AUTOMATIC CALIBRATION METHOD, MANIPULATOR AND COMPUTER-READABLE STORAGE MEDIUM

TECHNICAL FIELD

The present disclosure relates generally to a technical field of manipulator, and more specifically, relates to an automatic calibration method, a manipulator and a computer-readable storage medium.

BACKGROUND

With the popularization and application of mechanical automation, mechanical drive apparatuses have been widely used. Among which, manipulator, as a large category of mechanical drive apparatuses, is often used to assist or even replace manual production, assembly, storage and other operations. When using a manipulator to perform various tasks, the most concerned thing is the accuracy of the manipulator, that is, whether the manipulator can accurately grip the specified item according to the expectation of the user, and whether the manipulator can accurately install or place the specified item at the specified position, so as to truly realize automation and reduce manual intervention.

However, the accuracy of the current manipulator for placing item is not high. When the manipulator moves to a target position according to a preset path, the manipulator may actually deviate from the target position due to a variety of factors, but the control system of the manipulator cannot find this problem, which results in that the manipulator cannot accurately place the item, and seriously affects the working efficiency of the manipulator, and even causes immeasurable economic losses.

SUMMARY

The object of embodiments of the present application is to provide an automatic calibration method, a manipulator and a computer-readable storage medium, aiming at the technical problem in the prior art that the accuracy of the current manipulator for placing item is relatively low during operation.

In a first aspect, an automatic calibration method is provided, which is applied to a manipulator and includes:

acquiring a plurality of images to be compared according to an inputted movement instruction;

determining a target image according to the image to be compared and a preset reference image;

determining a target position according to the target image; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

In an embodiment of this disclosure, acquiring a plurality of images to be compared according to an inputted movement instruction, includes:

moving from a current position to an initial position according to the movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position; and

taking a set of the primary image and the secondary image as the plurality of images to be compared.

In an embodiment of this disclosure, determining a target image according to the image to be compared and a preset reference image, includes:

comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared; and

taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image.

In an embodiment of this disclosure, determining a target position according to the target image, includes:

determining an image coordinate range which corresponds to the feature image having the highest matching degree in the target image;

determining a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information; and

determining the target position according to the midpoint coordinate and the relative position information.

In an embodiment of this disclosure, comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared, includes:

acquiring a contour point to be compared in the image to be compared;

comparing the contour point to be compared with a reference feature point set of the reference image to obtain a plurality of similarity values;

determining a plurality of local contour points in the contour point to be compared whose similarity value is greater than a preset similarity threshold; and

determining the feature image having the highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points.

In an embodiment of this disclosure, comparing the contour point to be compared with a reference feature point set of the reference image to obtain a plurality of similarity values, includes:

scaling down the image to be compared and the reference image according to a preset pixel scaling rule, and comparing the contour point to be compared in the scaled-down image to be compared with the reference feature point set of the scaled-down reference image to acquire the plurality of similarity values.

In an embodiment of this disclosure, determining the feature image having the highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points, includes:

determining the feature image which corresponds to the plurality of local contour points;

restoring a plurality of feature images according to the preset pixel scaling rule;

comparing the plurality of feature images with the reference image to acquire a plurality of matching values; and

taking the feature image with the highest matching value as the feature image having the highest matching degree with the reference image in the image to be compared.

In an embodiment of this disclosure, determining a target position according to the target image further includes:

generating a grid according to the target image;

acquiring a deviation value of the target image according to the grid and the target image;

adjusting a current position of the manipulator to the target position which corresponds to the deviation value which is less than a first preset offset threshold, if the deviation value is greater than or equal to the first preset offset threshold but less than a second preset offset threshold; or

moving the manipulator to a preset recovery position and sending out alarm information, if the deviation value is greater than or equal to the second preset offset

threshold, wherein the second preset offset threshold is greater than the first offset threshold.

In a second aspect, an automatic calibration method is provided, which is applied to a manipulator and includes:

moving from a current position to an initial position according to a movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position;

taking a set of the primary image and the secondary image as a plurality of images to be compared;

comparing the image to be compared with a reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared;

taking the image to be compared which corresponds to the feature image having the highest matching degree as a target image;

determining an image coordinate range which corresponds to the feature image having the highest matching degree in the target image;

determining a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information;

determining the target position according to the midpoint coordinate and the relative position information; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

