, and a vehicle movement distance corresponding to the capture interval between the first image frame and the second image frame.

[0133] For example, when the difference between the first distance-measurement range and the second distance-measurement range is equal or approximately equal to the vehicle movement distance corresponding to the capture interval between the first image frame and the second image frame, the distance-measurement confidence state of the first target may be determined to be credible.

[0134] In some embodiments, the vehicle movement distance corresponding to the capture interval between the first image frame and the second image frame may be determined according to the vehicle speeds and moments corresponding to the first image frame and the second image frame, respectively.

[0135] In some embodiments, the vehicle movement distance may be the product of the average vehicle speed corresponding to the first image frame and the second image frame, and the duration corresponding to the capture interval between the first image frame and the second image frame.

5 [0136] Exemplarily, the vehicle speed corresponding to the first image frame is $speed_0$, the vehicle speed corresponding to the second image frame is $speed_1$, the timestamp recorded for the first image frame is $time_0$, and the timestamp recorded for the second image frame is $time_1$. The average vehicle speed $speed_{agv}$ corresponding to the first image frame and the second image frame
 10 may be $(speed_0 + speed_1)/2$, the capture interval $time_{span}$ between the first image frame and the second image frame may be $time_1 - time_0$, and the vehicle movement distance may be $speed_{agv} * time_{span}$.

[0137] Step S13: Determining, when the distance-measurement confidence state of the first target indicates that the second distance-measurement
 15 range is credible, a second predicted size of a second target according to a size relationship between the first target and the second target detected in the second image frame, and a first predicted size of the first target. The second distance-measurement range is determined according to the first predicted size.

[0138] Here, the second target is a target detected in the second image
 20 frame that is different from the first target.

[0139] The size relationship between the first target and the second target may be a mapping relationship between the size of the first target and the size of the second target.

[0140] For example, the size relationship between the first target and the second target may include, but is not limited to, one of the following: the first target and the second target have exactly the same size, the first target and the second target are partially identical in size, and the sizes of the first target and the second target are in a proportional relationship.

[0141] The first predicted size may be the true size of the first target obtained through calculation.

[0142] The second predicted size may be the true size of the second target obtained through calculation.

[0143] In some embodiments, the first predicted size may be determined based on detection box information of the first target in the first image frame, and position information of the first target in the vehicle coordinate system obtained through external parameter transformation.

[0144] The detection box information may include bounding box information of the first target in the first image frame, where the bounding box information may include the position, size, etc., of the bounding box.

[0145] Exemplarily, the bounding box coordinates of the first target in the first image frame may be $(M_{top}, M_{left}, M_{right}, M_{bottom})$, where M_{top} , M_{left} , M_{right} , and M_{bottom} are the top coordinate, left coordinate, right coordinate, and bottom coordinate of the bounding box of the first target, respectively. Using internal parameters and external parameters and via the ZHANG Zhengyou calibration formula, combined with multiple points with known horizontal and longitudinal VCS coordinates during calibration, the corresponding external parameter

transformation matrix $H_{\text{cam_gnd}}$ can be obtained for converting points in the image coordinate system to VCS coordinates, where $H_{\text{cam_gnd}} = R \cdot T$; where R is a rotation matrix, and T is a translation vector. The ZHANG Zhengyou calibration formula can be referred to as formula (1):

$$[0146] \quad z_c \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \begin{bmatrix} \frac{f}{dx} & 0 & u_0 & 0 \\ 0 & \frac{f}{dy} & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} R_{3 \times 3} & T_{3 \times 1} \\ 0^T & 1 \end{bmatrix} \begin{pmatrix} x_w \\ y_w \\ z_w \\ 1 \end{pmatrix} \quad (1);$$

[0147] where $\begin{bmatrix} R_{3 \times 3} & T_{3 \times 1} \\ 0^T & 1 \end{bmatrix}$ is the external parameter matrix, and

$\begin{bmatrix} \frac{f}{dx} & 0 & u_0 & 0 \\ 0 & \frac{f}{dy} & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$ is the internal parameter matrix.

[0148] Exemplarily, the coordinates Pt_{img} of a point in the image can be converted to coordinates Pt_{vcs} in the VCS coordinate system using the external parameter transformation matrix $H_{\text{cam_gnd}}$. The approach for converting the coordinates Pt_{img} to the coordinates Pt_{vcs} is shown in formula (2):

$$[0149] \quad Pt_{\text{vcs}} = H_{\text{cam_gnd}} * Pt_{\text{img}} \quad (2).$$

[0150] The coordinates $Pt_{\text{img_lb}}$ and $Pt_{\text{img_rb}}$ of the point l_b corresponding to the lower-left corner and the point r_b corresponding to the lower-right corner of the bounding box of the first target in the first image frame may be represented as $(M_{\text{left}}, M_{\text{bottom}})$ and $(M_{\text{right}}, M_{\text{bottom}})$, respectively.

[0151] As shown in FIG. 1D, the VCS coordinate values of the point l_b corresponding to the lower-left corner and the point r_b corresponding to the lower-right corner of the bounding box of the first target 12 obtained through the external parameter transformation matrix are $Pt_{vcs_lb}(x_{lb}, y_{lb}, z_{lb})$ and $Pt_{vcs_rb}(x_{rb}, y_{rb}, z_{rb})$,
 5 respectively.

[0152] In some embodiments, detection box information of a target in the first image frame may be determined by a target model based on the first image frame.

[0153] For example, a U-Net neural network (a convolutional neural
 10 network for image segmentation) model may be pre-built. The model acquires bounding box information of all targets in the image frame, and determines VCS coordinate values of all targets based on the bounding box information of all targets.

[0154] Step S14: Determining a first target distance-measurement range
 15 between the second target in the second image frame and the vehicle according to the second predicted size and detection box information of the second target in the second image frame.

[0155] Here, the first target distance-measurement range may include a lateral distance and a longitudinal distance between the second target in the
 20 second image frame and the vehicle.

[0156] In some embodiments, according to the principle of pinhole imaging, the first target distance-measurement range between the second target in the second image frame and the vehicle may be determined based on the detection

box of the second target imaged in the second image frame and the actual size of the second target, i.e., the second predicted size.

[0157] It is understandable that when the second distance-measurement range is credible, the first predicted size is credible. Since the second predicted size is determined based on the first predicted size, the second predicted size can be determined to be credible. Therefore, the first target distance-measurement range determined based on the credible second predicted size is credible.

[0158] In embodiments of the present disclosure, the second predicted size of the second target is inferred based on the first predicted size of the first target with a credible distance-measurement confidence state and the size relationship between the first target and the second target, and then the first target distance-measurement range between the second target and the vehicle is inferred based on the second predicted size. In this way, since the second distance-measurement range of the first target is credible and the second distance-measurement range of the first target is determined based on the first predicted size, the first predicted size can also be considered credible. Therefore, a relatively accurate second predicted size can be inferred based on the first predicted size and the size relationship between the first target and the second target, so that the first target distance-measurement range between the second target and the vehicle can be inferred relatively accurately based on the second predicted size, reducing the distance measurement error of the second target.

[0159] It is understandable that the perception accuracy for near targets is generally higher than that for distant targets. The distance measurement method

in the above embodiments can address the issue that the distance measurement accuracy cannot fully meet the requirements of practical application scenarios due to systematic errors such as road bumps when the target is far from the vehicle. That is, in a multi-target scenario, the position of a distant target or nearby target
5 can be inferred from the position of a near target, improving the distance measurement accuracy for distant targets or targets near the near target.

[0160] In some embodiments, determining the second predicted size of the second target according to the size relationship between the first target and the second target detected in the second image frame, and the first predicted size of
10 the first target may include the following step S111:

[0161] Step S111: determining, when the size relationship indicates that the first target and the second target have the same size specification, the first predicted size as the second predicted size. The first predicted size and the second predicted size correspond to a same size parameter, and the size parameter may
15 include a height parameter and/or a width parameter.

[0162] Here, since the first target and the second target in the second image frame have the same size specification, and the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, the first predicted size is credible. The first target distance-
20 measurement range is determined directly based on the second predicted size identical to the first predicted size, which can improve distance measurement efficiency on the basis of increasing the distance-measurement confidence state of the first target distance-measurement range.

[0163] For example, when all targets in the second image frame have the same size specification, the distance measurement ranges of all targets can be determined based on one predicted size.

[0164] In embodiments of the present disclosure, when the size
5 relationship indicates that the first target and the second target have the same size specification, the first predicted size is determined as the second predicted size. In this way, the overall distance measurement efficiency can be improved on the basis of increasing the distance-measurement confidence state of the first target distance-measurement range, and the distance measurement task can be
10 completed timely and accurately.

[0165] In some embodiments, the first target may include a first traffic cone, and the second target may include a second traffic cone. The above step S111 may include the following step S1111:

[0166] Step S1111: determining, when the size relationship indicates that
15 the first traffic cone and the second traffic cone have the same size specification, the first predicted size as the second predicted size. The first predicted size and the second predicted size correspond to a same size parameter, and the size parameter may include a height parameter and/or a width parameter.

[0167] In embodiments of the present disclosure, when the size
20 relationship indicates that the first traffic cone and the second traffic cone have the same size specification, the first predicted size is determined as the second predicted size. In this way, the overall distance measurement efficiency can be improved on the basis of increasing the distance-measurement confidence state of

the first target distance-measurement range, and the distance measurement task can be completed timely and accurately.

[0168] In some embodiments, the detection box information includes a detection box size and a detection box position. The above step S14 may include
5 steps S141 to S143:

[0169] Step S141: Determining a longitudinal distance-measurement range between the second target in the second image frame and the vehicle according to an internal parameter of the image capture device, the second predicted size, and the detection box size of the second target in the second image
10 frame.

