

# **ROBOT POSITIONING METHOD AND APPARATUS, DEVICE, AND STORAGE MEDIUM**

## **CROSS-REFERENCE TO RELATED APPLICATION**

- [ 0001] The disclosure is based on and claims priority to Chinese patent application No. 202011157118.7 filed on October 26, 2020 and entitled “Robot Positioning Method and Apparatus, Device and Storage Medium”, the disclosure of which is hereby incorporated by reference in its entirety.

## **TECHNICAL FIELD**

- [ 0002] The disclosure relates to the technical field of Artificial Intelligence (AI), and particularly to a robot positioning method and apparatus, a device and a storage medium.

## **BACKGROUND**

- [ 0003] In recent years, AI has become increasingly popular, which involves a variety of functions, and its integrated positioning system has become increasingly common in various fields. For example, in AI education, both teachers and students are often exposed to contents of positioning, planning, control, multi-agents, etc. The most basic and important part is a robot positioning system.

## **SUMMARY**

- [ 0004] The disclosure provides a robot positioning method and apparatus, a device and a storage medium.
- [ 0005] A first technical solution provided by the present disclosure is to provide a robot positioning method, which may include that: first position information of a robot at a first moment is acquired; a second image of the robot at a second moment is acquired, and first estimated position information of the robot at the second moment is acquired based on the second image; a movement parameter of the robot from the first moment to the second moment is collected; second estimated position information of the robot at the second moment is calculated based on the first position information and the movement parameter; and second position information of the robot at the second moment is obtained through the first estimated position information and the second estimated position information.
- [ 0006] Thus, a detection result of a vision system and a detection result of a dynamic system are fused, so that the obtained position information is more accurate.
- [ 0007] In some embodiments of the present disclosure, the operation of obtaining the first position information of the robot at the first moment may include that: a first image of the robot at the first moment is acquired; and the first position information of the robot at the first moment is acquired based on the first image.
- [ 0008] In some embodiments of the present disclosure, the first image may include a first reference object. The operation of acquiring the first position information of the robot at the first moment based on the first image may include that: the first reference object on a simulated sand table is acquired; a pixel position of the first reference object and a first pixel position of the robot in the first image are determined; a simulated position of the first reference object on the simulated sand table at the first moment is determined; a first projection relationship is calculated by using the pixel position of the first reference object

and the simulated position of the first reference object on the simulated sand table; the simulated position of the robot on the simulated sand table is calculated based on the first projection relationship and the first pixel position of the robot; and the first position information of the robot at the first moment is determined by using the simulated position of the robot on the simulated sand table.

[ 0009] Thus, an initial position of the robot is determined by using the vision system by means of the simulated sand table, which does not need additional calibration reference objects and reduces additional calibration moments.

[ 0010] In some embodiments of the present disclosure, the second image may include a first reference object. The operation of acquiring the first estimated information of the robot at the second moment based on the second image may include that: the second reference object on the simulated sand table is acquired; a pixel position of the second reference object and a second pixel position of the robot in the second image are determined; a simulated position of the second reference object on the simulated sand table at the second moment is determined; a second projection relationship is calculated by using the pixel position of the second reference object and the simulated position of the second reference object on the simulated sand table; the simulated position of the robot on the simulated sand table is calculated based on the second projection relationship and the second pixel position of the robot; and the first estimated position information of the robot at the second moment is determined by using the simulated position of the robot on the simulated sand table.

[ 0011] Thus, a destination position of the robot is determined by using the vision system by means of the simulated sand table, which does not need additional calibration reference objects and reduces additional calibration moments.

[ 0012] In some embodiments of the present disclosure, the operation of determining the pixel position of the first reference object and the first pixel position of the robot in the first image may include that: the first image is identified by using a first deep learning network to determine the pixel position of the first reference object and the first pixel position of the robot in the first image. The operation of determining the pixel position of the second reference object and the second pixel position of the robot in the second image may include that: the second image is identified by using the first deep learning network to determine the pixel position of the second reference object and the second pixel position of the robot in the second image. The first deep learning network may include one or any combination of a Region-CNN (RCNN) deep network structure, a Single Shot MultiBox Detector (SSD) deep network structure, a You Only Look Once (Yolo) deep network structure, or a RetinaNet network structure.

[ 0013] In some embodiments of the present disclosure, the operation of acquiring the first image of the robot at the first moment may further include that: an orientation of the robot at the first moment is acquired based on the first image.

[ 0014] The operation of acquiring the orientation of the robot at the first moment based on the first image may include that: an area image in which the robot is located is identified by using a second deep learning network to determine the orientation of the robot. The second deep learning network may include one or any combination of a ResNet deep network structure, a MobileNet deep network structure, a GhostNet deep network structure or an EfficientNet deep network structure.

[ 0015] Thus, the orientation of the robot is detected, so that the result is more accurate when the position information of the robot is calculated by the dynamic system, subsequently.

- [ 0016] In some embodiments of the present disclosure, the positioning method may further include that: a historical movement parameter of the robot at the first moment is acquired. The operation of collecting the movement parameter of the robot from the first moment to the second moment may include that: a current movement parameter of the robot at the second moment is acquired; and the movement parameter of the robot from the first moment to the second moment is calculated through the historical movement parameter and the current movement parameter.
- [ 0017] Thus, a moving distance of the robot from the first moment to the second moment is calculated, and the orientation of the robot is combined, so that the result is more accurate when the position information of the robot is calculated by the dynamic system, subsequently.
- [ 0018] In some embodiments of the present disclosure, the operation of calculating the second estimated position information of the robot at the second moment based on the first position information and the movement parameter may include that: the second estimated position information of the robot at the second moment is acquired by combining the orientation of the robot within the first moment with the movement parameter of the robot from the first moment to the second moment.
- [ 0019] Thus, the dynamic system is used to detect the position information of the robot at the second moment, thereby reducing the hardware cost.
- [ 0020] In some embodiments of the present disclosure, the operation of obtaining the second position information of the robot at the second moment through the first estimated position information and the second estimated position information may include that: weighted averaging is performed the first estimated position information and the second estimated position information by means of a Kalman filter so as to obtain the second position information of the robot at the second moment.
- [ 0021] Thus, the position information obtained by the vision system and the position information obtained by the dynamic system are fused to obtain the position information of the robot at the second moment, which improves the positioning accuracy and increases easiness of deployment of the system.
- [ 0022] A second technical solution provided by the present disclosure is to provide a robot positioning apparatus, which may include: a first position acquisition part, which is configured to acquire first position information of a robot at a first moment and acquire a first estimated position information of the robot at a second moment; a parameter acquisition part, which is configured to collect a movement parameter of the robot from the first moment to the second moment; a second position acquisition part, which is configured to calculate second estimated position information of the robot at the second moment based on the first position information and the movement parameter; and a calibration part, which is configured to obtain second position information of the robot at the second moment through the first estimated position information and the second estimated position information.
- [ 0023] A third technical solution provided by the present disclosure is to provide a robot positioning device, which may include a memory and a processor. The memory stores a program instruction. The processor calls the program instruction from the memory to execute the above-mentioned robot positioning method.
- [ 0024] A fourth technical solution provided by the present disclosure is to provide a computer readable storage medium, a memory and a processor. The memory stores a program instruction. The processor calls the program instruction from the memory to execute the above-mentioned robot positioning method.

[ 0025] A fifth technical solution provided by the present disclosure is to provide a computer program, which may include a computer readable code. The computer readable code executes the above-mentioned robot positioning method when the computer readable code runs in a robot positioning device and is executed by a processor in the robot positioning device.

[ 0026] According to the robot positioning method provided by the disclosure, the positioning results of the robot obtained in two different ways are fused, that is, the detection result of the vision system and the detection result of the dynamic system are fused, so that the position information is obtained. The positioning method enables the obtained position information more accurate and effectively improves the positioning accuracy of the robot.