In a third aspect, an automatic calibration method is provided, which is applied to a manipulator and includes:

moving from a current position to an initial position according to a movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position;

taking a set of the primary image and the secondary image as a plurality of images to be compared;

acquiring a contour point to be compared in the image to be compared;

comparing the contour point to be compared with a reference feature point set of a reference image to obtain a plurality of similarity values;

determining a plurality of local contour points in the contour point to be compared whose similarity value is greater than a preset similarity threshold;

determining a feature image having a highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points;

taking the image to be compared which corresponds to the feature image having the highest matching degree as a target image;

determining an image coordinate range which corresponds to the feature image having the highest matching degree in the target image;

determining a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information;

determining the target position according to the midpoint coordinate and the relative position information; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

In a fourth aspect, an automatic calibration method is provided, which is applied to a manipulator and includes:

moving from a current position to an initial position according to a movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position;

taking a set of the primary image and the secondary image as the plurality of images to be compared;

comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared;

taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image;

comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared;

taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image;

determining a target position according to the target image; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

In an embodiment of this disclosure, the movement instruction is generated when the manipulator traverses storage grooves.

In an embodiment of this disclosure, a generation process of the movement instruction includes:

determining the movement path from a recovery position of the manipulator to a storage position of the manipulator corresponding to a storage groove according to the recovery position and the storage position, so as to generate the movement instruction.

In an embodiment of this disclosure, the reference image is an image of a convex part which is arranged at a surface of a storage groove.

In an embodiment of this disclosure, the reference image is arranged as images of four convex part which are arranged at a surface of a storage groove.

In a fifth aspect, a manipulator is provided, which includes a memory, a processor and an automatic calibration program which is stored in the memory and capable of being implemented by the processor, wherein when the automatic calibration program is implemented by the processor, the automatic calibration method described above is implemented.

In a sixth aspect, a computer-readable storage medium is provided, on which an automatic calibration program is stored, wherein when the automatic calibration program is implemented by a processor, the automatic calibration method described above is implemented.

The automatic calibration method according to this disclosure acquires a plurality of images to be compared according to an inputted movement instruction, determines a target image according to the image to be compared and a preset reference image, such that the manipulator can be finely adjusted and moved during finding the target position. In additional, the automatic calibration method according to this disclosure determines the target image having a relatively high matching degree with the reference image in a plurality of images to be compared which are taken at various actual positions, and then determines a target position according to the target image, such that a more accurate target position is determined. Furthermore, the automatic calibration method according to this disclosure

determines an adjustment signal which is configured to adjust a movement path of the manipulator, according to the target position, such that the manipulator is moved to the target position accurately. The automatic calibration method according to this disclosure enable the manipulator to accurately place or take out items from the target position by a finely self-adaptive adjustment during the operation of the manipulator, thus ensuring that the manipulator always maintains a high accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to more clearly illustrate the technical solution in the embodiment of the present disclosure, the drawings used in the embodiments or prior arts will be briefly introduced. It is obvious that the drawings in the following description are only some embodiments of the present application. For ordinary technicians in the present art, they can also obtain other drawings without paying creative labor according to these drawings.

Fig. 1 is a structure diagram of a terminal for a manipulator involved in an embodiment of this disclosure.

Fig. 2 is a flow diagram of an automatic calibration method according to a first embodiment of this disclosure.

Fig. 3 is a detailed flow diagram of step S10 of the automatic calibration method according to the first embodiment of this disclosure.

Fig. 4 is a detailed flow diagram of step S20 of the automatic calibration method according to the first embodiment of this disclosure.

Fig. 5 is a detailed flow diagram of step S21 of the automatic calibration method according to the first embodiment of this disclosure.

Fig. 6 is a flow diagram of an automatic calibration method according to a second embodiment of this disclosure.

Fig. 7 is a flow diagram of an automatic calibration method according to a fifth embodiment of this disclosure.

Fig. 8 is a schematic diagram of a manipulator involved in an embodiment of this disclosure.

The reference number for each component in the drawings are as follows.

Reference number	Component name	Reference number	Component name
10	Manipulator	1	Embedded control board
2	Visual camera module	3	Acoustic module
4	Wireless communication module	5	Light module

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In order to make the item, technical scheme and advantages of the present application clearer, the present application will be further described in detail in combination with the drawings and the embodiments. It should be understood that the specific embodiments described herein are only used to explain the present application and are not used to limit the present application.

Fig. 1 is a structure diagram of a terminal for a manipulator involved in an embodiment of this disclosure.

As shown in Fig.1, the terminal includes a processor 1001, such as CPU, a network interface 1004, a user interface 1003, a memory 1005, and a communication bus 1002. Among them, the communication bus 1002 is configured to realize communication connection between these components. The user interface 1003 may include a display, an input unit, such as a control panel. Optionally, the user interface 1003 may also include a standard wired interface and a wireless interface. Optionally, the network interface 1004 can include a standard wired interface and wireless interface (such as WLAN interface). The memory 1005 can be high-speed RAM memory or non-volatile memory, such as disk

memory. Optionally, the memory 1005 may be a storage apparatus independent of the aforementioned processor 1001. The memory 1005 can also be a computer-readable storage medium which stores with an automatic calibration program.