[0170] Here, the internal parameter may correspond to the internal parameter in the above distance measurement method.

[0171] As shown in FIG. 1E, taking a traffic cone as an example of a target, the distance relationship between a real traffic cone 21 in the scene and a pixel
15 traffic cone 22 corresponding to the traffic cone 21 on the imaging plane can be obtained according to the principle of pinhole imaging for distance measurement. O_C is the focal point of the image capture device, f_x is the longitudinal focal length between the pixel traffic cone 22 and the focal point O_C , W_{world} is the real width of the traffic cone 21, and D_{world} is the longitudinal actual distance between the
20 traffic cone 21 and the focal point O_C . The approach for determining D_{world} according to the property of similar triangles is shown in formula (3):

$$[0172] \quad D_{world} = W_{world} * f_x / W_{img} \quad (3)$$

[0173] where W_{img} is the pixel width of the traffic cone.

[0174] That is, the internal parameter distance-measurement value dist_{in} corresponding to the distance D_{world} of the traffic cone along the x-axis direction of the vehicle coordinate system is obtained.

[0175] It is understandable that W_{world} in FIG. 1E may correspond to the
 5 predicted size of the target in the above distance measurement method, and W_{img} may correspond to the detection box information of the target. Therefore, the actual distance D_{world} between the target and the focal point of the image capture device, i.e., the distance measurement range between the target and the vehicle, can be determined based on the predicted size and detection box information of
 10 the target.

[0176] When the second distance-measurement range is credible, the first predicted size is credible. Since the second predicted size is determined based on the first predicted size, the second predicted size can be determined to be credible. Therefore, according to formula (3), when W_{img} corresponds to the detection box
 15 information of the second target and W_{world} corresponds to the credible second predicted size of the second target, the determined first target distance-measurement range is credible.

[0177] Step S142: Determining a lateral distance-measurement range between the second target in the second image frame and the vehicle according to
 20 the internal parameter, the detection box position of the second target in the second image frame, and the longitudinal distance-measurement range.

[0178] In some embodiments, a translation transformation matrix between the CCD center of the image capture device and the coordinate system

determined by the vehicle may be determined according to the installation position and internal parameters of the image capture device.

[0179] Exemplarily, the translation transformation matrix may be denoted as T_{Cam2Vcs} . The transformation relationship between any point in the image frame and the coordinate system determined by the vehicle may be determined based on the translation transformation matrix.

[0180] For example, the coordinates of a point in the image frame may be denoted as P_{img} in the image coordinate system, and the coordinates converted into the VCS coordinate system may be denoted as P_{vcs} . The approach for determining P_{vcs} is shown in formula (4):

$$[0181] \quad P_{\text{vcs}} = P_{\text{img}} * T_{\text{Cam2Vcs}} \quad (4)$$

[0182] In some embodiments, the position of the CCD center in the image frame may be acquired according to the calibration parameters of the image capture device, and the position of the target relative to the CCD center may be determined.

[0183] For example, when the coordinates of the CCD center of the camera in the image frame are $\text{Cam}_{\text{img}}(x_{\text{ci}}, y_{\text{ci}})$, the approach for determining the lateral distance coordinate value $y_{\text{wid_dist}_{\text{img}}}$ of the target relative to the CCD center is shown in formula (5):

$$[0184] \quad y_{\text{wid_dist}_{\text{img}}} = x_{\text{ci}} - M_{\text{left}} \quad (5)$$

[0185] According to the principle of pinhole imaging and the property of similar triangles, the approach for determining the lateral distance-measurement value $y_{\text{dist}_{\text{in}}}$ between the target and the vehicle may be shown in formula (6):

$$[0186] \quad y_dist_{in} = dist_{in} * y_wid_dist_{img} / f_y \quad (6)$$

[0187] where y_dist_{in} is the lateral distance-measurement value between the target and the vehicle, i.e., the distance measurement value along the y-axis direction of the vehicle; f_y is the focal length in the height direction.

5 [0188] Step S143: Determining the first target distance-measurement range according to the longitudinal distance-measurement range and the lateral distance-measurement range.

[0189] In some embodiments, the longitudinal distance-measurement range and/or the lateral distance-measurement range may be determined as the
10 first target distance-measurement range, or the first target distance-measurement range may be calculated based on the longitudinal distance-measurement range and/or the lateral distance-measurement range.

[0190] In embodiments of the present disclosure, the longitudinal distance-measurement range and the lateral distance-measurement range between
15 the second target in the second image frame and the vehicle are respectively determined according to the internal parameter of the image capture device, and the first target distance-measurement range is determined according to the longitudinal distance-measurement range and the lateral distance-measurement range. In this way, on the basis of increasing the accuracy of the longitudinal
20 distance-measurement value, the accuracy of the lateral distance-measurement value determined by the longitudinal distance-measurement value is increased, and the accuracy of the first target distance-measurement range is improved.

[0191] It is understandable that distance measurement combining internal and external parameters can address the issue that the distance measurement accuracy is affected by road bump situations when using only external parameters for distance measurement, as well as excessive jitter in distance measurement results caused by directly adopting fixed values to estimate traffic cone sizes when
5 using only internal parameters for distance measurement.

[0192] In some embodiments, the above step S143 may include the following steps S1431 to S1433:

[0193] Step S1431: Determining coordinates of a plurality of edge points
10 at the bottom of the second target according to the longitudinal distance-measurement range and the lateral distance-measurement range.

[0194] Here, the edge points at the bottom of the second target may be points on the outer edge of the bottom of the second target.

[0195] In some embodiments, the first target may include a first traffic
15 cone, and the second target may include a second traffic cone. The above step S1431 may include the following step S14311:

[0196] Step S14311: Determining coordinates of a plurality of edge points at the bottom of the second traffic cone according to the longitudinal distance-measurement range and the lateral distance-measurement range.

20 [0197] As shown in FIG. 1F, taking a second traffic cone as an example of the second target, the x-axis coordinate of the second traffic cone in the second image frame at the midpoint A of the bottom edge of the bounding box under the vehicle coordinate system may be determined based on the longitudinal distance-

measurement range dist_{in} , and the y-axis coordinate of the midpoint of the bottom edge of the second traffic cone may be determined based on the lateral distance-measurement range y_dist_{in} , so as to obtain the VCS coordinate $\text{cb}_{\text{ctr_vcs}}(\text{dist}_{\text{in}}, y_dist_{\text{in}}, 0)$ of point A. Similarly, when the width value of the second predicted
 5 size corresponding to the second traffic cone is W_{world} , the coordinates of the lower-left corner point B, lower-right corner point C, and radius far-end point D of the bounding box of the second traffic cone in the VCS coordinate system may be obtained as $\text{lb}_{\text{vcs}}(\text{dist}_{\text{in}}, y_dist_{\text{in}} - W_{\text{world}}/2, 0)$, $\text{lr}_{\text{vcs}}(\text{dist}_{\text{in}}, y_dist_{\text{in}} + W_{\text{world}}/2, 0)$, and $\text{ct}_{\text{ctr_vcs}}(\text{dist}_{\text{in}} + W_{\text{world}}/2, y_dist_{\text{in}}, 0)$, respectively.

10 [0198] Step S1432: Determining coordinates of a center point at the bottom of the second target according to the coordinates of the plurality of edge points.

[0199] In some embodiments, the coordinates of the center point at the bottom of the second target may be calculated from the coordinates of the plurality
 15 of edge points.

[0200] For example, the average of the coordinates of the plurality of edge points may be determined as the coordinates of the center point at the bottom of the second target.

[0201] In some embodiments, the first target may include a first traffic
 20 cone, and the second target may include a second traffic cone. The above step S1432 may include the following step S14321:

[0202] Step S14321: Determining coordinates of a center point at the bottom of the second traffic cone according to the coordinates of the plurality of edge points.

[0203] Exemplarily, the average of the coordinates of points A, B, C, and D in FIG. 1F may be determined as the coordinate value of the center point M.

[0204] In some embodiments, the coordinates of the center point at the bottom of the second target may be determined using a filter based on the coordinates of the plurality of edge points.

[0205] Exemplarily, points A, B, C, and D in FIG. 1F may be taken as edge points at the bottom of the second traffic cone in the VCS coordinate system. Filtered edge point coordinates $\text{Edgs}_i = (x_i, y_i, z_i)$ of the second traffic cone in the VCS coordinate system may be obtained using an Extended Kalman Filter (EKF), where $i = A, B, C, D$. The approach for determining the VCS coordinate $\text{center}_{\text{vcs}}$ of the center point M of the second traffic cone by averaging the four filtered edge point coordinates may be referred to formula (7):

$$[0206] \quad \text{center}_{\text{vcs}} = \sum_{i=A}^4 \frac{(x_i, y_i, z_i)}{4} \quad (7).$$

[0207] Step S1433: Determining the first target distance-measurement range according to the coordinates of the center point.

[0208] Here, the first target distance-measurement range may be determined based on the coordinate value of the center point of the second target.

[0209] For example, the vertical ordinate of the center point of the second traffic cone may be determined as the first target distance-measurement range representing the longitudinal distance-measurement range.

[0210] For another example, the horizontal coordinate of the center point
5 of the second traffic cone may be determined as the first target distance-measurement range representing the lateral distance-measurement range.

[0211] In embodiments of the present disclosure, coordinates of a plurality of edge points at the bottom of the second target are determined according to the longitudinal distance-measurement range and the lateral
10 distance-measurement range; coordinates of a center point at the bottom of the second target are determined according to the coordinates of the plurality of edge points; and the first distance-measurement range is determined according to the coordinates of the center point. In this way, a coordinate for distance measurement between the second target and the vehicle can be determined based on the
15 coordinates of the plurality of edge points of the second target, improving the accuracy of the distance measurement result.