## BRIEF DESCRIPTION OF THE DRAWINGS

[ 0027] In order to describe the technical solutions in the embodiments of the disclosure more clearly, the drawings required to be used in descriptions about the embodiments will be simply introduced below, obviously, the drawings described below are only some embodiments of the disclosure, and other drawings may further be obtained by those of ordinary skill in the art according to the drawings without creative work.

[ 0028] FIG. 1 is a schematic flowchart of an embodiment of a robot positioning method according to an embodiment of the disclosure.

[ 0029] FIG. 2 is a schematic flowchart of an embodiment of a step S11 in FIG. 1 according to an embodiment of the disclosure.

[ 0030] FIG. 3 is a schematic flowchart of an embodiment of a step S12 in FIG. 1 according to an embodiment of the disclosure.

[ 0031] FIG. 4 is a schematic flowchart of an embodiment of a step S13 in FIG. 1 according to an embodiment of the disclosure.

[ 0032] FIG. 5 is a schematic diagram of the principle of a robot positioning method according to an embodiment of the disclosure.

[ 0033] FIG. 6 is a structural schematic diagram of an embodiment of a robot positioning apparatus according to an embodiment of the present disclosure.

[ 0034] FIG. 7 is a schematic structural diagram of an embodiment of a robot positioning device according to an embodiment of the disclosure.

[ 0035] FIG. 8 is a schematic structural diagram of a computer readable storage medium according to an embodiment of the disclosure.

## DETAILED DESCRIPTION

[ 0036] The technical solutions in the embodiments of the disclosure will be clearly and completely described below in combination with the drawings in the embodiments of the disclosure, and it is apparent that the described embodiments are only a part rather all of embodiments of the disclosure. All other embodiments obtained by those of ordinary skill in the art based on the embodiments of the disclosure without creative efforts shall fall within the protection scope of the disclosure.

[ 0037] Terms "first", "second" and "third" in the disclosure are only used for describing purposes, and cannot be understood as indicating or implying relative importance or implicitly indicating the number of indicated technical features. Therefore, the features defined with "first", "second" and "third" may include at least one of the features explicitly or implicitly. In the descriptions of the disclosure, "multiple" means at least two, such as two, three, etc., unless otherwise specifically defined. All directional indicators (such as

up, down, left, right, front and back) in the embodiments of the disclosure are only used to explain the relative position relationship and movement situation among components in a certain specific posture (as shown in the appended drawings). If the specific posture changes, the directional indicators will change accordingly. Furthermore, terms "include" and "have" and any variations thereof are intended to cover non-exclusive inclusion. For example, a process, method, system, product or device including a series of steps or units is not limited to the listed steps or units, but may optionally include steps or units not listed, or may optionally include other steps or units inherent to the process, method, product or device.

[ 0038] Reference to an "embodiment" herein means that a particular feature, structure or characteristic described in connection with an embodiment may be included in at least one embodiment of the present disclosure. The appearance of this phrase in various places in the specification does not necessarily mean the same embodiment, nor is it an independent or alternative embodiment mutually exclusive with other embodiments. Those skilled in the art understand explicitly and implicitly that the embodiments described herein may be combined with other embodiments.

[ 0039] Due to the diversity of application scenarios, the deployment difficulty of the positioning system needs to be considered. Spending a lot of time on environment modeling often leads to poor user experience and more waste of time. In addition, the positioning system requires a lot of computing resources, but it is often lacking in accuracy and high in cost. For example, many robots may be usually used for teaching in schools. If high-performance computing devices are embedded in robots to support various positioning algorithms, the cost of the robots will increase greatly, and it is difficult to make high-performance embedded positioning devices at low cost. Therefore, limited hardware resources are required for achieving a better positioning result and obtaining a set of robot positioning system with high precision, low cost and easy deployment.

[ 0040] The embodiments of the disclosure provide a robot positioning method and apparatus, a device, and a storage medium. Herein, a movement parameter of a robot from a first moment to a second moment is collected by acquiring first position information of the robot at a first moment and first estimated position information of the robot at the second moment; second estimated position information of the robot at the second moment is calculated based on the first position information and the movement parameter; and second position information of the robot at the second moment is obtained through the first estimated position information and the second estimated position information. According to the embodiment of the disclosure, a vision positioning system and a dynamic positioning system are combined and fused to obtain a robot positioning result with higher precision.

[ 0041] The vision positioning system performs positioning based on an image obtained by a camera, while the dynamic positioning system performs positioning based on an initial position of the robot and a walking parameter of the robot. When the vision positioning system performs positioning, a second image of the robot at the second moment is acquired through the camera, and the first estimated position information of the robot on a simulated sand table is determined based on the second image in combination with the simulated sand table. When the dynamic positioning system performs positioning, the movement parameter of the robot from the first moment to the second moment and the orientation of the robot are acquired, that is, a traveling distance of the robot towards a certain direction may be determined by the orientation and movement parameter of the robot, and the second estimated position information of the robot at the second moment may be obtained by combining the first position information of the robot at the first moment. Here, in order to

accurately locate the robot, the first estimated position information obtained by the vision positioning system and the second estimated position information obtained by the dynamic positioning system are fused by means of a Kalman filter, that is, weighted averaging, and finally the more accurate second position information of the robot at the second moment is acquired.

[ 0042] An executive subject of the robot positioning method may be a robot positioning device, for example, the robot positioning method may be executed by terminal equipment or a server or other processing equipment. Herein, the terminal equipment may be User Equipment (UE), mobile equipment, a user terminal, a terminal, a cellular phone, a cordless phone, Personal Digital Assistant (PDA), a handheld device, a computing device, a vehicle-mounted device, a wearable device, etc. In some possible implementations, the robot positioning method may be implemented in a manner that a processor calls a computer readable instruction stored in a memory.

[ 0043] The disclosure is elaborated in detail below with reference to the drawings and embodiments.

[ 0044] Referring to FIG. 1, a schematic flowchart of an embodiment of a robot positioning method according to an embodiment of the disclosure is shown. The following operations are included.

[ 0045] At S11, first position information of a robot at a first moment is acquired.

[ 0046] In an implementation mode of the embodiment of the present disclosure, when the robot is located, the first position information of the robot at the first moment and first estimated position information of the robot at a second moment may be directly acquired by using a positioning system. The positioning system may be Global Positioning system (GPS).

[ 0047] In an implementation mode of the embodiment of the present disclosure, a first image of the robot at the first moment may also be acquired by a photographic apparatus such as a camera. The robot is a mobile mechanical device or intelligent device, such as a forklift and a mechanical trolley.

[ 0048] In a feasible embodiment, a timer may be integrated in the camera, and when the timer reaches the first moment, the camera takes a picture of the robot to obtain the first image. The position of the camera may or may not be fixed. The shooting angle of the camera may or may not be fixed. Here, the camera may be installed at a certain position and cannot rotate, that is, its shooting range is fixed. The camera may also be installed at a certain position and can rotate, that is, its reflection range is variable. Of course, the camera may also be installed on a mobile device. The disclosure does not limit the position and shooting range of the camera, as long as it can shoot the robot.

[ 0049] In a feasible embodiment, the first image acquired by the camera may be uploaded to the robot positioning device, for example, the robot positioning device is in communication connection with the camera, and after the camera acquires the first image, the first image is sent to the robot positioning device through communication connection. In another embodiment, the first image acquired by the camera may also be saved in a memory card and then uploaded to the robot positioning device, which is not limited in detail as long as the robot positioning device can acquire the first image.

[ 0050] Here, the first image is uploaded to the robot positioning device so that the robot positioning device may obtain the first position information of the robot at the first moment based on the first image by using the vision system. For details, reference may be made to FIG. 1.