In an embodiment of this disclosure, the terminal can also include a microphone, speaker, RF (Radio Frequency) circuit, sensor, audio circuit, wireless module, etc. Among them, sensors such as infrared sensors, distance sensors and other sensors, and no limitations are made for this.

Those skilled in the art can understand that the structure shown in Fig. 1 never constitutes a restriction on the terminal, and the terminal can include more or fewer components than those shown in drawings, or some components shown in the drawings can be combined, or other components different from the components shown in the drawings can also be arranged.

Fig. 2 is a flow diagram of an automatic calibration method according to a first embodiment of this disclosure. In this embodiment, the method includes following steps.

In step S10, a plurality of images to be compared are acquired according to an inputted movement instruction.

In this embodiment, the method can be applied to a manipulator 10. Referring Fig.8, the manipulator 10 is provided with a visual camera module 2 and an embedded control board 1. The embedded control board 1 can include PLC (Programmable Logic Controller). The visual camera module 2 can include a CCD industrial camera and a lens with depth of field. The manipulator 10 can also be provided with an acoustic module 3, a wireless communication module 4 and a light module 5. Among them, the visual camera module 2, the acoustic module 3, the wireless communication module 4 and the light module 5 are connected with the embedded control board 1.

It should be noted that the manipulator in this embodiment is mainly configured to place items, such as paper documents, archives, documents, notebooks, books and other items, into a storage groove. Inlet and outlet of the storage groove are rectangular, and four corners of the inlet and outlet are provided with convex parts. It should be noted here that the convex part is a structure which is configured to fix the items, and can be considered as the four corner structures of the rectangular storage groove.

Storage frames are formed by connecting the storage grooves through connection pieces, and then a plurality of storage frames can be combined to form a warehouse. If this disclosure is applied to place or assemble other items, it should also fall into the scope of protection of this disclosure.

The movement instruction is generated when the manipulator traverses the storage grooves, that is, the manipulator can be manually adjusted from a recovery position (the specific position when the manipulator is reset) to a corresponding position of each storage groove successively. Optionally, the manipulator can traverse each storage groove automatically according to a relevant image recognition technology. For example, after collecting overall image of the storage frame through the visual camera module on the manipulator, a coordinate system can be established with a midpoint of the storage frame as the origin point. An image coordinate position corresponding to each storage groove is converted into a manipulator coordinate with the manipulator as a reference system. The conversion method can be based on the nine-point calibration method, and can also be based on a rotation matrix and a translation matrix.

The generation process of the movement instruction in this embodiment can be simply described as follows. A movement path from the recovery position (recovery coordinate) of the manipulator to the storage position (storage coordinate) corresponding to the storage groove is determined according to the recovery

position and the storage position. The movement path can be the shortest path between the two to improve the working efficiency of the manipulator. The movement instruction is formed by associating a sequence change matrix of the manipulator coordinate corresponding to the movement path with a preset movement instruction character. It should be noted that each position of this embodiment can be represented by manipulator coordinate, and the manipulator coordinate can be two-dimensional coordinates or three-dimensional coordinate. After the movement instruction is generated, it can be stored in the eMMC memory of the embedded control board.

When the user needs to use the manipulator to access the item, he/she can input name of the corresponding movement instruction through a user terminal, to trigger one or more corresponding movement instructions. The user terminal is communicationally connected with the manipulator and can manually control the manipulator, so that it can be convenient to manually calibrate the manipulator when the accuracy of the manipulator is seriously reduced, and each storage groove can be manually traversed remotely without going to the site installing the manipulator during the generation process of the movement instruction.

Specifically, in an embodiment, as shown in Fig. 3, the step S10 further includes following steps.

In step S11, the manipulator moves from a current position to an initial position according to the movement instruction and acquires a primary image which corresponds to the initial position, when receiving the inputted movement instruction.

The initial position is a relative position of the manipulator to the storage groove, that is, the position of the manipulator with a preset distance from the storage groove. In brief, the initial position refers to a position which is in front of or above the storage groove. After confirming the position, the manipulator can

move forward or backward to access the item. The initial position refers to a final position to which the manipulator moves from the recovery position according to the movement path corresponding to the movement instruction. However, due to various factors, such as the aging of the manipulator, the displacement of the recovery position of the manipulator, the change of the current position of the manipulator due to the falling of items, or the deformation and looseness of the storage frame and storage groove, the manipulator cannot move to the expected position according to the original movement path. This is the problem to be solved by this disclosure.