[0212] It is understandable that when the first target includes a first traffic cone and the second target includes a second traffic cone, coordinates of a plurality of edge points at the bottom of the second traffic cone are determined
20 according to the longitudinal distance-measurement range and the lateral distance-measurement range; coordinates of a center point at the bottom of the second traffic cone are determined according to the coordinates of the plurality of edge points; and the first distance-measurement range is determined according to

the coordinates of the center point. In this way, a coordinate for distance measurement between the second traffic cone and the vehicle can be determined based on the coordinates of the plurality of edge points of the second traffic cone, improving the accuracy of the distance measurement result.

5 [0213] In some embodiments, the above step S12 may include the following steps S121 to S122:

 [0214] Step S121: Determining a distance measurement variation corresponding to the second image frame according to a difference between the first distance-measurement range and the second distance-measurement range.

10 [0215] Here, the variation of the distance between the first target and the vehicle during the capture interval between the first image frame and the second image frame, i.e., the distance measurement variation corresponding to the second image frame, may be determined based on the difference between the first distance-measurement range and the second distance-measurement range.

15 [0216] Step S122: Determining a distance-measurement confidence state of the first target according to the distance measurement variation corresponding to the second image frame and a vehicle movement distance corresponding to the second image frame. The vehicle movement corresponding to the second image frame is the movement distance of the vehicle during the capture interval between
20 the first image frame and the second image frame.

 [0217] In some embodiments, the distance-measurement confidence state of the first target may be determined based on a difference between the distance

measurement variation corresponding to the second image frame and the vehicle movement distance corresponding to the second image frame.

[0218] It is understandable that the variation of the distance between the first target and the vehicle during the capture interval between the first image frame and the second image frame is equal or approximately equal to the movement distance of the vehicle during the capture interval between the first image frame and the second image frame.

[0219] In some embodiments, a credible distance-measurement result or a non-credible distance-measurement result may be determined as the distance-measurement confidence state of the first target.

[0220] In some embodiments, a convergence flag may be set to indicate whether the distance measurement result of the first target has converged. The distance-measurement confidence state of the first target may be determined based on whether the distance measurement result of the first target has converged.

[0221] For example, when the convergence flag of the first target is set to true, the distance measurement result of the first target is determined to have converged and be credible; when the convergence flag of the first target is set to false, the distance measurement result of the first target is determined not to have converged and not to be credible.

[0222] In embodiments of the present disclosure, the distance measurement variation corresponding to the second image frame is determined according to the difference between the first distance-measurement range and the second distance-measurement range; and the distance-measurement confidence

state of the first target is determined according to the distance measurement variation corresponding to the second image frame and the vehicle movement distance corresponding to the second image frame. In this way, comprehensively considering the difference between the distance measurement ranges of the first target in different image frames and the vehicle movement distance during the capture interval of the corresponding image frames, the accuracy of determining the distance-measurement confidence state of the first target can be improved.

[0223] In some embodiments, the first image frame is a previous frame of the second image frame, and the above step S122 may include the following steps S1221 to S1222:

[0224] Step S1221: Determining a distance measurement variation and a vehicle movement distance respectively corresponding to at least one historical image frame. The distance measurement variation corresponding to the historical image frame is determined according to a difference between a first historical distance-measurement range of the first target in the historical image frame and a second historical distance-measurement range of the first target in a previous frame of the historical image frame. The vehicle movement distance corresponding to the historical image frame is the movement distance of the vehicle during the capture interval between the historical image frame and the previous frame of the historical image frame.

[0225] Here, the historical image frame may include the first image frame.

[0226] In some embodiments, the distance measurement variation of the historical image frame may be determined based on a difference between the

coordinates of the center point of the first target corresponding to the first historical distance-measurement range in the historical image frame and the coordinates of the center point of the first target corresponding to the second historical distance-measurement range in the previous frame of the historical image frame.

[0227] Step S1222: Determining a distance-measurement confidence state of the first target according to distance measurement variations and vehicle movement distances respectively corresponding to a plurality of target image frames. The plurality of target image frames include at least one historical image frame and the second image frame.

[0228] In some embodiments, the distance-measurement confidence state of the first target may be determined based on a difference between the distance measurement variation and the vehicle movement distance respectively corresponding to each target image frame.

[0229] For example, when the differences between the distance measurement variations and the vehicle movement distances respectively corresponding to target image frames are not greater than a difference threshold, the confidence state of the target image frame is determined to be credible; when the ratio of the number of credible image frames in a plurality of target image frames to the total number of image frames is not less than a ratio threshold, the distance-measurement confidence state of the first target is determined to be credible.

[0230] In embodiments of the present disclosure, the distance-measurement confidence state of the first target is determined according to the distance measurement variations and the vehicle movement distances respectively corresponding to a plurality of target image frames; and a plurality of target image frames include at least one historical image frame and the second image frame. In this way, comprehensively considering the distance measurement variation and the vehicle movement distance respectively corresponding to each target image frame, the accuracy of determining the distance-measurement confidence state of the first target can be improved.

10 [0231] In some embodiments, the above step S1222 may include the following step S12221:

[0232] Step S12221: Determining, when the distance measurement variations and the vehicle movement distances respectively corresponding to a plurality of target image frames satisfy a target confidence condition, the distance-measurement confidence state of the first target as a first state indicating that the second distance-measurement range is credible.

[0233] The target confidence condition includes at least one of the following:

[0234] a sum of the distance measurement variations respectively corresponding to the plurality of target image frames is less than a first target-distance threshold, where the first target-distance threshold is determined according to a sum of the vehicle movement distances respectively corresponding to the plurality of target image frames;

[0235] a difference between the distance measurement variation and the vehicle movement distance respectively corresponding to each target image frame is less than a distance difference threshold;

[0236] for each target image frame, the distance measurement variation
5 and the vehicle movement distance corresponding to the target image frame are both positive numbers or both negative numbers.

[0237] Here, considering calculation errors and other factors, the first target-distance threshold may be calculated based on the sum of the vehicle movement distances respectively corresponding to the target image frames.

10 [0238] For example, the first target-distance threshold may include the sum of the vehicle movement distances respectively corresponding to the target image frames, or 50% of the sum of the vehicle movement distances respectively corresponding to the target image frames.

[0239] At the same time, the vehicle movement distance corresponding to
15 each target image frame corresponds to the distance measurement variation corresponding to the target image frame. The difference between the distance measurement variation and the vehicle movement distance respectively corresponding to each target image frame may represent the distance measurement error corresponding to each target image frame. When the
20 difference is less than the distance difference threshold, the distance measurement error is considered to be less than the error threshold, i.e., the distance measurement result is credible.

[0240] It is understandable that, when retaining the positive and negative signs of the distance measurement variations and the positive and negative signs of the vehicle movement distances corresponding to the target image frames, the positive and negative signs may represent the transformation direction corresponding to each target image frame. When the distance measurement variation and the vehicle movement distance corresponding to the target image frame are both positive numbers or both negative numbers, the distance measurement variation and the vehicle movement distance of the target image frame can be determined as matched and reasonable. Therefore, the accuracy of determining the distance-measurement confidence state of the first target can be improved.

[0241] In embodiments of the present disclosure, when the distance measurement variations and the vehicle movement distances respectively corresponding to a plurality of target image frames satisfy the target confidence condition, the distance-measurement confidence state of the first target is determined as the first state indicating that the second distance-measurement range is credible. In this way, on the one hand, whether the sum of the distance measurement variations respectively corresponding to the target image frames is credible can be determined based on the sum of the distance measurement variations and the sum of the vehicle movement distances respectively corresponding to the target image frames; on the other hand, whether the value of the distance measurement variation of each target image frame is credible can be determined based on the difference between the distance measurement variation and the vehicle movement distance corresponding to each target image frame;

furthermore, whether the direction of the distance measurement variation of each target image frame is reasonable can be determined based on whether the positive and negative signs of the distance measurement variation and the vehicle movement distance corresponding to each target image frame are consistent. Thus, on the basis of improving the accuracy of the distance-measurement confidence state of the first target, various distance measurement scenarios and requirements can be flexibly adapted.

[0242] In some embodiments, the above distance measurement method may further include the following step S15:

10 [0243] Step S15: Determining, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, a third distance-measurement range between the first target in a third image frame and the vehicle according to the second distance-measurement range and a movement distance of during a capture interval between the third
15 image frame and the second image frame. The second image frame and the third image frame are sequentially captured by the image capture device during travel of the vehicle.

[0244] Here, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, the
20 distance measurement variation between the first distance-measurement range and the second distance-measurement range is credible, i.e., the size of the first target and the relative positional relationship of the first target with regard to the vehicle are credible.

[0245] On this basis, when performing distance measurement on the first target in the third image frame with a capture moment after a capture moment of the second image frame, there is no need to recalculate based on the predicted size of the first target. Instead, the position of the first target in the third image frame, 5 i.e. the third distance-measurement range between the first target in the third image frame and the vehicle, can be directly determined based on the position of the first target in the second image frame and the movement distance of the vehicle between the second image frame and the third image frame.

[0246] Exemplarily, the center point coordinate of the first target in the 10 second image frame may be denoted as $center_{last}$, the capture interval between the second image frame and the third image frame may be denoted as $time_{span}$, the average speed of the vehicle during the capture interval between the second image frame and the third image frame may be denoted as $speed_{agv}$, and the center point coordinate of the first target in the third image frame may be denoted as $center_{output}$. 15 The approach for determining $center_{output}$ may refer to Formula (8):

$$[0247] \quad center_{output} = center_{last} - speed_{agv} * time_{span} \quad (8).$$

[0248] In embodiments of the present disclosure, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, the third distance-measurement range between the 20 first target in the third image frame and the vehicle is determined based on the second distance-measurement range and the movement distance of the vehicle during the capture interval between the third image frame and the second image frame. The second image frame and the third image frame are sequentially

captured by the image capture device during travel of the vehicle. In this way, when the distance-measurement confidence state of the first target is credible, the workload of distance measurement for the first target in the third image frame captured after the second image frame can be reduced, and the distance measurement efficiency can be improved on the basis of increasing the distance measurement accuracy of the first target.