[ 0051] The robot positioning device uses the vision system to acquire the first position

information of the robot at the first moment based on the first image. In a feasible embodiment, the first image may be combined by means of scene modeling to determine the first position information of the robot. Here, referring to FIG. 2, a schematic flowchart of an embodiment of a step S11 in FIG. 1 according to an embodiment of the disclosure is shown, which specifically includes the following operations.

[ 0052] At S111, a first reference object on the simulated sand table is acquired.

[ 0053] In an implementation mode of the embodiment of the present disclosure, the first position information of the robot is determined by establishing the simulated sand table. It is to be understood that the established simulated sand table is a simulated design diagram of the space where the robot is located.

[ 0054] The simulated sand table is established according to a scenario where the robot is located. The simulated sand table may be established on a scale of 1:1 to the scenario where the robot is located. For example, the sizes, positions and coordinates of all objects on the simulated sand table are the same as those of all objects in the scenario where the robot is located. Of course, the simulated sand table may also be established on a scale of 1:2. For example, the sizes, positions and coordinates of all objects on the simulated sand table are twice or half the sizes, positions and coordinates of all objects in the scenario where the robot is located. Of course, the simulated sand table may also be established according to other scales, which is not limited in the present disclosure.

[ 0055] In a feasible embodiment, considering the simplicity of calculation, the simulated sand table may be established on the scale of 1:1, so that the scale conversion is not required in the subsequent calculation process, and the calculation amount is reduced. In another embodiment, considering the space occupied by the simulated sand table, for example, if the scenario where the robot is located is too large, the simulated sand table may be established on a scale of 1:2, 1:3, 1:4, etc., so as to reduce the space occupied by the simulated sand table. For example, all the above processes may be performed in the robot positioning device. The simulated sand table is established in the robot positioning device. In the case that the robot positioning device acquires the first image from the camera, the robot positioning device uses the vision system to determine the first position information of the robot based on the simulated sand table and the first image.

[ 0056] When the robot is located by using the vision system, the first image and the simulated sand table need to have the first reference object at the same time. The first reference object may be used to calculate a first projection relationship of the first image projected to the simulated sand table. Here, the first reference object may be selected according to the first image. For example, if the first image includes the same table as that on the simulated sand table besides the robot, the table may be used as the first reference object. For another example, if the first image includes the same television as that on the simulated sand table besides the robot, the television may be used as the first reference object, that is, the first reference object is an object shared by the first image and the simulated sand table.

[ 0057] At S112, the pixel position of the first reference object and the first pixel position of the robot in the first image are determined.

[ 0058] In an embodiment, the first image may be identified by using a first deep learning network to determine the pixel position of the first reference object and the first pixel position of the robot in the first image.

[ 0059] In an embodiment, the first deep learning network may be a model integrated with a deep learning network with a positioning function. The first image is input into the model, and the model identifies the first image, thereby obtaining the pixel position of the

first reference object in the first image and the first pixel position of the robot in the first image.

[ 0060] In an implementation mode of an embodiment, the first deep learning network is used to detect the first image to determine the pixel position of the first reference object in the first image and the first pixel position of the robot in the first image. The first deep learning network may include a Region-CNN (RCNN) deep network structure, a Single Shot MultiBox Detector (SSD) deep network structure, a You Only Look Once (Yolo) deep network structure, a RetinaNet network structure, etc.

[ 0061] In an implementation mode of an embodiment, considering the cost and the accuracy of position coordinate detection, the position coordinate detection may be performed through the Yolo deep network structure. Detection may be performed by using a Yolo-tiny deep network structure in the Yolo deep network structure.

[ 0062] In the Yolo deep network structure, the idea of its algorithm is to divide the whole graph into some square lattices, predict some possible bounding boxes of an object whose center falls in a lattice in a cell, and give confidence. Such an algorithm may obtain the result of an object detection box in one step, which is faster than two-stage Faster-RCNN series algorithms. Since the shape and color of the object to be detected in an application scenario are relatively fixed, this fast algorithm with a small network structure has higher detection accuracy and occupies less computing resources. Required real-time detection effect may be achieved on a Central Processing Unit (CPU) with slow operation speed on a mobile terminal, such as Raspberry Pi, and the required cost is lower.

[ 0063] The pixel position of the first reference object and the first pixel position of the robot acquired on the first image may be representative points. For example, the pixel position of a center point of the first reference object and the pixel position of a center point of the robot may be acquired on the first image, the pixel position of a frame of the first reference object and the pixel position of a frame of the robot may also be acquired, and the pixel positions of diagonal lines of the frame of the first reference object and the pixel positions of diagonal lines of the frame of the robot may also be selected, which is not specifically limited.

[ 0064] Since the image is formed by a plurality of red sub-pixel (R), green sub-pixel (G) and blue sub-pixel (B) pixel points which are superimposed to produce different colors, the pixel positions of the robot and the first reference object in the first image may be obtained by using the first deep learning network, where the first pixel position of the robot in the first image is the position of the sub-pixel in the image.

[ 0065] At S113, the simulated position of the first reference object on the simulated sand table at the first moment is determined.

[ 0066] The first reference object selected in the first image and the first reference object selected on the simulated sand table are the same object. After the simulated sand table is established, the simulated positions of all objects on the simulated sand table are known.

[ 0067] In the embodiment of the present disclosure, when the simulated position of the first reference object is obtained, it is necessary to correspond to the pixel position of the first reference object to perform determination. For example, in an embodiment, in the case that the acquired pixel position of the first reference object is the pixel position of the center point of the first reference object, the acquired simulated position of the first reference object is the simulated position of the center point of the first reference object. For another example, in the case that the acquired pixel position of the first reference object is the pixel position of the frame of the first reference object, the acquired simulated position of the first reference object is the simulated position of the frame of the first reference object.

[ 0068] At S114, the first projection relationship is calculated by using the pixel position of the first reference object and the simulated position of the first reference object on the simulated sand table.

[ 0069] Here, after the pixel position of the first reference object in the first image and the simulated position of the first reference object in the simulated sand table are determined in the manners of the above steps S112 and S113, the first projection relationship may be calculated by using the pixel position of the first reference object in the first image and the simulated position of the first reference object on the simulated sand table.

[ 0070] In an embodiment, it is assumed that the acquired pixel position of the first reference object in the first image is the pixel position of the center point of the first reference object, and the simulated position of the first reference object on the simulated sand table is the simulated position of the center point of the first reference object. Assuming that the pixel position of the center point of the first reference object is (u, v, w) and the simulated position of the center point of the first reference object is (x', y', w'), a relation equation is established based on the pixel position (u, v, w) of the center point of the first reference object and the simulated position of the center point of the first reference object.

[ 0071] The relation equation is established by the pixel position (u, v, w) of the center point of the first reference object and the simulated position of the center point of the first reference object as shown in the following formula (1).

$$(x', y', w') = (u, v, w) \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \quad (1)$$

In the formula (1),  $\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$  is the first projection relationship.

[ 0072] In the embodiment of the disclosure, there are more than three reference objects to be selected, and the pixel positions of the center points of a plurality of reference objects on the first image and the simulated positions on the simulated sand table may be acquired respectively, and then multiple sets of relation equations are established and solved by the above formula (1). When the obtained results are inconsistent, multiple projection relationships may be processed by weighted averaging and other methods to acquire accurate results. Here, on the same first image, the first projection relationships of different first reference objects projected onto the simulated sand table are the same.

[ 0073] In an embodiment, since the first image is a two-dimensional image and the acquired position coordinates of the first reference object on the first image are also two-dimensional coordinates, w in the pixel position (u, v, w) of the first reference object in the first image is a constant, which is not a number expressed by Z coordinate. Here, w may be 1. Specifically, since all objects are set relative to the ground, the simulated sand table established in the solution is a two-dimensional simulated sand table, the simulated position (x', y', w') of the first reference object on the simulated sand table is also two-dimensional coordinates, that is, w' is also a constant, which is also not a number expressed by the Z coordinate. Here, w' may also be 1. Therefore, the number a<sub>33</sub> in the lower right corner of the first projection relationship described in the formula (1) is always 1.