After reaching the initial position, the primary image of the initial position is taken through the visual camera module of the manipulator.

In step S12, the manipulator can move from the initial position to at least one secondary position according to a preset swing rule, and acquires a secondary image which corresponds to each secondary position.

In step S13, a set of the primary image and the secondary image are taken as the plurality of images to be compared.

The preset swing rule can include a preset swing amplitude which refers to a finely adjusted movement of the manipulator in four directions of left, right, up and down, based on the current position of the manipulator which includes the initial position. More specifically, the preset swing amplitude is the change of the manipulator coordinate. For example, when the preset swing amplitude is x+2, that is, the manipulator moves two units along a positive direction of x-coordinate axis, and when the preset swing amplitude is y-3, that is, the manipulator moves two units in a negative direction of y-coordinate axis, and when the preset swing amplitude is (x+2, y-3), that is, the manipulator moves two units in the positive direction of the x-coordinate axis and two units in the negative direction of the y-coordinate axis. Assuming that the manipulator coordinate of the current position

of the manipulator is (15.6, 26) now, and it moves to the secondary position with the manipulator coordinate of (17.6, 23) after the finely adjusted movement with the preset swing amplitude (x+2, y-3). Similarly, after reaching one secondary position, the manipulator can also be further finely adjusted and moved to acquire the corresponding secondary image.

In one embodiment, the preset swing rule can include a swing amplitude of preset number and preset sequence, and a preset swing frequency. There can be one or more secondary positions and secondary images. Correspondingly, the manipulator moves from the initial position to the secondary position. When the manipulator reaches the secondary position, the secondary position can also be considered as the initial position, so that it can further move to the next secondary position. For example, the plurality of swing amplitudes are (x+2, y-3), (x-5, y+4), (x+6, y-1) in sequence, and the preset swing frequency is to finely swing once every 1s. In this way, the plurality of images to be compared, which include the primary image and a plurality of secondary images, are obtained.

In step S20, a target image is determined according to the image to be compared and a preset reference image.

The preset reference image can be an image of the above convex part included in the storage groove, or an image of the storage groove including four convex parts.

The preset reference image is set as the image of one of the convex parts at the surface of the storage groove. Additionally, or optionally, the preset reference image is set as the images of four convex parts at the surface of the storage groove.

The reference image is an image defined by an administrator.

In this embodiment, the automatic calibration method also includes acquiring the reference image and constructing a reference feature point set of the corresponding reference image according to the reference image. Specifically, the

reference image is rotated according to a preset angle to obtain a feature contour point of the reference image corresponding to each preset angle. The obtained feature contour point is defined as the feature contour points at the current rotation angle, and the feature contour points at the plurality of rotation angles are taken as the reference feature point set.

Optionally, the preset angle can be set as any angle between 1 ° and 60 °, such as 1 °, 2 °, 3 °, 4 °, 5 °, 10 °, 15 °, 20 °, 25 °, 30 °, 35 °, 40 ° and 45 °.

Specifically, in an embodiment, as shown in Fig. 4, the step S20 includes:

Step 21, comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared; and

Step 22, taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image.

When comparing the plurality of images to be compared with the reference image in an image matching model simultaneously can speed up the comparison efficiency and determine the feature image having the highest matching degree more quickly.

It should be noted that each image to be compared is an overall image including a plurality of feature images, that is, each image to be compared is composed of various feature images. For example, the image to be compared includes an image of a storage groove numbered A1 and an image of a convex part of the storage groove numbered A2. Herein, both the image of storage groove A1 and the image of the convex part of storage groove A2 can be used as feature images.

It is also mentioned above that the reference image can be an image of one convex part or an image of one storage groove. To determine the feature image that has the highest matching degree with the reference image in the image to be

compared; the feature image of each image to be compared, which matches with the reference image, should be firstly determined. Taking the image of convex part as the reference image, the image to be compared has the feature image which matches with the reference image, refers to that the image to be compared contains the image of the convex part. That is, the image to be compared matches with the reference image when the image to be compared contains the image of the convex part. In this way, the feature image having a highest matching degree with the reference image can be determined and then the image to be compared, which corresponds to the feature image having the highest matching degree, can be obtained.

Specifically, refer to Fig. 5. In an embodiment, in step S21, comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared, further includes following steps.

In step S210, a contour point to be compared in the image to be compared, is acquired.

It can be understood that the contour point to be compared in the image to be compared, is formed based on a connection between each point and line, and all the contour points to be compared in each image to be compared can be obtained.

In step S211, the contour point to be compared, is compared with the reference feature point set of the reference image to obtain the plurality of similarity values.