[0249] In some embodiments, obtaining the second distance-measurement range between the first target in the second image frame and the vehicle in the above step S11 may include the following steps S112 to S113:

10 [0250] Step S112: Determining the first predicted size based on the external parameters of the image capture device and the detection box coordinates of the first target in the second image frame.

[0251] Here, the external parameters correspond to the external parameters in the above distance measurement method.

15 [0252] In some embodiments, the actual size of the first target in the vehicle-based coordinate system can be obtained as the first predicted size by transforming the detection coordinates of the first target in the second image frame according to the external parameters of the image capture device.

[0253] For example, the difference in the Y-axis direction under the vehicle coordinate system between the lower-right corner point and the lower-left corner point of the detection box for the first target in the second image frame may be determined as the $width_{ex}$ of the first target.

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[0254] Step S113: Determining the second distance-measurement range based on the first predicted size, the detection box size of the first target in the second image frame, and the detection box coordinates of the first target in the second image frame.

5 [0255] In some embodiments, the longitudinal distance-measurement range between the first target in the second image frame and the vehicle can be determined based on the internal parameters of the image capture device, the first predicted size, and the detection box size of the first target in the second image frame; the lateral distance-measurement range between the first target in the
10 second image frame and the vehicle can be determined based on the internal parameters, the detection box coordinates of the first target in the second image frame, and the longitudinal distance-measurement range; the second distance-measurement range can be determined based on the longitudinal distance-measurement range and the lateral distance-measurement range.

15 [0256] In embodiments of the present disclosure, the first predicted size is determined based on the external parameters of the image capture device and the detection box coordinates of the first target in the second image frame; then the second distance-measurement range is determined based on the first predicted size, the detection box size of the first target in the second image frame, and the
20 detection box coordinates of the first target in the second image frame. In this way, the accuracy of the obtained second distance-measurement range can be improved.

[0257] In some embodiments, the above step S112 may include the following steps S1121 to S1124:

[0258] Step S1121: Determining a first candidate size based on the external parameters of the image capture device and the detection box coordinates of the first target in the first image frame.

[0259] Here, the first candidate size may be the initially determined actual
5 size of the first target, such as width_{ex} in step S112.

[0260] In some embodiments, the first target includes a first traffic cone, the second target includes a second traffic cone, and the above step S1121 may include the following step S11211:

[0261] Step S11211: Determining a first candidate size of the first traffic
10 cone based on the external parameters of the image capture device and the detection box coordinates of the first traffic cone in the first image frame.

[0262] Step S1122: Determining the detection box aspect ratio of the first target in the second image frame.

[0263] In some embodiments, the pixel values of the detection box size of
15 the first target in the first image frame can be obtained based on the detection box coordinates of the first target in the first image frame; the detection box aspect ratio of the first target in the second image frame can be determined based on the obtained pixel values of the detection box size of the first target in the first image frame.

[0264] In some embodiments, the first target includes a first traffic cone, the second target includes a second traffic cone, and the above step S1122 may include the following step S11221:

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[0265] Step S11221: Determining the detection box aspect ratio of the first traffic cone in the second image frame.

[0266] Exemplarily, the pixel value W_{img} of the width the first traffic cone can be obtained via the difference between the right coordinate value M_{right} and the left coordinate value M_{left} of the detection box of the first traffic cone in the first image frame, i.e., $M_{right} - M_{left}$; similarly, the pixel value H_{img} of the height of the first traffic cone can be obtained via the difference between the bottom coordinate value M_{bottom} and the top coordinate value M_{top} of the detection box of the first traffic cone in the first image frame, i.e., $M_{bottom} - M_{top}$; the detection box aspect ratio $Ratio_{img_wh}$ of the first traffic cone in the second image frame can be expressed as W_{img} / H_{img} .

[0267] Step S1123: Determining a second candidate size corresponding to the detection box aspect ratio from a preset target size set.

[0268] Here, the preset target size set includes the actual size of at least one target, and a proportional relationship between the width and height of at least one target can be obtained based on the actual size of the target.

[0269] In some embodiments, widths and heights of a set of targets, in the preset target size set, that are equal or approximately equal to the detection box aspect ratio can be determined as the second candidate size.

[0270] In some embodiments, the first target includes a first traffic cone, the second target includes a second traffic cone, and the above step S1123 may include the following step S11231:

[0271] Step S11231: Determining a second candidate size corresponding to the detection box aspect ratio from a preset traffic-cone size set.

[0272] Exemplarily, the preset traffic-cone size set includes a first size combination with a width of 20.5cm and a height of 30cm, and a second size combination with a width of 30cm and a height of 47cm. The aspect ratios corresponding to the first size combination and the second size combination are 0.68 and 0.64, respectively. When the detection box aspect ratio is 0.65, the width and height corresponding to the second size combination can be determined as the second candidate size.

10 [0273] Step S1124: Determining the first predicted size based on the first candidate size and the second candidate size.

[0274] In some embodiments, the first predicted size can be selected from the first candidate size and the second candidate size; or, the first predicted size may also be calculated based on the first candidate size and the second candidate size.

15 size.

[0275] In embodiments of the present disclosure, the first candidate size of the first target is determined based on the external parameters of the image capture device and the detection box coordinates of the first target in the first image frame; the detection box aspect ratio of the first target in the second image frame is determined; then the second candidate size corresponding to the detection box aspect ratio is determined from the preset target size set, and the first predicted size is determined based on the first candidate size and the second

20

candidate size. In this way, the rationality and accuracy of the first predicted size of the first target can be improved based on various candidate sizes.

[0276] It is understandable that when the first target includes a first traffic cone and the second target includes a second traffic cone, the first candidate size of the first traffic cone is determined based on the external parameters of the image capture device and the detection box coordinates of the first traffic cone in the first image frame; the detection box aspect ratio of the first traffic cone in the second image frame is determined; then the second candidate size corresponding to the detection box aspect ratio is determined from the preset traffic-cone size set, and the first predicted size is determined based on the first candidate size and the second candidate size. In this way, the rationality and accuracy of the first predicted size of the first traffic cone can be improved based on various candidate sizes.

[0277] In some embodiments, the above step S1124 may include one of the following steps S11241 to S11242:

[0278] Step S11241: Determining the second candidate size as the first predicted size when the difference between the first candidate size and the second candidate size is greater than a size difference threshold.

[0279] Here, a set of size difference thresholds can be preset. When the difference between the first candidate size and the second candidate size is greater than the size difference threshold, the first candidate size is determined to be not credible, and the second candidate size in the preset traffic-cone size set shall prevail, so as to improve the accuracy of the first predicted size.

[0280] Step S11242: Determining the first candidate size as the first predicted size when the difference between the first candidate size and the second candidate size is not greater than the size difference threshold.

[0281] Here, when the difference between the first candidate size and the second candidate size is not greater than the size difference threshold, the first candidate size is determined to be credible, and the obtained first candidate size is regarded as the first predicted size, so as to improve the adaptability of the distance-measurement range calculation based on the first predicted size.

[0282] Exemplarily, the actual width and/or height of the traffic cone corresponding to $\text{Ratio}_{\text{img_wh}}$ in the preset traffic cone size set may be matched according to the detection box aspect ratio $\text{Ratio}_{\text{img_wh}}$ of the first traffic cone in the second image frame.

[0283] For example, the width in the second candidate size corresponding to the $\text{Ratio}_{\text{img_wh}}$ can be denoted as $\text{width}_{\text{world_pre}}$, and the height can be denoted as $\text{height}_{\text{world_pre}}$. The absolute value of the difference between the width width_{ex} in the first candidate size and the width $\text{width}_{\text{world_pre}}$ in the second candidate size is calculated as $\text{width}_{\text{dif}}$. When $\text{width}_{\text{dif}}$ is greater than a difference threshold δ , $\text{width}_{\text{world_pre}}$ is used as the first predicted size; when $\text{width}_{\text{dif}}$ is not greater than the difference threshold δ , the width_{ex} is used as the first predicted size.

[0284] In embodiments of the present disclosure, the first predicted size is determined from the first candidate size and the second candidate size based on the size difference threshold and the magnitude relationship of the difference between the first candidate size and the second candidate size. In this way, when

the difference between the first candidate size and the second candidate size is greater than the size difference threshold, the first candidate size is determined to be not credible and the second candidate size in the more credible preset traffic cone size set is determined as the first predicted size; when the difference is not

5 greater than the size difference threshold, the first candidate size is determined to be credible, and the first candidate size determined based on a first image frame and having better adaptability to a scenario is determined as the first predicted size, which improves the accuracy and rationality of the first predicted size.

[0285] In some embodiments, a plurality of first targets are provided.

10 Before the above step S12, the above distance measurement method may further include the following step S16:

[0286] Step S16: Determining a layout type of targets in the second image frame based on distribution information of each target detected in the second image frame.

15 [0287] Here, the layout type of the target may include, but is not limited to, discrete layout, dense arrangement layout, etc.

[0288] In some embodiments, distribution information may be determined based on coordinates of each target detected in the second image frame in the image coordinate system.

20 [0289] For example, whether the total number of targets in the second image frame is greater than N may be determined first. When the total number of targets is greater than N, all targets in the second image frame are traversed, and coordinates of the midpoints of the bottom edges of the detection boxes of each

target in the image coordinate system are stored. The stored target coordinates are sorted by bubble sort based on longitudinal coordinate values. According to the sorted target queue, coordinates of the midpoints of the bottom edges of detection boxes of two adjacent targets, i.e., $P_{img_ctr_a}$ and $P_{img_ctr_b}$, are obtained sequentially.