[ 0074] It is to be seen that there are eight unknowns in the first projection relationship in the formula (1), and it is necessary to calculate four pairs of coordinates to get the results

of these eight unknowns. Each pair of coordinates includes a pixel position in the first image and a simulated position on the simulated sand table. The four pairs of coordinates may be selected on the same first reference object, four pixel positions in the first image are selected on the same first reference object, and then four simulated positions on the simulated sand table are selected. Here, the first reference object may be the same as or different from the first reference object used in establishing the relation equation. The four selected points may be the same as or different from those selected in the first reference object and used in establishing the relation equation.

[ 0075] Here, when the relation equation is solved, in order to effectively improve the accuracy and robustness of the calculation result of the first projection relation, a random sampling consistency algorithm may be used for calculation, and finally the first projection relation is output. The random sampling consistency algorithm may estimate the parameters of a mathematical model from a group of observation data sets containing "outliers" in an iterative manner, which can improve the accuracy and robustness of the calculation of the first projection relationship.

[ 0076] According to the embodiment of the present disclosure, the relation equation is established by the pixel position of the first reference object in the first image and the simulated position in the simulated sand table, and the relation equation is solved to obtain the first projection relationship. The accuracy and robustness of the calculation of the first projection relationship are improved by combining the random sampling consistency algorithm for calculation.

[ 0077] At S115, the simulated position of the robot on the simulated sand table is calculated based on the first projection relationship and the first pixel position of the robot.

[ 0078] In the embodiment of the present disclosure, in the case that the first pixel position of the robot in the first image has been acquired at S112, and the first projection relationship of the first image projected onto the simulated sand table has been acquired at S114, the simulated position of the robot on the simulated sand table may be calculated through the first projection relationship and the first pixel position of the robot. The simulated position of the robot in the simulated sand table is determined by the above formula (1).

[ 0079] At S116, the first position information of the robot at the first moment is determined by using the simulated position of the robot on the simulated sand table.

[ 0080] In an embodiment, in the case that the simulated sand table is established on a scale of 1:1 to a real scenario, the simulated position of the robot on the simulated sand table that may be calculated is the first position information of the robot at the first moment. However, in the case that the simulated sand table is established on a scale of 1:2 to the real scenario, after calculating the simulated position of the robot on the simulated sand table, it is necessary to perform conversion through the relevant scale, so as to obtain the first position information of the robot at the first moment.

[ 0081] According to the embodiment of the present disclosure, the simulated sand table is established and the calculation of the first projection relation is performed by taking objects existing on the simulated sand table as reference objects. The method does not need to additionally set markers on the sand table, thus simplifying the operation. It identifies the pixel position of the robot on the first image through deep learning, determines the simulated position of the robot on the simulated sand table in combination with the first projection relationship, and then determines the first position information of the robot at the first moment. The positioning process of the robot simplifies the operation, reduces the cost and greatly improves the user experience.

- [ 0082] In an embodiment, when the first position information of the robot at the first moment is acquired, it is also necessary to detect the orientation of the robot, that is, to detect the angle of the robot.
- [ 0083] Here, the orientation of the robot may be detected by an angle and attitude estimation model. Firstly, the first image is identified by the first deep learning network, and the position of the robot is acquired in the first image. Then, an area image in which the robot is located is extracted, the extracted area image is input into an angle estimation model, and the angle of the robot is detected by the angle estimation model, so as to obtain the orientation of the robot. Here, after the orientation of the robot is acquired, the moving direction of the robot from the first moment to the second moment may be known.
- [ 0084] A second deep learning network may be integrated into the angle estimation model, and the second deep learning network is used to identify the area image in which the robot is located, so as to determine the orientation of the robot. The second deep learning network may be a convolutional neural network structure used for numerical regression in the related art, such as a ResNet deep network structure, a MobileNet deep network structure, a GhostNet deep network structure, an EfficientNet deep network structure, etc.
- [ 0085] At S12, a second image of the robot at the second moment is acquired, and first estimated position information of the robot at the second moment is acquired based on the second image.
- [ 0086] In the embodiment of the present disclosure, after the first position information of the robot at the first moment is acquired, the first estimated position information of the robot at the second moment may also be continuously acquired. The second image of the robot at the second moment may be acquired by the camera, and then the first estimated position information of the robot at the second moment is acquired based on the second image. Referring to FIG. 3 for details, a schematic flowchart of an embodiment of a step S12 in FIG. 1 according to an embodiment of the disclosure is shown, which includes the following specific operations.
- [ 0087] At S121, the second reference object on the simulated sand table is acquired.
- [ 0088] At S122, the pixel position of the second reference object and the second pixel position of the robot in the second image are determined.
- [ 0089] At S123, the simulated position of the second reference object on the simulated sand table at the second moment is determined.
- [ 0090] At S124, a second projection relationship is calculated by using the pixel position of the second reference object and the simulated position of the second reference object on the simulated sand table.
- [ 0091] At S125, the simulated position of the robot on the simulated sand table is calculated based on the second projection relationship and the second pixel position of the robot.
- [ 0092] At S126, the first estimated position information of the robot at the second moment is determined by using the simulated position of the robot on the simulated sand table.
- [ 0093] The specific processes of steps S121 to S126 are the same as those of steps S111 to S116 shown in FIG. 2, and will not be repeated here.
- [ 0094] According to the robot positioning method provided by the embodiments of the present disclosure, on one hand, the vision system is used to establish the simulated sand table, so that the projection relationship is obtained first, and then the first position information of the robot at the first moment and the first estimated position information at

the second moment are obtained; on the other hand, the dynamic system is used to obtain the second estimated position information of the robot at the second moment by detecting the initial orientation of the robot, the moving distance from the first moment to the second moment and the initial position information; then, the second position information of the robot, namely the final position information, is determined by fusing the result of the vision system and the result of the dynamic system by means of the Kalman filter. It employs multi-terminal fusion for positioning, which improves the accuracy of global positioning, reduces the hardware cost and makes the system easy to deploy. In addition, when the first estimated position information is obtained through the vision system, the simulated sand table is established, and no additional calibration reference object is needed, thereby reducing the calibration moments.

[ 0095] At S13, the movement parameter of the robot from the first moment to the second moment is collected.

[ 0096] In an implementation mode of the embodiment of the present disclosure, the movement parameter of the robot is acquired from the first moment to the second moment. Referring to FIG. 4 for details, a schematic flowchart of an embodiment of a step S13 in FIG. 1 according to an embodiment of the disclosure is shown, which includes the following specific operations.

[ 0097] At S131, a historical movement parameter of the robot is acquired at the first moment.

[ 0098] It is to be understood that when the robot is moving, an encoder inside the robot may record the walking distance of the robot, and the historical walking distance of the robot may be reflected in a steering engine. Therefore, in an embodiment of the present disclosure, at the first moment, the robot positioning device may record the historical walking information of the robot, namely, the historical movement parameter, through the encoder and steering engine of the robot. Here, the historical movement parameter of the robot may be acquired while the first image of the robot is shot.

[ 0099] At S132, a current movement parameter of the robot is acquired at the second moment.

[ 00100] In an implementation mode of the embodiment of the present disclosure, at the second moment, the information of the encoder and the steering engine of the robot is read again, and then the current movement parameter of the robot is obtained.

[ 00101] The historical movement parameter includes the historical moving distance of the robot, for example, the historical rotation number of a wheel of the robot. The current movement parameter may be the rotation number of the wheel of the robot at the second moment.

[ 00102] At S133, the movement parameter of the robot from the first moment to the second moment is calculated through the historical movement parameter and the current movement parameter.