Specifically, in one embodiment, the automatic calibration method in this disclosure is applied to the storage frame, which includes a plurality of storage grooves. Each storage groove includes at least four convex parts. If the reference image is an image of the storage groove. The automatic calibration method of this disclosure can further include following steps before step S211:

determining the four convex parts of the storage groove;

determining a midpoint of the storage groove according to the four convex parts;

taking the midpoint as a center and a contour between the four convex parts as a boundary to obtain the reference image of the storage groove;

taking a first gradient of the reference image as a standard, rotating the reference image every preset angle to obtain several rotated reference images;

determining all reference contour points constituting a reference image contour, obtaining a two-point angle between each two reference contour points of the same reference image contour and a second gradient, and associating the two -point angle and the second gradient as the reference feature point;

taking all the reference feature points as the reference feature point set of the reference image.

If the reference image is an image of the convex part, the automatic calibration method of this disclosure can further include following steps before step S211:

taking a first gradient of the reference image as a standard, rotating the reference image every preset angle to obtain several rotated reference images;

determining all reference contour points constituting a reference image contour, obtaining a two-point angle between each two reference contour points of the same reference image contour and a second gradient and associating the two -point angle and the second gradient as the reference feature point;

taking all the reference feature points as the reference feature point set of the reference image.

More specifically, in an embodiment, the step S211 further includes:

step a, determining a corresponding feature set to be compared, according to the contour point to be compared;

step b, comparing the feature set to be compared with the reference feature point set of the reference image to obtain the plurality of similarity values.

After obtaining the contour point to be compared of the image to be compared, it is necessary to determine the feature set to be compared of each image to be compared according to parameters (such as angle, gradient and so on) between the contour points to be compared, and then compare the feature set to be compared of each image to be compared with the reference feature point set synchronously to determine the similarity value between each image to be compared and the reference image. That is, there are as many similarity values as images to be compared.

Based on the above, whether a current image to be compared has a certain matching degree with the reference image through gradient values between a plurality of each two adjacent contour points.

In step S212, a plurality of local contour points in the contour point to be compared whose similarity value is greater than a preset similarity threshold, are determined.

After obtaining the plurality of similarity values, each similarity value is compared with the preset similarity threshold to determine the plurality of local contour points whose similarity is greater than the preset similarity threshold, in the image to be compared. The local contour points here constitute the storage groove or convex part mentioned above. The preset similarity thresholds can be set according to actual needs, such as 80%, 85%, 90%, etc.

In step S213, the feature image having the highest matching degree with the reference image in the image to be compared, is determined according to the plurality of local contour points.

After determining the local contour points, some images to be compared can also be filtered, because if there is no local contour point whose similarity is

greater than the preset similarity threshold, in the contour points to be compared of the image to be compared, it means that the image to be compared does not contain image of the storage groove or image of the convex part. The other reserved images to be compared are compared with the reference image for a second time, so that the exclusive feature image having the highest matching degree with the reference image can be determined from the reserved images to be compared, and then the image to be compared (the target image) that is the nearest counterpart of the reference image among the plurality of images to be compared can be determined.

In step S30, a target position is determined according to the target image.

If the reference image is an image of the storage groove, an image taking position of the target image can be directly determined as the target position, and then the manipulator can directly move to the target position for a series of operations to placing the items.

If the reference image is an image of the convex part, it is necessary to determine the relative positions of the four convex parts according to the image of the convex part, and then the midpoint of the storage groove is determined and taken as the target position.

In step S40, an adjustment signal is determined according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

After determining the target position, the target coordinate of the corresponding manipulator and the movement path to the target position of the corresponding manipulator are also determined, and the adjustment signal of the manipulator controls the manipulator to move along the corresponding movement path to achieve the accurate target position.

The automatic calibration method according to this disclosure acquires a plurality of images to be compared according to an inputted movement instruction, determines a target image according to the image to be compared and a preset reference image, such that the manipulator can be finely adjusted and moved during finding the target position. In additional, the automatic calibration method according to this disclosure determines the target image having a relatively high matching degree with the reference image in a plurality of images to be compared which are taken at various actual positions, and then determines a target position according to the target image, such that a more accurate target position is determined. Furthermore, the automatic calibration method according to this disclosure determines an adjustment signal which is configured to adjust a movement path of the manipulator, according to the target position, such that the manipulator is moved to the target position accurately. The automatic calibration method according to this disclosure enables the manipulator to accurately place or take out items from the target position by a finely self-adaptive adjustment during the operation of the manipulator, thus ensuring that the manipulator always maintains a high accuracy.

As shown in Fig. 6, which is a flow diagram of an automatic calibration method according to a second embodiment of this disclosure. Furthermore, based on the first embodiment of the automatic calibration method of this disclosure, the second embodiment of the automatic calibration method of this disclosure is proposed. In this embodiment, the step S30 includes following steps.