- 5 The Euclidean distance D_{a_b} between the two points is calculated. Width information W_{img_a} and W_{img_b} of the two adjacent targets are obtained respectively.

[0290] When a ratio of the distance D_{a_b} between the two adjacent targets to a sum of widths $W_{img_a} + W_{img_b}$, i.e., $D_{a_b} / (W_{img_a} + W_{img_b})$, is less than a
10 ratio threshold γ , the two targets are determined to be adjacent and to conform to the scene feature of densely arranged targets. When the ratio is not less than the ratio threshold, the two targets are determined to be in a discrete arrangement scene.

[0291] In some embodiments, when the layout type is a discrete
15 arrangement scene, the first target may be determined from all targets based on a distance measurement variation and a vehicle movement distance corresponding to each target in each target image frame.

[0292] Exemplarily, when the layout type is a discrete arrangement scene, a center point value of each target in the vehicle coordinate system, a convergence
20 status bit, and a VCS coordinate output externally may be obtained. The convergence status bit may correspond to the distance-measurement confidence state bit in the above distance measurement method. When the VCS coordinate of a target is calculated for the first time, the VCS coordinate is maintained as an

output coordinate. When the VCS coordinate of a target is not calculated for the first time, the output coordinate is determined based on the convergence status bit of the target.

[0293] When the convergence status bit of the target indicates that the distance measurement state of the target has converged, coordinates of the target in the second image frame may be output directly based on a difference between lateral and longitudinal distances traveled by the vehicle, and a VCS coordinate output in the previous frame of the target, while maintaining the convergence status bit to indicate that the distance measurement state of the target has converged and the distance measurement state of the target is credible. When the convergence status bit of the target indicates that the distance measurement state of the target has not converged, a determination is made as to whether the distance measurement range between the target in each target image frame and the vehicle satisfies a target confidence condition. When the target confidence condition is satisfied, the convergence status bit of the target is set to converged. When the target confidence condition is not satisfied, the convergence status bit of the target is set to not converged, and the distance measurement range of the target is calculated based on other targets that satisfy the target confidence condition.

[0294] In some embodiments, a straight line may be constructed based on positions of center points of the bottoms of traffic cones that satisfy the dense arrangement condition. When a slope of the straight line is less than a slope threshold, the layout type of the traffic cones corresponding to the straight line is determined as a dense arrangement layout.

[0295] For example, a fitted straight line of traffic cones is constructed using a least squares approach. When an absolute value of the slope of the fitted straight line is less than $\tan 10^\circ$, the layout type of the traffic cones is determined as a dense arrangement layout. When the absolute value of the slope of the fitted
5 straight line is not less than $\tan 10^\circ$, a possibility of road closure using traffic cones is determined. In this way, the accuracy of determining the scene and layout type of traffic cones can be improved by combining the positions of traffic cones.

[0296] The above step S12 may include the following step S123:

[0297] Step S123: Determining, for each first target, a distance-
10 measurement confidence state of the first target when the layout type is a dense arrangement based on the first distance-measurement range and the second distance-measurement range corresponding to the first target.

[0298] In some embodiments, when the layout type is a dense arrangement, a plurality of candidate targets may be determined from the second
15 image frame. In each candidate target, when a difference between a distance measurement variation and a vehicle movement distance of each target image frame corresponding to the target is less than a target difference threshold, the candidate target is determined as the first target. Then, the distance-measurement confidence state is determined for each first target based on the first distance-
20 measurement range and the second distance-measurement range corresponding to the first target.

[0299] In embodiments of the present disclosure, the layout type of targets in the second image frame is determined based on distribution information of each

target detected in the second image frame. When the layout type is a dense arrangement, the distance-measurement confidence state of the first target is determined for each first target based on the first distance-measurement range and the second distance-measurement range corresponding to the first target. In this way, the distance-measurement confidence states of a plurality of first targets can be analyzed in a dense arrangement scenario of the targets, so that a more accurate second predicted size can be determined based on the first predicted sizes of a plurality of first targets with credible distance measurements, thereby improving the accuracy of distance measurement for the second target.

[0300] In some embodiments, a difference between a distance measurement variation and a vehicle movement distance corresponding to a target image frame is less than a target difference threshold. The target image frame includes the second image frame or a historical image frame captured before the second image frame. The distance measurement variation corresponding to the target image frame is determined based on a difference between a first historical distance-measurement range of the first target in the target image frame and a second historical distance-measurement range of the first target in a previous frame of the target image frame. The vehicle movement distance corresponding to the target image frame is a movement distance of the vehicle during a capture interval between the target image frame and the previous frame of the target image frame.

[0301] Exemplarily, when the layout type is a dense arrangement, all targets may be traversed to calculate a distance measurement variation D_{del} and a vehicle movement distance $move_{cur}$ corresponding to each target in each target

image frame. When an absolute value of a difference between the D_{del} and $move_{cur}$ of the target is less than a difference threshold, the target is determined as the first target.

[0302] For example, targets with a difference between the distance measurement variation and the vehicle movement distance corresponding to each target image frame less than the target difference threshold may be marked as verifiable targets, and their numbers and existing information may be recorded. Based on coordinate values of the verifiable targets in the vehicle-based coordinate system, three targets that have longitudinal distances to a vehicle of less than 80 meters and are similar in distance to the vehicle (for example, including the closest one) may be selected as first targets. Thus, since the targets are relatively close to the vehicle, distance measurement performed based on the positions of the first targets achieves higher accuracy.

[0303] It is understandable that, with the above distance measurement method, the distance measurement range of near targets relative to the vehicle can be determined based on the sizes of the near targets relative to the vehicle. When the distance measurement range of a near target relative to the vehicle is credible, the distance measurement range between a distant target or a nearby target of the vehicle and the vehicle can be determined based on the mapping relationship between the size of the near target of the vehicle and the size of the distant target or the nearby target of the vehicle. Based on the target information of the near target of the vehicle, the distance measurement accuracy between the distant target or the nearby target of the vehicle and the vehicle can be improved.

[0304] In embodiments of the present disclosure, a difference between a distance measurement variation and a vehicle movement distance corresponding to a target image frame being less than a target difference threshold indicates that distance measurement for the first targets is more credible. Thus, a more accurate
5 second predicted size can be determined based on the first predicted sizes of a plurality of first targets with more credible distance measurement, improving the accuracy of distance measurement for the second target.

[0305] In some embodiments, the above distance measurement method may further include the following steps S124 to S126:

10 [0306] Step S124: Obtaining a third image frame when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is not credible.

[0307] In some embodiments, when the distance-measurement confidence state of the first target indicates that the second distance-measurement
15 range is not credible, the third image frame may be captured after the second image frame is captured. The third image frame may or may not include the first target.

[0308] Step S125: Determine third predicted sizes of a plurality of third targets when third distance-measurement ranges between the plurality of third
20 targets in the third image frame and the vehicle are less than a target distance threshold.

[0309] In some embodiments, when the third distance-measurement ranges between the plurality of third targets in the third image frame and the

vehicle are less than the target distance threshold, the distance-measurement confidence state of each third target may be determined.

[0310] When the distance-measurement confidence state of each third target indicates that the third distance-measurement range is credible, third
5 predicted sizes of the plurality of third targets are determined respectively.

[0311] When the distance-measurement confidence state of each third target indicates that the third distance-measurement range is not credible, third candidate sizes of the plurality of third targets are determined respectively. An average value of the third candidate sizes of the third targets is calculated to obtain
10 a set of third predicted sizes.

[0312] Step S126: Determining a second target distance-measurement range between a fourth target in the third image frame and the vehicle based on the third predicted size and detection box information of the fourth target in the third image frame.

15 [0313] Here, the second target distance-measurement range may include a lateral distance and a longitudinal distance between the fourth target in the third image frame and the vehicle.

[0314] In some embodiments, the second target distance-measurement range between the fourth target in the third image frame and the vehicle may be
20 determined using the principle of pinhole imaging based on the third predicted size and the detection box of the fourth target imaged in the third image frame.

[0315] In embodiments of the present disclosure, when the distance-measurement confidence state of the first target indicates that the second distance-

measurement range is not credible, the third image frame is obtained. When the third distance-measurement ranges between the plurality of third targets in the third image frame and the vehicle are less than the target distance threshold, the third predicted sizes of the plurality of third targets are determined. The second
5 target distance-measurement range between the fourth target in the third image frame and the vehicle is determined based on the third predicted size and the detection box information of the fourth target in the third image frame. In this way, predicting the fourth target based on the third target close to the vehicle can improve the accuracy of distance measurement for the fourth target when the first
10 target is not credible.

[0316] In some embodiments, the above distance measurement method may further include the following steps S17 to S18:

[0317] Step S17: Determining a relative positional relationship of the second target with respect to a lane line point in the second image frame, and a
15 lane distance-measurement range between the lane line point in the second image frame and the vehicle.

[0318] In some embodiments, at least one lane line point that is similar in distance to the second target (for example, including the closest one) in the second image frame may be determined. A lateral relative position of the second target
20 with respect to the lane line point is determined based on the position of the lane line point in the second image frame. For example, the second target is located at the left side or the right side of the lane line point, or on the lane line corresponding to the lane line point.

[0319] Step S18: Updating the first target distance-measurement range based on the relative positional relationship and the lane distance-measurement range.