[ 00103] For example, assuming that the historical movement parameter of the robot at the first moment is 100 meters and the current movement parameter detected at the second moment is 101 meters, it may be found that the robot has moved 1 meter in total from the first moment to the second moment. Or, assuming that the historical movement parameter of the robot at the first moment is the historical rotation number of the wheel being 200 turns, and the current movement parameter at the second moment is the rotation number of the wheel being 250 turns, it may be known that the robot has rotated 50 turns from the first moment to the second moment, that is, the total moving distance of the robot from the first moment to the second moment may be calculated by the diameter of the wheel and

the like.

- [ 00104] In the embodiment of the present disclosure, in the case that the orientation of the robot at the first moment has been obtained, the moving distance of the robot from the first moment to the second moment is also known, and the first position information of the robot at the first moment is known, the second estimated position information of the robot at the second moment may be obtained. Reference is continuously made to FIG. 1 for details.
- [ 00105] According to the robot positioning method provided by the embodiments of the present disclosure, on one hand, the vision system is used to establish the simulated sand table, so that the projection relationship is obtained first, and then the first position information of the robot at the first moment and the first estimated position information at the second moment are obtained; on the other hand, the dynamic system is also used to obtain the second estimated position information of the robot at the second moment by detecting the initial orientation of the robot, the moving distance from the first moment to the second moment and the initial position information; then, the second position information of the robot, namely the final position information, is determined by fusing the result of the vision system and the result of the dynamic system by means of Kalman filter. It employs a multi-terminal fusion positioning manner, which not only improves the accuracy of global positioning and reduces the hardware cost, but also makes the system easy to deploy. In addition, when the first estimated position information is obtained through the vision system, the simulated sand table is established, and no additional calibration reference object is needed, reducing the calibration moments.
- [ 00106] At S14, the second estimated position information of the robot at the second moment is calculated based on the first position information and the movement parameter.
- [ 00107] In the embodiment of the disclosure, through the above steps, in the case that the orientation of the robot at the first moment is known, the moving distance from the first moment to the second moment is also known, and the first position information of the robot at the first moment is known, the second estimated position information of the robot at the second moment may be calculated in combination with the moving distance and orientation on the basis of the first position information, namely through the dynamic system.
- [ 00108] In an embodiment, in order to detect the position information of the robot in real time, the interval between the first moment and the second moment is very short, for example, the interval time may be 1 second. In another embodiment, in the case that the direction of the robot changes from the first moment to the second moment, the robot is continuously photographed from the first moment to the second moment, and the orientation of the robot is detected based on the shot images. When the robot is photographed, the moving distance of the robot may be detected at the same time, so that the moving distance in each direction may be recorded in real time in the case that the orientation of the robot changes.
- [ 00109] It is to be understood that in order to accurately acquire the position of the robot, the interval time between the first moment and the second moment may be set as short as possible, so that it is to be considered that the direction of the robot may not change during the process from the first moment to the second moment.
- [ 00110] In an implementation, at least one camera may be arranged in a site where the robot is located, and the camera is connected with the robot positioning device. A timer is arranged in the robot positioning device or the camera, and the interval time from the first moment to the second moment is set as a timing moment of the timer. At the timing moment, the camera acquires the image of the robot and the movement parameter of the

robot, and transmits the image to the robot positioning device. The robot positioning device obtains the first estimated position information of the robot at the second moment by using the vision system in the manner shown in FIG. 3 above, and calculates the second estimated position information of the robot at the second moment by using the dynamic system in combination with the initial position information (i.e., the first position information), the orientation and movement parameters of the robot.

[ 00111] The manner of acquiring the first estimated position information of the robot at the second moment by using the second image is the same as the manner of acquiring the first position information of the robot at the first moment by using the first image, that is, both the simulated sand table and the second image contain a second reference object. Firstly, the pixel position of the second reference object and the second pixel position of the robot are acquired from the second image, and the simulated position of the second reference object is acquired from the simulated sand table. A second projection relationship is calculated based on the pixel position of the second reference object and the simulated position of the second reference object. Then, the simulated position of the robot on the simulated sand table is calculated through the second projection relationship and the second pixel position of the robot. Then, the first estimated position information of the robot at the second moment is determined by using the simulated position of the robot on the simulated sand table. Reference is continuously made to FIG. 3 for details, which will not be repeated here.

[ 00112] At S15, the second position information of the robot at the second moment is obtained through the first estimated position information and the second estimated position information.

[ 00113] In an embodiment, weighted averaging may be performed on the first estimated position information and the second estimated position information by means of the Kalman filter so as to obtain the second position information of the robot at the second moment.

[ 00114] In another embodiment, the first estimated position information and the second estimated position information may also be fused by means of a mean statistics method and a Gaussian Mixture Model (GMM), so as to obtain the second position information.

[ 00115] In the positioning method shown in the embodiment of the disclosure, the first estimated position information and the second estimated position information may be subjected to weighted averaging by means of Kalman filter, so as to obtain the second position information of the robot at the second moment. Here, since the first estimated position information obtained by the vision positioning system is known, and the second estimated position information obtained by the dynamic system is known, state prediction may be first performed on the first estimated position information and the second estimated position to obtain a covariance prediction result. Then, the covariance prediction result is updated to obtain an updated covariance, and then the second position information is obtained through the updated covariance.

[ 00116] According to the disclosure, the position estimation of the extended Kalman filter at different time nodes may be obtained through evolution in discrete time.

[ 00117] It is to be seen that the embodiment of the present disclosure combines the visual positioning system with the dynamic positioning system and fuses the positioning results to obtain the positioning result of the robot with higher accuracy. Referring to FIG. 5, a schematic diagram of the principle of a robot positioning method according to an embodiment of the disclosure is shown. The positioning process of the vision positioning system mainly includes: (1) the camera reads the image; (2) a YOLO-tiny detector detects

a vehicle, that is, detects the vehicle, namely the robot in the image, to obtain regional coordinates in the image where the robot is located; (3) Mobilenet calculates the angle, that is, the area image where the robot is located is extracted and sent to an attitude estimation module to implement attitude estimation; and (4) plane vision positioning is performed, that is, a calibration parameter is used to map the attitude and coordinates in the image back to real coordinates. On the other hand, the positioning process of the dynamic positioning system mainly includes: (1) the information of the encoder and the steering engine of the vehicle is acquired, that is, based on the information, the historical movement parameter and current movement parameter of the robot, namely the walking information of the robot are obtained; and (2) the position is estimated through a vehicle dynamics model, that is, the current position information of the robot is estimated by the model based on the historical movement parameter and the current movement parameter. Then, the result obtained by the video positioning system and the result obtained by the dynamic system are fused by the extended Kalman filter, so as to realize accurate positioning of the robot.

[ 00118] According to the robot positioning method provided by the embodiment of the present disclosure, on one hand, the vision system is used to establish the simulated sand table, so that the projection relationship is obtained first, and then the first position information of the robot at the first moment and the first estimated position information at the second moment are obtained; on the other hand, the dynamic system is used to obtain the second estimated position information of the robot at the second moment by detecting the initial orientation of the robot, the moving distance from the first moment to the second moment and the initial position information; then, the second position information of the robot, namely the final position information, is determined by fusing the results of the vision system and the dynamic system by means of the Kalman filter. The positioning manner employs a multi-terminal fusion manner, which not only improves the accuracy of global positioning and reduces the hardware cost, but also makes the system easy to deploy. In addition, when the first estimated position information is obtained through the vision system, the simulated sand table is established, and no additional calibration reference object is needed, reducing the calibration moments.

[ 00119] Referring to FIG. 7, a schematic structural diagram of an embodiment of a robot positioning device according to an embodiment of the disclosure is shown, which includes: a first position acquisition part 41, a parameter acquisition part 42, a second position acquisition part 43 and a calibration part 44.