In step S31, an image coordinate range which corresponds to the feature image having the highest matching degree in the target image, is determined.

In this embodiment, the reference image is an image of the convex part.

It can be understood that the convex part corresponding to the feature image having the highest matching degree occupies a certain space range. In order to determine the target position more accurately, it is necessary to determine the

image coordinate range of the overall contour of the convex part, that is, the coordinate range of the convex part reflected in the image.

In step S32, a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information, are determined.

In step S33, the target position is determined according to the midpoint coordinate and the relative position information.

After determining the image coordinate range, the midpoint coordinate in the image coordinate range can be calculated, that is, the coordinate of the midpoint of the convex part in the image can be calculated. In this way, according to the midpoint coordinate of the convex part, the midpoint coordinates of the other three convex parts are determined according to the preset relative positions of the four convex parts of the storage groove, and then the midpoint of the rectangle formed by the four convex parts can be determined. That is, the midpoint of the storage groove is determined, and the midpoint of the storage groove can be used as the target position. Correspondingly, the manipulator is enabled to automatically reach the midpoint to perform the work of item placing by converting this target position to the corresponding coordinate of the manipulator. In addition, in order to further improve the accuracy for determining the target position, it is also possible to determine a label position of the storage groove, and further determine the position of the convex part in the storage groove according to the label position of the storage groove (i.e., upper left, lower left, upper right and lower right), and then determine a more accurate target position according to the midpoint coordinate corresponding to the image coordinate range and the preset relative position information.

It is understandable that the four convex parts are arranged in an array. Through the two longitudinal convex parts, the center position between the two longitudinal convex parts is determined firstly, and then the midpoint of the

storage groove is determined through the two center positions of the two groups of longitudinal convex parts. Alternatively, the midpoint is determined by connecting each two of the four convex parts.

The second embodiment of this disclosure can accurately locate the specific target position according to the specific midpoint coordinates and the preset relative position information, and enable the manipulator to reach the midpoint of the storage groove to realize the accurate storage of the items.

Furthermore, the third embodiment of the automatic calibration method of this disclosure is proposed based on the above embodiment of the automatic calibration method of this disclosure. In this embodiment, the step S211 that comparing the contour point to be compared with a reference feature point set of the reference image to obtain a plurality of similarity values, includes:

step c, scaling down the image to be compared and the reference image according to a preset pixel scaling rule, and comparing the contour point to be compared in the scaled-down image to be compared with the reference feature point set of the scaled-down reference image to acquire the plurality of similarity values.

The preset pixel scaling rule refers to that pixels of the image to be compared and the reference image are collected by every preset pixel interval to form the image to be compared and the reference image with the scaled-down pixels. In this way, the contour points corresponding to the image to be compared and the reference image are greatly reduced according to the image to be compared and the reference image with the scaled-down pixels. Such that, the capacity of the feature set to be compared and the reference feature point set corresponding to the contour point to be compared, that is, the data, is also greatly reduced, thus greatly improving the efficiency of comparing each image to be compared with the reference image to obtain a plurality of similarity values, as well as the working efficiency of the manipulator. In addition, for the scaling of the reference image,

initial comparison feature point set in the reference feature point set can be determined according to the preset pixel scaling rule when the reference image forms the reference feature point set, and then the initial comparison feature point set can be used as the reference feature point set of the reference image with the scaled-down pixels.

In an embodiment of this disclosure, the preset pixel scaling rule can be defined as a scaling ratio of 0.4 to 0.8 times to reduce the comparison of nearly half of the contour points. For example, the preset pixel scaling rule can be defined as a scaling factor of 0.5 times.

In an embodiment, the step S213 that determining the feature image having the highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points, further includes:

step d, determining the feature image which corresponds to the plurality of local contour points;

step e, restoring a plurality of feature images according to the preset pixel scaling rule;

step f, comparing the plurality of feature images with the reference image to acquire a plurality of matching values;

step g, taking the feature image with the highest matching value as the feature image having the highest matching degree with the reference image in the image to be compared.

In this embodiment, the preset pixel scaling rule also include a recovery rule corresponding to the pixels of the image to be compared and the reference image collected by every preset pixel interval, that is, the way for scaling down the pixels, corresponds to the way for recovering the pixels. Specifically, the feature image and the reference image corresponding to the local contour point are recovered. A plurality of matching values can be obtained by comparing the feature image

corresponding to each local contour point with the reference image through the preset image recognition technology or by comparing the corresponding contour point sets or feature point sets corresponding to the feature image and the reference image, respectively. The feature image corresponding to the local contour point with the largest matching value is regarded as the feature image having the highest matching degree with the reference image in the image to be compared, and then the target image is determined.