[0320] In some embodiments, the position of the second target relative to the lane line point may be adjusted based on the relative positional relationship of the second target with respect to the lane line point in the second image frame. Coordinates of the lane line point in the vehicle-based coordinate system are determined based on the lane distance-measurement range between the lane line point in the second image frame and the vehicle, and coordinates of the second target in the vehicle-based coordinate system are adjusted. The first target distance-measurement range is updated based on the coordinates of the second target in the vehicle-based coordinate system.

[0321] Exemplarily, with reference to FIG. 1G and FIG. 1H, a relative position of the second target 32 with respect to a point on the lane line 31 in the second image frame 30 corresponding to FIG. 1G may be obtained first, that is, the second target 32 is located at the right side of the point on the lane line 31. Then, the VCS coordinates of the second target 32 are adjusted according to the point on the lane line 31 and the VCS coordinates of the second target 32 in the second image frame 30 corresponding to FIG. 1H, so as to obtain the first target distance-measurement range.

[0322] In embodiments of the present disclosure, a relative positional relationship of the second target with respect to a lane line point in the second image frame, and a lane distance-measurement range between the lane line point

in the second image frame and the vehicle are determined; and the first target distance-measurement range is updated according to the relative positional relationship and the lane distance-measurement range. In this way, the distance measurement error of the second target can be reduced based on the position of the lane line point in the second image frame, and the authenticity and accuracy of the first target distance-measurement range can be improved.

[0323] It can be understood that updating the first target distance-measurement range based on the relative positional relationship of the second target with respect to the lane line point can improve the authenticity and accuracy of the first target distance-measurement range, and address the issues of inaccurate distance measurement results in special curve scenarios, which lead to false braking caused by lane invasion into the main lane, and missed braking caused by target extraction when high-precision maps fail to reflect real road conditions such as construction or rerouting

[0324] Embodiments of the present disclosure further provide a traffic cone distance-measurement method, which may be executed by an electronic device. Taking traffic cone distance-measurement in autonomous driving as an example, as shown in FIG. 2, the method includes the following steps S201 to S207:

[0325] Step S201: Obtaining external parameters and prior parameters.

[0326] Here, the external parameters may correspond to the external parameters of the vision system in the above distance measurement method, and

the prior parameters may correspond to the common sizes of traffic cones in the above distance measurement method.

[0327] During implementation, a vehicle with an autonomous driving function and equipped with a monocular CCD vision system may be deployed.

5 [0328] Step S202: Performing model inference to obtain information about traffic cones and the like.

[0329] During implementation, a U-NET neural network model may be constructed, and batch data annotation and training may be performed on data such as traffic cones and lane lines to obtain position information of traffic cones
10 and lane line points in image frames.

[0330] Step S203: Performing external parameter distance-measurement and internal parameter correction.

[0331] Here, external parameter distance-measurement may correspond to the process of converting coordinates of points in an image into VCS
15 coordinates via an external parameter transformation matrix in the above distance measurement method, as shown in Formula (2); internal parameter correction may correspond to the process of obtaining the coordinate positions of the CCD center of the image capture device in the image and determining the position of the traffic cone relative to the CCD center based on calibrated internal parameters of the
20 image capture device in the above distance measurement method, as shown in Formula (5), so as to reduce the deviation of the traffic cone coordinates relative to the image coordinates of the CCD center.

[0332] Step S204: Performing EKF optimization.

[0333] Here, this step may correspond to the process of determining the center point coordinates at the bottom of the second traffic cone using a filter based on a plurality of edge point coordinates in the above distance measurement method. The EKF filter is used to optimize the coordinates of a plurality of edge points at the bottom of the traffic cone to obtain the coordinates of the center point at the bottom of the traffic cone.

[0334] During implementation, the EKF filter is initialized for the first measurement; for subsequent measurements, normal EKF optimization is performed.

10 [0335] Step S205: Performing vehicle speed and inter-frame duration verification.

[0336] Here, vehicle speed and inter-frame duration verification may correspond to the process of determining whether the distance measurement variation and the vehicle movement distance of a target in each target image frame satisfy a target confidence condition in the above distance measurement method. The inter-frame duration may correspond to the capture interval between two image frames. The vehicle movement distance between the two image frames may be determined based on the vehicle speed and the inter-frame duration between two image frames.

20 [0337] Step S206: Performing genetic optimization to infer positions of other traffic cones.

[0338] Here, genetic optimization may correspond to the process of determining the first target distance-measurement range between the second

target in the second image frame and the vehicle based on the second predicted size of the first target in the above distance measurement method, that is, the size of credible traffic cones is used to conduct gene expression on other traffic cones, so as to determine the distance measurement range between other traffic cones and the vehicle.

[0339] Step S207: Correcting the lateral position of the traffic cone according to lane line information.

[0340] Here, the lane line information may include position information of points on the lane line, which may include the relative position of the traffic cone with respect to the points on the lane line in the image frame, and may further include the coordinate information of the points on the lane line in the VCS coordinate system.

[0341] The lateral position may correspond to the coordinate information of the traffic cone along the y-axis direction of the VCS coordinate system in the above distance measurement method.

[0342] In embodiments of the present disclosure, traffic cone information is obtained via model inference; external parameter distance-measurement is performed on the traffic cone, and distance-measurements result is corrected using the internal parameters; coordinates are optimized via the EKF filter; after verifying the distance measurement result based on vehicle speed and inter-frame duration, the positions of other traffic cones are inferred based on the credible traffic cone size; and the lateral position of the traffic cone is corrected based on lane line information. This improves overall processing efficiency via model

processing, enhances distance measurement accuracy through multi-step corrections, and reduces jitter caused by systematic errors, thereby increasing traffic cone distance measurement precision.

[0343] In this way, on one hand, processing traffic cone information
5 through the model can improve the overall processing efficiency; on the other
hand, performing external parameter distance-measurement on the traffic cone,
correcting the distance-measurement result based on internal parameters,
adopting an EKF filter, and correcting traffic cone positions based on lane line
information all improve the accuracy of distance measurement values.
10 Furthermore, inferring other traffic cones based on the size of credible traffic
cones can mitigate jitter caused by systematic errors in the distance measurement
process and enhance the precision of traffic cone distance-measurement.

[0344] Embodiments of the present disclosure further provide a distance
measurement apparatus. As shown in FIG. 3, the apparatus 300 includes:

15 [0345] a first acquisition station 301, configured to obtain a first distance-
measurement range between a first target in a first image frame and a vehicle, and
a second distance-measurement range between the first target in a second image
frame and the vehicle, where the first image frame and the second image frame
are sequentially captured by an image capture device mounted on the vehicle
20 during travel of the vehicle;

[0346] a first determination station 302, configured to determine a
distance-measurement confidence state of the first target according to the first
distance-measurement range and the second distance-measurement range;

[0347] a second determination station 303, configured to determine, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, a second predicted size of a second target according to a size relationship between the first target and the second target detected in the second image frame, and a first predicted size of the first target, where the second distance-measurement range is determined according to the first predicted size; and

[0348] a third determination station 304, configured to determine a first target distance-measurement range between the second target in the second image frame and the vehicle according to the second predicted size and detection box information of the second target in the second image frame.

[0349] In some embodiments, the first target includes a first traffic cone, and the second target includes a second traffic cone. The second determination station may further be configured to: determine, when the size relationship indicates that the first traffic cone and the second traffic cone have a same size specification, the first predicted size as the second predicted size; where the first predicted size and the second predicted size correspond to a same size parameter, and the size parameter may include a height parameter and/or a width parameter.

[0350] In some embodiments, the detection box information includes a detection box size and a detection box position. The third determination station may further be configured to: determine a longitudinal distance-measurement range between the second target in the second image frame and the vehicle according to an internal parameter of the image capture device, the second

predicted size, and the detection box size of the second target in the second image frame; determine a lateral distance-measurement range between the second target in the second image frame and the vehicle according to the internal parameter, the detection box position of the second target in the second image frame, and the
5 longitudinal distance-measurement range; and determine the first target distance-measurement range according to the longitudinal distance-measurement range and the lateral distance-measurement range.

[0351] In some embodiments, the first target includes a first traffic cone, and the second target includes a second traffic cone. The third determination
10 station may further be configured to: determine coordinates of a plurality of edge points at a bottom of the second traffic cone according to the longitudinal distance-measurement range and the lateral distance-measurement range; determine coordinates of a center point at the bottom of the second traffic cone according to the coordinates of the plurality of edge points; and determine the first
15 target distance-measurement range according to the coordinates of the center point.

[0352] In some embodiments, the first determination station may further be configured to: determine a distance measurement variation corresponding to the second image frame according to a difference between the first distance-measurement range and the second distance-measurement range; and determine
20 the distance-measurement confidence state of the first target according to the distance measurement variation corresponding to the second image frame and a vehicle movement distance corresponding to the second image frame, where the vehicle movement distance corresponding to the second image frame is a

movement distance of the vehicle during a capture interval between the first image frame and the second image frame.

[0353] In some embodiments, the first image frame is a previous frame of the second image frame. The first determination station may further be configured to: determine a distance measurement variation and a vehicle movement distance respectively corresponding to at least one historical image frame, where the distance measurement variation corresponding to the historical image frame is determined according to a difference between a first historical distance-measurement range of the first target in the historical image frame and a second historical distance-measurement range of the first target in a previous frame of the historical image frame, and the vehicle movement distance corresponding to the historical image frame is a movement distance of the vehicle during a capture interval between the historical image frame and the previous frame of the historical image frame; and determine the distance-measurement confidence state of the first target according to distance measurement variations and vehicle movement distances respectively corresponding to a plurality of target image frames, where the plurality of target image frames include the at least one historical image frame and the second image frame.