[ 00120] The first position acquisition part 41 is configured to acquire first position information of the robot at a first moment; and the first position acquisition part 41 is further configured to acquire a second image of the robot at a second moment and acquire first estimated position information of the robot at the second moment based on the second image.

[ 00121] In some embodiments, when the robot is located, the first position information of the robot at the first moment and the first estimated position information of the robot at the second moment may be directly acquired by using the positioning system. The positioning system may be a GPS positioning system.

[ 00122] In some embodiments, the first image of the robot at the first moment may also be acquired by a photographic apparatus, such as a camera. The robot is a mobile mechanical device or robot positioning device, such as a forklift or a mechanical trolley.

[ 00123] In some embodiments, a timer may be integrated in the camera, and when the timing length of the timer reaches the first moment, the camera takes a picture of the robot

to obtain the first image. The position of the camera may or may not be fixed. The shooting angle of the camera may or may not be fixed. Here, the camera may be installed at a certain position and cannot rotate, that is, its shooting range is fixed. The camera may also be installed at a certain position and can rotate, that is, its reflection range is variable. Of course, the camera may also be installed on a mobile device. The disclosure does not limit the position and shooting range of the camera, as long as it can shoot the robot.

[ 00124] In some embodiments, the first position acquisition part 41 is further configured to acquire the first image of the robot at the first moment and acquire the first position information of the robot at the first moment based on the first image.

[ 00125] In some embodiments, the first image acquired by the camera may be uploaded to the robot positioning device, for example, the robot positioning device is in communication connection with the camera, and after the camera acquires the first image, the first image is sent to the robot positioning device through communication connection. In another embodiment, the first image acquired by the camera may also be saved in a memory card and then uploaded to the robot positioning device, which is not limited in detail as long as the robot positioning device can acquire the first image.

[ 00126] In some embodiments, the first position acquisition part 41 is further configured to acquire a first reference object on a simulated sand table and determine the first position information of the robot by establishing the simulated sand table. It is to be understood that the established simulated sand table is a simulated design diagram of the space where the robot is located. The pixel position of the first reference object and the first pixel position of the robot in the first image are determined.

[ 00127] In some embodiments, the first image may be identified by using the first deep learning network, and then the pixel position of the first reference object and the first pixel position of the robot in the first image are determined.

[ 00128] In some embodiments, the first deep learning network may be a model integrated with a deep learning network with a positioning function. The first image is input into the model, and the model identifies the first image, thereby obtaining the pixel position of the first reference object in the first image and the first pixel position of the robot in the first image.

[ 00129] Here, the first deep learning network is used to detect the first image to determine the pixel position of the first reference object in the first image and the first pixel position of the robot in the first image. Its feasible first deep learning network includes the RCNN deep network structure, the SSD deep network structure, the Yolo deep network structure, the RetinaNet network structure, etc.

[ 00130] Considering the cost and the accuracy of position coordinate detection, the position coordinate detection may be performed through the Yolo deep network structure. Herein, detection may be performed by using the Yolo-tiny deep network structure in the Yolo deep network structure.

[ 00131] In the Yolo deep network structure, the idea of its algorithm is to divide the whole graph into some square lattices, predict some possible bounding boxes of an object whose center falls in a lattice in a cell, and give confidence. Such an algorithm may obtain the result of an object detection box in one step, which is faster than two-stage Faster-RCNN series algorithms. Since the shape and color of the object to be detected in the application scenario are relatively fixed, this fast algorithm with the small network structure has higher detection accuracy and occupies less computing resources. Required real-time detection effect may be achieved on the CPU with slow operation speed on the mobile terminal, such as Raspberry Pi, and the required cost is lower.

- [ 00132] In some embodiments, it is necessary to determine the pixel position of the first reference object to acquire the simulated position of the first reference object, and calculate the first projection relationship by using the pixel position of the first reference object and the simulated position of the first reference object on the simulated sand table.
- [ 00133] In some embodiments, the first position acquisition part 41 is further configured to acquire a second reference object on the simulated sand table. The pixel position of the second reference object and the second pixel position of the robot in the second image are determined. The simulated position of the second reference object on the simulated sand table at the second moment is determined. A second projection relationship is calculated by using the pixel position of the second reference object and the simulated position of the second reference object on the simulated sand table. The simulated position of the robot on the simulated sand table is calculated based on the second projection relationship and the second pixel position of the robot. The first estimated position information of the robot at the second moment is determined by using the simulated position of the robot on the simulated sand table.
- [ 00134] According to the embodiment of the present disclosure, the simulated sand table is established and the calculation of the first projection relation is performed by taking objects existing on the simulated sand table as reference objects. It does not need to additionally set markers on the sand table, thus simplifying the operation. It identifies the pixel position of the robot on the first image through deep learning, determines the simulated position of the robot on the simulated sand table in combination with the first projection relationship, and then determines the first position information of the robot at the first moment. The positioning process of the robot simplifies the operation, reduces the cost and greatly improves the user experience.
- [ 00135] In some embodiments, the first position acquisition part 41 is further configured to also detect the orientation of the robot, that is, to detect the angle of the robot when the first position information of the robot at the first moment is acquired. Here, the orientation of the robot may be detected by an angle and attitude estimation model.
- [ 00136] Firstly, the first image is identified by the first deep learning network, and the position of the robot is acquired in the first image. Then, an area image in which the robot is located is extracted, the extracted area image is input into an angle estimation model, and the angle of the robot is detected by the angle estimation model, so as to obtain the orientation of the robot. Here, after the orientation of the robot is acquired, the moving direction of the robot from the first moment to the second moment may be known.
- [ 00137] In some embodiments, the second deep learning network may be integrated into the angle estimation model, and the second deep learning network is used to identify the area image in which the robot is located, so as to determine the orientation of the robot. The second deep learning network may be a convolutional neural network structure used for numerical regression in the related art, such as the ResNet deep network structure, the MobileNet deep network structure, the GhostNet deep network structure, the EfficientNet deep network structure, and so on.
- [ 00138] In some embodiments, the parameter acquisition part 42 is configured to collect the movement parameter of the robot from the first moment to the second moment. A historical movement parameter of the robot is acquired at the first moment.
- [ 00139] When the robot is moving, an encoder inside the robot may record the walking distance of the robot, and the historical walking distance of the robot may be reflected in a steering engine. Therefore, at the first moment, the robot positioning device may record the historical walking information of the robot, namely, the historical movement

parameter, through the encoder and steering engine of the robot. Here, the historical movement parameter of the robot may be acquired while the first image of the robot is shot.

[ 00140] Subsequently, a current movement parameter of the robot continues to be acquired at the second moment. At the second moment, the robot positioning device may read the information of the encoder and the steering engine of the robot again, so as to obtain the current movement parameter of the robot.

[ 00141] The historical movement parameter includes the historical moving distance of the robot, for example, the historical rotation number of a wheel of the robot. The current movement parameter may be the rotation number of the wheel of the robot at the second moment. The movement parameter of the robot from the first moment to the second moment is calculated through the historical movement parameter and the current movement parameter. Here, assuming that the historical movement parameter of the robot at the first moment is 100 meters and the current movement parameter detected at the second moment is 101 meters, it may be found that the robot has moved 1 meter in total from the first moment to the second moment. Or, in another embodiment, assuming that the historical movement parameter of the robot at the first moment is the historical rotation number of the wheel being 200 turns, and the current movement parameter at the second moment is the rotation number of the wheel being 250 turns, it may be known that the robot has rotated 50 turns from the first moment to the second moment, that is, the total moving distance of the robot from the first moment to the second moment may be calculated by the diameter of the wheel and the like.