In the above third embodiment, the efficiency of image comparison is improved by scaling down the image pixels, and the accuracy of image comparison is improved by comparing and matching the images twice by image recovery, so that the manipulator can find the target position quickly and accurately, and the efficiency and accuracy of the manipulator are improved.

Further, the fourth embodiment of the automatic calibration method of this disclosure is proposed based on the above embodiment of the automatic calibration method of this disclosure. In this embodiment, after the step S20, the automatic calibration method further includes:

step h, generating a grid according to the target image;

step i, acquiring a deviation value of the target image according to the grid and the target image;

step j, adjusting the current position of the manipulator to the target position which corresponds to the deviation value which is less than a first preset offset threshold, if the deviation value is greater than or equal to the first preset offset threshold but less than a second preset offset threshold; or

step k, moving the manipulator to a preset recovery position and sending out alarm information, if the deviation value is greater than or equal to the second preset offset threshold, wherein the second preset offset threshold is greater than the first offset threshold.

The grid can be generated after the target image is taken, or the grid can be generated in a viewfinder of the visual camera module. After the target image is gridded, a deviation vector between the plane contour of the object in the target image and the grid can be obtained by intersecting the plane contour and the grid. If the deviation vector is greater than or equal to a first preset offset threshold, the current position of the manipulator is adjusted until the deviation vector is less than first preset offset threshold. Thus, when the manipulator is slightly deviated, it can automatically be corrected to the correct position, which improves the accuracy of the manipulator, and saves human resources as requiring no manual adjustment.

In addition, a coordinate adjustment parameter corresponding to the manipulator can be determined according to the deviation value of the target image. Specifically, the reference image is gridded to obtain a reference deviation value of the gridded reference image, and the coordinate adjustment parameters corresponding to the manipulator can be determined according to the target image and the reference deviation value of the reference image. The coordinate adjustment parameter is used to move the manipulator from the current position to the target position corresponding to the coordinate adjustment parameter, so that the deviation value of the object image is equal to the deviation value of the reference image.

In an embodiment, if the deviation value is less than the first preset offset threshold, the position corresponding to the target image is determined as the target position, and the above step S40 is performed, in which the adjustment signal is determined according to the target position, wherein the adjustment signal is configured to adjust the movement path of the manipulator. If the deviation value is greater than or equal to the second preset offset threshold, the position of the manipulator is seriously deviated from the target position. Therefore, the manipulator is restored. That is, the manipulator is moved from the current position

to the recovery position, and alarm information for the serious deviation of the manipulator is sent out, so as to facilitate the timely manual access of the user to reduce economic losses. The alarm information herein includes but is not limited to followings. The manipulator can be provided with a light module, such as LED, to send the alarm information through flashing the light module. The manipulator can also be provided with an acoustic module, such as speaker, to send the alarm information through voice broadcast or whistle. The manipulator can also be provided with a wireless communication module, such as WIFI module, to send the alarm information to the user terminal connected with the manipulator through the LAN.

As shown in Fig. 7. Fig. 7 is a flow diagram of an automatic calibration method according to a fifth embodiment of this disclosure. Further, based on the above embodiments of the automatic calibration method of this disclosure, the fifth embodiment of the automatic calibration method of this disclosure is proposed. In this embodiment, after the step S40, the automatic calibration method according to this embodiment further includes:

Step S50, acquiring target item information corresponding to the manipulator;

Step S60, updating the movement instruction according to the target position and the target item information;

Step S70, moving the manipulator to the target position, when the receiving the movement instruction and item information of a same item type corresponding to the target item information but the manipulator is not at the target position.

In this embodiment, an item recognition technology can be configured to identify the acquired image to be compared, so as to obtain the target item information corresponding to the item being gripped by the manipulator. For example, the target item information is passport, ID card, degree certificate, notebook, book, etc.

The target position has been determined in the previous step, and the movement path corresponding to the movement instruction can be updated according to the target position. Specifically, the shortest movement path between the recovery coordinate and the target coordinate can be determined according to the recovery coordinate and the target coordinate, and the shortest movement path and the movement instruction can be associated and stored to update the movement path of the movement instruction. The item type corresponding to the target item information can be determined. For example, the degree certificate can be divided into bachelor's degree certificate and master's degree certificate. Herein, the bachelor's degree certificate and master's degree certificate belong to two different item types of the same item information of degree certificate. The above shortest movement paths and item types are stored to update the movement instruction.

When the next time the manipulator grips an item which has the same item type corresponding to the target item information, this item can be place into the target position or taken out of the target position. For example, if the manipulator takes out a bachelor’s degree certificate from the storage groove corresponding to the target position last time, when the manipulator grips a bachelor’s degree certificate currently, it can put the bachelor’s degree certificate into the storage groove corresponding to the target position.