[0354] In some embodiments, the first determination station may further be configured to: determine, when the distance measurement variations and the vehicle movement distances respectively corresponding to the plurality of target image frames satisfy a target confidence condition, the distance-measurement confidence state of the first target as a first state indicating that the second distance-measurement range is credible;

[0355] where the target confidence condition includes at least one of the following: a sum of the distance measurement variations respectively corresponding to the plurality of target image frames is less than a first target-distance threshold, where the first target-distance threshold is determined
5 according to a sum of the vehicle movement distances respectively corresponding to the plurality of target image frames; a difference between the distance measurement variation and the vehicle movement distance respectively corresponding to each of the plurality of target image frames is less than a distance difference threshold; where for each of the plurality of target image frames, the
10 distance measurement variation and the vehicle movement distance respectively corresponding to the target image frame are both positive numbers or both negative numbers.

[0356] In some embodiments, the above distance measurement apparatus may further include a fourth determination station, configured to: determine,
15 when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, a third distance-measurement range between the first target in a third image frame and the vehicle according to the second distance-measurement range and a movement distance of the vehicle during a capture interval between the third image frame and the second image
20 frame, where the second image frame and the third image frame are sequentially captured by the image capture device during travel of the vehicle.

[0357] In some embodiments, the first acquisition station may further be configured to: determine the first predicted size according to an external

parameter of the image capture device and detection box coordinates of the first target in the second image frame; and determine the second distance-measurement range according to the first predicted size, a detection box size of the first target in the second image frame, and the detection box coordinates of the first target in the second image frame.

[0358] In some embodiments, the first target includes a first traffic cone, and the second target includes a second traffic cone. The first acquisition station may further be configured to: determine a first candidate size of the first traffic cone according to the external parameter of the image capture device and detection box coordinates of the first traffic cone in the first image frame; determine a detection box aspect ratio of the first traffic cone in the second image frame; determine a second candidate size corresponding to the detection box aspect ratio from a preset traffic-cone size set; and determine the first predicted size according to the first candidate size and the second candidate size.

[0359] In some embodiments, the first acquisition station may further be configured to perform one of the following steps: determine the second candidate size as the first predicted size when a difference between the first candidate size and the second candidate size is greater than a size difference threshold; and determine the first candidate size as the first predicted size when a difference between the first candidate size and the second candidate size is not greater than the size difference threshold.

[0360] In some embodiments, a plurality of the first targets are presented. The above distance measurement apparatus may further include a fifth

determination station, configured to: determine a layout type of targets in the second image frame according to distribution information of each of the targets detected in the second image frame before determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range;

[0361] The first determination station may further be configured to: determine, for each of the first targets, the distance-measurement confidence state of the first target when the layout type is dense arrangement according to the first distance-measurement range and the second distance-measurement range corresponding to the first target.

[0362] In some embodiments, a difference between a distance measurement variation corresponding to a target image frame and a vehicle movement distance corresponding to the target image frame is less than a target difference threshold; where the target image frame includes the second image frame or a historical image frame captured before the second image frame, where the distance measurement variation corresponding to the target image frame is determined according to a difference between a first historical distance-measurement range of the first target in the target image frame and a second historical distance-measurement range of the first target in a previous frame of the target image frame, and the vehicle movement distance corresponding to the target image frame is a movement distance of the vehicle during a capture interval between the target image frame and the previous frame of the target image frame.

[0363] In some embodiments, the above distance measurement apparatus may further include a sixth determination station, configured to: obtain a third image frame when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is not credible; determine, 5 when third distance-measurement ranges between a plurality of third targets in the third image frame and the vehicle are less than a target distance threshold, third predicted sizes of the plurality of third targets; and determine a second target distance-measurement range between a fourth target in the third image frame and the vehicle according to the third predicted sizes and detection box information 10 of the fourth target in the third image frame.

[0364] In some embodiments, the third determination station may further be configured to: determine a relative positional relationship of the second target with respect to a lane line point in the second image frame, and a lane distance-measurement range between the lane line point in the second image frame and the 15 vehicle; and update the first target distance-measurement range according to the relative positional relationship and the lane distance-measurement range.

[0365] Embodiments of the present disclosure further provide an electronic device, including a memory and a processor. As shown in FIG. 4, the electronic device 400 includes:

20 [0366] a memory 401, configured to store computer instructions executable on a processor 402; and

[0367] the processor 402, configured to execute the instructions stored in the memory 401 to implement the above distance measurement method.

[0368] Embodiments of the present disclosure further provide a vehicle, including the above electronic device.

[0369] Embodiments of the present disclosure further provide a computer program, including computer-readable code. When the computer-readable code
5 runs on a computer device, a processor of the computer device executes part or all of the steps of the above distance measurement method.

[0370] Embodiments of the present disclosure further provide a computer program product, including computer instructions. When executed by a processor, the computer instructions implement part or all of the steps of the above distance
10 measurement method.

[0371] Embodiments of the present disclosure further provide a computer-readable storage medium storing computer instructions executable by a processor to implement the above distance measurement method.

[0372] The present application is described with reference to flowcharts
15 and/or block diagrams of methods, apparatuses, and devices according to embodiments of the present disclosure. Each process and/or block in the flowcharts and/or block diagrams, and combinations of processes and/or blocks in the flowcharts and/or block diagrams, may be implemented by computer instructions. These computer instructions may be provided to a processor of a
20 general-purpose computer, a special-purpose computer, an embedded processor, or another programmable data processing device to produce a machine, such that the instructions executed by the processor of the computer or the another programmable data processing device produce an apparatus for implementing the

functions specified in one or more processes of the flowcharts and/or one or more blocks of the block diagrams..

[0373] These computer instructions may also be stored in a computer-readable memory capable of directing a computer or another programmable data processing device to operate in a specific manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including an instruction apparatus, and the instruction apparatus implements the functions specified in one or more processes of the flowcharts and/or one or more blocks of the block diagrams.

10 [0374] These computer instructions may also be loaded onto a computer or another programmable data processing device, such that a series of operational steps are performed on the computer or the another programmable device to produce a computer-implemented process, and thus the instructions executed on the computer or the another programmable device provide steps for implementing
15 the functions specified in one or more processes of the flowcharts and/or one or more blocks of the block diagrams.

[0375] The above description is merely embodiments of the present application, but the protection scope of the present application is not limited thereto. Any variations or modifications readily conceived by those skilled in the
20 art within the technical scope disclosed in the present application shall fall within the protection scope of the present application.

[0376] The descriptions of the above apparatus embodiments are similar to those of the above method embodiments, and have similar beneficial effects to

those of the method embodiments. For technical details not disclosed in the apparatus embodiments of the present application, reference may be made to the descriptions of the method embodiments of the present application for understanding.

5 [0377] Reference throughout the specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with an embodiment is included in at least one embodiment of the present application. Thus, the appearances of the phrase “in one embodiment” or “in an embodiment” in various places throughout the
10 specification are not necessarily all referring to the same embodiment. Furthermore, these particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In various embodiments of the present application, the magnitude of the sequence numbers of the above processes does not imply an order of execution. The execution order
15 of the processes shall be determined by functions and inherent logic thereof, and shall not constitute any limitation on the implementation process of the embodiments of the present disclosure. The sequence numbers of the above embodiments of the present disclosure are merely for description, and do not represent the superiority or inferiority of the embodiments.

20 [0378] In the present disclosure, the terms “include”, “comprise”, or any other variants thereof are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that includes a set of elements includes not only those elements, but also other elements not explicitly listed, or elements inherent to such a process, method, article, or apparatus. Without further

limitations, an element defined by the phrase “include one...” does not exclude the presence of additional identical elements in the process, method, article, or apparatus that includes the element.

[0379] In the several embodiments provided in the present application, the disclosed devices and methods may be implemented in other manners. The apparatus embodiments described above are merely illustrative. For example, the division of the stations is merely a logical function division, and there may be other division manners in actual implementation, such as: a plurality of stations or components may be combined, or integrated into another system, or some features may be omitted, or not executed. In addition, the coupling, direct coupling, or communication connection between the various components shown or discussed may be indirect coupling or communication connection via some interfaces, devices, or stations, and may be electrical, mechanical, or of other forms.

[0380] The units described above as separate components may or may not be physically separate, and the components shown as units may or may not be physical units. A unit may be located in one place or distributed across a plurality of network units. Part or all of the units may be selected according to actual requirements to implement the embodiments of the present disclosure.

[0381] In addition, all functional units in the embodiments of the present disclosure may be integrated into one processing unit, or each unit may be separately provided as a unit, or two or more units may be integrated into one unit.

The above integrated units may be implemented in the form of hardware, or in the form of hardware plus software functional units.

[0382] Those skilled in the art may understand that all or part of the steps implementing the above method embodiments may be completed by hardware
5 related to instructions. The foregoing instructions may be stored in a computer-readable storage medium, and when executed, the instructions perform the steps of the above method embodiments. The foregoing storage medium includes a mobile storage device, a Read Only Memory (ROM), a magnetic disk, an optical disk, and other various media capable of storing program codes/instructions.

10 [0383] Alternatively, when the integrated unit of the present application is implemented in the form of a software functional module and sold or used as an independent product, the integrated unit may also be stored in a computer-readable storage medium. Based on such an understanding, the essential or contributing part of the technical solutions of the embodiments of the present
15 disclosure may be embodied in the form of a software product. The computer software product is stored in a storage medium and includes a plurality of instructions causing a computer device (may be a personal computer, a server, a network device, or the like) to execute all or part of the methods described in the embodiments of the present disclosure. The foregoing storage medium includes
20 various media capable of storing program codes/instructions, such as a mobile storage device, a ROM, a magnetic disk, or an optical disk.

[0384] The above embodiments are merely provided to fully illustrate the present application, and the protection scope of the present application is not

limited thereto. Equivalent substitutions or modifications made by those skilled in the art based on the present application shall fall within the protection scope of the present application.