[ 00142] The second position acquisition part 43 is configured to calculate the second estimated position information of the robot at the second moment based on the first position information and the movement parameter. Here, in the case that the orientation of the robot at the first moment is known, the moving distance from the first moment to the second moment is also known, and the first position information of the robot at the first moment is known, the second estimated position information of the robot at the second moment may be calculated in combination with the moving distance and orientation on the basis of the first position information, namely through the dynamic system.

[ 00143] In some embodiments, in order to detect the position information of the robot in real time, the interval between the first moment and the second moment is very short, for example, the interval time may be 1 second. In another embodiment, in the case that the direction of the robot changes from the first moment to the second moment, the robot is continuously photographed from the first moment to the second moment, and the orientation of the robot is detected based on the photographed images. When the robot is photographed, the moving distance of the robot may be detected at the same time, so that the moving distance in each direction may be recorded in real time in the case that the orientation of the robot changes.

[ 00144] It is to be understood that in order to accurately acquire the position of the robot, the interval time between the first moment and the second moment may be set as short as possible, so that it is to be considered that the direction of the robot may not change during the process from the first moment to the second moment.

[ 00145] In some embodiments, at least one camera may be arranged in a site where the robot is located, and the camera is connected with the robot positioning device. A timer is arranged in the robot positioning device or the camera, and the interval time from the first moment to the second moment is set as a timing moment of the timer. At the timing moment, the camera acquires the image of the robot and the movement parameters of the

robot, and transmits the image to the robot positioning device. The robot positioning device obtains the first estimated position information of the robot at the second moment by using the vision system in the manner shown in FIG. 3 above, and calculates the second estimated position information of the robot at the second moment by using the dynamic system in combination with the initial position information (i.e., the first position information), the orientation and movement parameters of the robot.

[ 00146] The calibration part 44 is configured to obtain second position information of the robot at the second moment through the first estimated position information and the second estimated position information. In some embodiments of the present disclosure, the first estimated position information and the second estimated position information may be subjected to weighted averaging by means of Kalman filter so as to obtain the second position information of the robot at the second moment.

[ 00147] In other embodiments, the first estimated position information and the second estimated position information may also be fused by means of a mean statistics method and a GMM, so as to obtain the second position information.

[ 00148] According to the robot positioning method provided by the embodiments of the present disclosure, on one hand, the vision system is used to establish the simulated sand table, so that the projection relationship is obtained first, and then the first position information of the robot at the first moment and the first estimated position information at the second moment are obtained; on the other hand, the dynamic system is used to obtain the second estimated position information of the robot at the second moment by detecting the initial orientation of the robot, the moving distance from the first moment to the second moment and the initial position information; then, the second position information of the robot, namely the final position information, is determined by fusing the result of the vision system and the result of the dynamic system by means of Kalman filter. The positioning manner employs a multi-terminal fusion manner, which not only improves the accuracy of global positioning and reduces the hardware cost, but also makes the system easy to deploy. In addition, when the first estimated position information is obtained through the vision system, the simulated sand table is established, and no additional calibration reference object is needed, reducing the calibration moments.

[ 00149] Referring to FIG. 7, a schematic structural diagram of an embodiment of a robot positioning device according to an embodiment of the disclosure is shown. A memory 52 and a processor 51, which are connected to each other, are included.

[ 00150] The memory 52 is configured to store a program instruction for implementing any one of the robot positioning methods described above.

[ 00151] The processor 51 is configured to execute the program instruction stored in the memory 52.

[ 00152] Herein, the processor 51 may also be called CPU. The processor 51 may be an integrated circuit chip with signal processing capability. The processor 51 may also be a general-purpose processor, a Digital Signal Processing (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA) or another programmable logic device, a discrete gate or transistor logic device, or a discrete hardware component. The general-purpose processor may be a microprocessor or the processor may be any conventional processor, etc.

[ 00153] The memory 52 may be a memory bank, TF card, etc., and may store all the information in the robot positioning device, including the input original data, a computer program, an intermediate operation result and a final operation result. It stores and retrieves information according to the location specified by a controller. With the memory, the robot

positioning device has the memory function, which can ensure normal operation. The memory of the robot positioning device may be divided into a main memory (an internal memory) and an auxiliary memory (an external memory) according to purpose memory, and also has a classification method of the external memory and the internal memory. The external memory is usually a magnetic medium or an optical disc, which can store information for a long time. The internal memory refers to a storage component on a motherboard, which is used to store data and programs which are currently being executed, but only used to temporarily store the programs and data. If the power is turned off, the data will be lost.

- [ 00154]       The embodiments of the disclosure provide a computer program, which includes a computer readable code. The computer readable code executes the robot positioning method described above when the computer readable code runs in the robot positioning device and is executed by a processor in the robot positioning device.
- [ 00155]       In several embodiments provided by the disclosure, it should be understood that the disclosed methods and devices may be implemented in other ways. For example, the device embodiment described above is only schematic, and for example, division of the modules or units is only logic function division, and other division manners may be adopted during practical implementation. For example, multiple units or components may be combined or integrated into another system, or some characteristics may be neglected or not executed. In addition, coupling or direct coupling or communication connection between each displayed or discussed component may be indirect coupling or communication connection, implemented through some interfaces, of the device or the units, and may be electrical and mechanical or adopt other forms.
- [ 00156]       The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected according to actual needs to achieve the objectives of the solutions of the embodiments.
- [ 00157]       In addition, functional units in the embodiments of the disclosure may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units are integrated into one unit. The integrated unit may be implemented in a hardware form and may also be implemented in form of software functional unit.
- [ 00158]       When being implemented in form of software functional unit and sold or used as an independent product, the integrated unit may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of the disclosure essentially, or the part contributing to the related art, or all or part of the technical solutions may be implemented in a form of a software product. The computer software product is stored in a storage medium and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) or a processor to perform all or some of the steps of the methods described in the embodiments of the disclosure.
- [ 00159]       Referring to FIG. 8, which is a schematic structural diagram of a computer readable storage medium according to an embodiment of the disclosure. The storage medium of the present disclosure stores a program file 61 that can implement all the above-mentioned robot positioning methods. The program file 61 may be stored in the storage medium in form of software product and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) or a processor to perform all or some of the steps of the methods described in the embodiments

of the disclosure. The foregoing storage apparatus includes any medium that can store program code, such as a U disk, a removable hard disk, a Read-Only Memory (ROM), a Random Access Memory (RAM), a magnetic disk, or an optical disc, or a terminal device such as a computer, a server, a mobile phone or a tablet.

[ 00160] The above is only the embodiments of the disclosure, and does not limit the scope of patent of the disclosure. Any equivalent structure or equivalent flow transformation made by using the contents of the specification and drawings of the disclosure, or directly or indirectly applied to other related technical fields, is similarly included in the protection scope of the patent of the disclosure.

#### INDUSTRIAL PRACTICABILITY

[ 00161] In the embodiments of the present disclosure, first position information of a robot at a first moment is acquired; a second image of the robot at a second moment is acquired, and first estimated position information of the robot at the second moment is acquired based on the second image; a movement parameter of the robot from the first moment to the second moment is collected; second estimated position information of the robot at the second moment is calculated based on the first position information and the movement parameters; and second position information of the robot at the second moment is obtained through the first estimated position information and the second estimated position information. It fuses robot positioning results acquired in two different manners, thereby obtaining accurate position information and effectively improving the positioning accuracy.

## CLAIMS

1. A robot positioning method, comprising:
  - acquiring first position information of a robot at a first moment;
  - acquiring a second image of the robot at a second moment, and acquiring first estimated position information of the robot at the second moment based on the second image;
  - collecting a movement parameter of the robot from the first moment to the second moment;
  - calculating second estimated position information of the robot at the second moment based on the first position information and the movement parameter; and
  - obtaining second position information of the robot at the second moment through the first estimated position information and the second estimated position information.
2. The positioning method of claim 1, wherein acquiring the first position information of the robot at the first moment comprises:
  - acquiring a first image of the robot at the first moment; and
  - acquiring the first position information of the robot at the first moment based on the first image.
3. The positioning method of claim 2, wherein the first image comprises a first reference object; wherein acquiring the first position information of the robot at the first moment based on the first image comprises:
  - acquiring the first reference object on a simulated sand table;
  - determining a pixel position of the first reference object and a first pixel position of the robot in the first image;
  - determining a simulated position of the first reference object on the simulated sand table at the first moment;
  - calculating a first projection relationship by using the pixel position of the first reference object and the simulated position of the first reference object on the simulated sand table;
  - calculating the simulated position of the robot on the simulated sand table based on the first projection relationship and the first pixel position of the robot; and
  - determining the first position information of the robot at the first moment by using the simulated position of the robot on the simulated sand table.
4. The positioning method of claim 1, wherein the second image comprises a second reference object; wherein acquiring the first estimated position information of the robot at the second moment based on the second image comprises:
  - acquiring the second reference object on the simulated sand table;
  - determining the pixel position of the second reference object and a second pixel position of the robot in the second image;
  - determining the simulated position of the second reference object on the simulated sand table at the second moment;
  - calculating a second projection relationship by using the pixel position of the second reference object and the simulated position of the second reference object on the simulated sand table;
  - calculating the simulated position of the robot on the simulated sand table based on the second projection relationship and the second pixel position of the robot; and
  - determining the first estimated position information of the robot at the second moment

by using the simulated position of the robot on the simulated sand table.

5. The positioning method of claim 4, wherein determining the pixel position of the second reference object and the second pixel position of the robot in the second image comprises:

identifying the second image using a first deep learning network to determine the pixel position of the second reference object and the second pixel position of the robot in the second image,

wherein the first deep learning network comprises one or any combination of a Region-CNN (RCNN) deep network structure, a Single Shot MultiBox Detector (SSD) deep network structure, a You Only Look Once (Yolo) deep network structure or a RetinaNet network structure.

6. The positioning method of claim 2, after acquiring the first image of the robot at the first moment, further comprising:

acquiring an orientation of the robot at the first moment based on the first image.

7. The positioning method of claim 6, wherein acquiring the orientation of the robot at the first moment based on the first image comprises:

identifying an area image in which the robot is located by using a second deep learning network to determine the orientation of the robot,

wherein the second deep learning network comprises one or any combination of a ResNet deep network structure, a MobileNet deep network structure, a GhostNet deep network structure or an EfficientNet deep network structure.

8. The positioning method of claim 6, further comprising:

acquiring a historical movement parameter of the robot at the first moment;

wherein collecting the movement parameter of the robot from the first moment to the second moment comprises:

acquiring a current movement parameter of the robot at the second moment; and

calculating the movement parameter of the robot from the first moment to the second moment through the historical movement parameter and the current movement parameter.

9. The positioning method of claim 6, wherein calculating the second estimated position information of the robot at the second moment based on the first position information and the movement parameters comprises:

acquiring the second estimated position information of the robot at the second moment by combining the orientation of the robot within the first moment with the movement parameter of the robot from the first moment to the second moment.

10. The positioning method of claim 1, wherein obtaining the second position information of the robot at the second moment through the first estimated position information and the second estimated position information comprises:

performing weighted averaging on the first estimated position information and the second estimated position information by means of a Kalman filter to obtain the second position information of the robot at the second moment.

11. A robot positioning device, comprising a memory and a processor, wherein the memory stores a program instruction, wherein when executing the program instruction in the memroy,

the processor is configured to:

- acquire first position information of a robot at a first moment;
- acquire a second image of the robot at a second moment, and acquire first estimated position information of the robot at the second moment based on the second image;
- collect a movement parameter of the robot from the first moment to the second moment;
- calculate second estimated position information of the robot at the second moment based on the first position information and the movement parameter; and
- obtain second position information of the robot at the second moment through the first estimated position information and the second estimated position information.

12. The robot positioning device of claim 11, wherein the processor is specifically configured to:

- acquire a first image of the robot at the first moment; and
- acquire the first position information of the robot at the first moment based on the first image.

13. The robot positioning device of claim 12, wherein the first image comprises a first reference object; wherein the processor is specifically configured to:

- acquire the first reference object on a simulated sand table;
- determine a pixel position of the first reference object and a first pixel position of the robot in the first image;
- determine a simulated position of the first reference object on the simulated sand table at the first moment;
- calculate a first projection relationship by using the pixel position of the first reference object and the simulated position of the first reference object on the simulated sand table;
- calculate the simulated position of the robot on the simulated sand table based on the first projection relationship and the first pixel position of the robot; and
- determine the first position information of the robot at the first moment by using the simulated position of the robot on the simulated sand table.

14. The robot positioning device of claim 11, wherein the second image comprises a second reference object; wherein the processor is specifically configured to:

- acquiring the second reference object on the simulated sand table;
- determine the pixel position of the second reference object and a second pixel position of the robot in the second image;
- determine the simulated position of the second reference object on the simulated sand table at the second moment;
- calculate a second projection relationship by using the pixel position of the second reference object and the simulated position of the second reference object on the simulated sand table;
- calculate the simulated position of the robot on the simulated sand table based on the second projection relationship and the second pixel position of the robot; and
- determine the first estimated position information of the robot at the second moment by using the simulated position of the robot on the simulated sand table,

wherein the processor is further specifically configured to:

- identify the second image using a first deep learning network to determine the pixel position of the second reference object and the second pixel position of the robot in the second image,

wherein the first deep learning network comprises one or any combination of a Region-CNN (RCNN) deep network structure, a Single Shot MultiBox Detector (SSD) deep network structure, a You Only Look Once (Yolo) deep network structure or a RetinaNet network structure.

15. The robot positioning device of claim 12, wherein the processor is further configured to:  
acquire an orientation of the robot at the first moment based on the first image.

16. The robot positioning device of claim 15, wherein the processor is specifically configured to:

identify an area image in which the robot is located by using a second deep learning network to determine the orientation of the robot,  
wherein the second deep learning network comprises one or any combination of a ResNet deep network structure, a MobileNet deep network structure, a GhostNet deep network structure or an EfficientNet deep network structure.

17. The robot positioning device of claim 15, wherein the processor is further configured to:

acquire a historical movement parameter of the robot at the first moment;  
wherein the processor is specifically configured to:  
acquire a current movement parameter of the robot at the second moment; and  
calculate the movement parameter of the robot from the first moment to the second moment through the historical movement parameter and the current movement parameter.

18. The robot positioning device of claim 15, wherein the processor is specifically configured to:

acquire the second estimated position information of the robot at the second moment by combining the orientation of the robot within the first moment with the movement parameter of the robot from the first moment to the second moment.

19. A computer readable storage medium, storing a program file, wherein when executed by a processor, the program file is configured to:

acquire first position information of a robot at a first moment;  
acquire a second image of the robot at a second moment, and acquire first estimated position information of the robot at the second moment based on the second image;  
collect a movement parameter of the robot from the first moment to the second moment;  
calculate second estimated position information of the robot at the second moment based on the first position information and the movement parameter; and  
obtain second position information of the robot at the second moment through the first estimated position information and the second estimated position information.

20. A computer program, comprising a computer readable code, wherein when the computer readable code runs in a robot positioning device, the computer readable code causes a processor in the robot positioning device to:

acquire first position information of a robot at a first moment;  
acquire a second image of the robot at a second moment, and acquire first estimated position information of the robot at the second moment based on the second image;  
collect a movement parameter of the robot from the first moment to the second moment;  
calculate second estimated position information of the robot at the second moment based

on the first position information and the movement parameter; and  
obtain second position information of the robot at the second moment through the first  
estimated position information and the second estimated position information.