WHAT IS CLAIMED IS:

1. A distance measurement method, comprising:

obtaining a first distance-measurement range between one or more first targets in a first image frame and a vehicle, and a second distance-measurement range between the first target in a second image frame and the vehicle, wherein the first image frame and the second image frame are sequentially captured by an image capture device mounted on the vehicle during travel of the vehicle;

determining a distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range;

determining, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, a second predicted size of a second target according to a size relationship between the first target and the second target detected in the second image frame, and a first predicted size of the first target, wherein the second distance-measurement range is determined according to the first predicted size; and

determining a first target distance-measurement range between the second target in the second image frame and the vehicle according to the second predicted size and detection box information of the second target in the second image frame.

2. The method according to claim 1, wherein the first target comprises a first traffic cone, wherein the second target comprises a second traffic cone; wherein determining the second predicted size of the second target according to the size

relationship between the first target and the second target detected in the second image frame, and the first predicted size of the first target, comprises:

determining, when the size relationship indicates that the first traffic cone and the second traffic cone have a same size specification, the first predicted size as
5 the second predicted size; wherein the first predicted size and the second predicted size correspond to a same size parameter, and the size parameter comprises a height parameter and/or a width parameter.

3. The method according to claim 1, wherein the detection box information comprises a detection box size and a detection box position;

10 wherein determining the first target distance-measurement range between the second target in the second image frame and the vehicle according to the second predicted size and the detection box information of the second target in the second image comprises:

determining a longitudinal distance-measurement range between the second
15 target in the second image frame and the vehicle according to an internal parameter of the image capture device, the second predicted size, and the detection box size of the second target in the second image frame;

determining a lateral distance-measurement range between the second target in the second image frame and the vehicle according to the internal parameter, the
20 detection box position of the second target in the second image frame, and the longitudinal distance-measurement range; and

determining the first target distance-measurement range according to the longitudinal distance-measurement range and the lateral distance-measurement range.

4. The method according to claim 3, wherein the first target comprises a first traffic cone, wherein the second target comprises a second traffic cone; wherein
5 determining the first target distance-measurement range according to the longitudinal distance-measurement range and the lateral distance-measurement range comprises:

determining coordinates of a plurality of edge points at a bottom of the second
10 traffic cone according to the longitudinal distance-measurement range and the lateral distance-measurement range;

determining coordinates of a center point at the bottom of the second traffic cone according to the coordinates of the plurality of edge points; and

determining the first target distance-measurement range according to the
15 coordinates of the center point.

5. The method according to claim 1, wherein determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range comprises:

determining a distance measurement variation corresponding to the second
20 image frame according to a difference between the first distance-measurement range and the second distance-measurement range; and

determining the distance-measurement confidence state of the first target according to the distance measurement variation corresponding to the second image frame and a vehicle movement distance corresponding to the second image frame, wherein the vehicle movement distance corresponding to the second image frame is a movement distance of the vehicle during a capture interval between the first image frame and the second image frame.

6. The method according to claim 5, wherein the first image frame is a previous frame of the second image frame; wherein determining the distance-measurement confidence state of the first target according to the distance measurement variation corresponding to the second image frame and the vehicle movement distance corresponding to the second image frame comprises:

determining a distance measurement variation and a vehicle movement distance respectively corresponding to at least one historical image frame, wherein the distance measurement variation corresponding to the historical image frame is determined according to a difference between a first historical distance-measurement range of the first target in the historical image frame and a second historical distance-measurement range of the first target in a previous frame of the historical image frame, and the vehicle movement distance corresponding to the historical image frame is a movement distance of the vehicle during a capture interval between the historical image frame and the previous frame of the historical image frame; and

determining the distance-measurement confidence state of the first target according to distance measurement variations and vehicle movement distances

respectively corresponding to a plurality of target image frames, wherein the plurality of target image frames comprise the at least one historical image frame and the second image frame.

7. The method according to claim 6, wherein determining the distance-
5 measurement confidence state of the first target according to the distance measurement variations and the vehicle movement distances respectively corresponding to the plurality of target image frames comprises:

determining, when the distance measurement variations and the vehicle
movement distances respectively corresponding to the plurality of target image
10 frames satisfy a target confidence condition, the distance-measurement confidence state of the first target as a first state indicating that the second distance-measurement range is credible, wherein the target confidence condition comprises at least one of the following:

a sum of the distance measurement variations respectively corresponding to
15 the plurality of target image frames is less than a first target-distance threshold, wherein the first target-distance threshold is determined according to a sum of the vehicle movement distances respectively corresponding to the plurality of target image frames;

a difference between the distance measurement variation and the vehicle
20 movement distance respectively corresponding to each of the plurality of target image frames is less than a distance difference threshold;

wherein for each of the plurality of target image frames, the distance measurement variation and the vehicle movement distance respectively

corresponding to the target image frame are both positive numbers or both negative numbers.

8. The method according to any of claim 1 to claim 7, further comprising:

determining, when the distance-measurement confidence state of the first
5 target indicates that the second distance-measurement range is credible, a third
distance-measurement range between the first target in a third image frame and
the vehicle according to the second distance-measurement range and a movement
distance of the vehicle during a capture interval between the third image frame
and the second image frame, wherein the second image frame and the third image
10 frame are sequentially captured by the image capture device during travel of the
vehicle.

9. The method according to any of claim 1 to claim 7, wherein obtaining the
second distance-measurement range between the first target in the second image
frame and the vehicle comprises:

15 determining the first predicted size according to an external parameter of the
image capture device and detection box coordinates of the first target in the second
image frame; and

determining the second distance-measurement range according to the first
predicted size, a detection box size of the first target in the second image frame,
20 and the detection box coordinates of the first target in the second image frame.

10. The method according to claim 9, wherein the first target comprises a first
traffic cone, wherein the second target comprises a second traffic cone; wherein

determining the first predicted size according to the external parameter of the image capture device and the detection box coordinates of the first target in the first image frame comprises:

5 determining a first candidate size of the first traffic cone according to the external parameter of the image capture device and detection box coordinates of the first traffic cone in the first image frame;

determining a detection box aspect ratio of the first traffic cone in the second image frame;

10 determining a second candidate size corresponding to the detection box aspect ratio from a preset traffic-cone size set; and

determining the first predicted size according to the first candidate size and the second candidate size.

11. The method according to claim 10, wherein determining the first predicted size according to the first candidate size and the second candidate size comprises one of the following:

determining the second candidate size as the first predicted size when a difference between the first candidate size and the second candidate size is greater than a size difference threshold; and

20 determining the first candidate size as the first predicted size when a difference between the first candidate size and the second candidate size is not greater than the size difference threshold.

12. The method according to any of claim 1 to claim 7, wherein a plurality of the first targets are presented; wherein before determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range, the method
5 further comprises:

determining a layout type of targets in the second image frame according to distribution information of each of the targets detected in the second image frame;

determining the distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range comprises:
10

determining, for each of the first targets, the distance-measurement confidence state of the first target when the layout type is dense arrangement according to the first distance-measurement range and the second distance-measurement range corresponding to the first target.

13. The method according to claim 12, wherein a difference between a distance measurement variation corresponding to a target image frame and a vehicle movement distance corresponding to the target image frame is less than a target difference threshold; wherein the target image frame comprises the second image frame or a historical image frame captured before the second image frame,
15 wherein the distance measurement variation corresponding to the target image frame is determined according to a difference between a first historical distance-measurement range of the first target in the target image frame and a second historical distance-measurement range of the first target in a previous frame of the
20

target image frame, and the vehicle movement distance corresponding to the target image frame is a movement distance of the vehicle during a capture interval between the target image frame and the previous frame of the target image frame.

14. The method according to claim 12, further comprising:

5 obtaining a third image frame when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is not credible;

 determining, when third distance-measurement ranges between a plurality of third targets in the third image frame and the vehicle are less than a target distance
10 threshold, third predicted sizes of the plurality of third targets; and

 determining a second target distance-measurement range between a fourth target in the third image frame and the vehicle according to the third predicted sizes and detection box information of the fourth target in the third image frame.

15. The method according to any of claim 1 to claim 7, further comprising:

15 determining a relative positional relationship of the second target with respect to a lane line point in the second image frame, and a lane distance-measurement range between the lane line point in the second image frame and the vehicle; and

 updating the first target distance-measurement range according to the relative positional relationship and the lane distance-measurement range.

20 16. A distance measurement apparatus, comprising:

 a first acquisition station, configured to obtain a first distance-measurement range between a first target in a first image frame and a vehicle, and a second

distance-measurement range between the first target in a second image frame and the vehicle, wherein the first image frame and the second image frame are sequentially captured by an image capture device mounted on the vehicle during travel of the vehicle;

- 5 a first determination station, configured to determine a distance-measurement confidence state of the first target according to the first distance-measurement range and the second distance-measurement range;

 a second determination station, configured to, when the distance-measurement confidence state of the first target indicates that the second distance-measurement range is credible, determine a second predicted size of a second
10 target according to a size relationship between the first target and the second target detected in the second image frame, and a first predicted size of the first target, wherein the second distance-measurement range is determined according to the first predicted size; and

- 15 a third determination station, configured to determine a first target distance-measurement range between the second target in the second image frame and the vehicle according to the second predicted size and detection box information of the second target in the second image frame.

 17. An electronic device, comprising a processor and a memory storing
20 computer instructions executable on the processor, wherein the processor is configured to implement steps of the method according to any of claim 1 to claim 15 when executing the computer instructions.

 18. A vehicle, comprising the electronic device according to claim 17.

19. A computer-readable storage medium, storing computer instructions executable by a processor to implement the method according to any of claim 1 to claim 15.

20. A computer program product, comprising computer instructions that,
5 when executed by a processor, implement the method according to any of claim 1 to claim 15.