This embodiment can not only speed up the work efficiency of the manipulator, ensure the orderly access of the manipulator to the items, but also reduce the cache of relevant information and the system load of the manipulator.

In addition, this disclosure also provides a manipulator, which includes a memory, a processor and an automatic calibration program which is stored in the memory and capable of being implemented by the processor, wherein when the automatic calibration program is implemented by the processor, the automatic calibration method described above is implemented.

The specific implementation of the manipulator of this disclosure is basically the same as that of the above automatic calibration method, and is not repeated here for concise.

In addition, this disclosure also provides a computer-readable storage medium is provided, on which an automatic calibration program is stored, wherein when the automatic calibration program is implemented by a processor, the automatic calibration method described above is implemented.

The specific implementation of the computer-readable storage medium of this disclosure is basically the same as that of the above automatic calibration method, and is not repeated here for concise.

The serial number of the above embodiments of this disclosure is only for description and does not represent the advantages and disadvantages of the embodiments.

Through the description of the above embodiments, ordinary technical personnel in the art can clearly understand that the above embodiments can be realized by means of software and necessary general hardware platform, and of course, can also be realized by means of hardware, but in many cases the former is the better implementation. Based on this understanding, the technical solution of this disclosure, or the part that contributes to the existing technology, can be embodied in the form of software products, which are stored in a storage medium (such as ROM/RAM, disk, optical disk) as described above. These computer software products include several instructions to enable a terminal device (which can be a manipulator, mobile phone, computer, server, controller, processor, or network device, etc.) to execute the methods described in various embodiments of this disclosure.

In the this disclosure, the terms "first", "second", "third", "fourth" and "fifth" are only used for the purpose of description, and cannot be understood as

indicating or implying relative importance. For ordinary technical personnel in the art, the specific meaning of the above terms in the this disclosure can be understood according to the specific situation.

In the description of this specification, the description referring to the terms "one embodiment", "some embodiments", " an embodiment"", "specific examples", or "some examples", means that the specific features, structures, materials, or features described in combination with the embodiment or example are included in at least one embodiment or example of this disclosure. In this specification, the schematic expression of the above terms does not have to refer to the same embodiment or example. Furthermore, the specific features, structures, materials or characteristics described may be combined in an appropriate manner in any one or more embodiments or examples. In addition, without contradiction, ordinary technical personnel in the art, can combine and integrate different embodiments or examples or the features of different embodiments or examples described in this specification.

Although the embodiments of this disclosure have been shown and described above, the scope of protection of this disclosure is not limited to this. It can be understood that the above embodiments are exemplary and cannot be understood as limitations of this disclosure. Ordinary technicians in the art can change, modify and replace the above embodiments within the scope of this disclosure. These changes, modifications and replacements should fall into in the scope of protection of this disclosure. Therefore, the protection scope of this disclosure shall be subject to the protection scope of the claims.

CLAIMS

1. An automatic calibration method which is applied to a manipulator and comprises:

acquiring a plurality of images to be compared according to an inputted movement instruction;

determining a target image according to the image to be compared and a preset reference image;

determining a target position according to the target image; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

2. The automatic calibration method according to claim 1, wherein acquiring a plurality of images to be compared according to an inputted movement instruction, comprises:

moving from a current position to an initial position according to the movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position; and

taking a set of the primary image and the secondary image as the plurality of images to be compared.

3. The automatic calibration method according to claim 1, wherein determining a target image according to the image to be compared and a preset reference image, comprises:

comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared; and

taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image.

4. The automatic calibration method according to claim 3, wherein determining a target position according to the target image, comprises:

determining an image coordinate range which corresponds to the feature image having the highest matching degree in the target image;

determining a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information; and

determining the target position according to the midpoint coordinate and the relative position information.

5. The automatic calibration method according to claim 3, wherein comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared, comprises:

acquiring a contour point to be compared in the image to be compared;

comparing the contour point to be compared with a reference feature point set of the reference image to obtain a plurality of similarity values;

determining a plurality of local contour points in the contour point to be compared whose similarity value is greater than a preset similarity threshold; and

determining the feature image having the highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points.

6. The automatic calibration method according to claim 5, wherein comparing the contour point to be compared with a reference feature point set of the reference image to obtain a plurality of similarity values, comprises:

scaling down the image to be compared and the reference image according to a preset pixel scaling rule, and comparing the contour point to be compared in the scaled-down image to be compared with the reference feature point set of the scaled-down reference image to acquire the plurality of similarity values.

7. The automatic calibration method according to claim 6, wherein determining the feature image having the highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points, comprises:

determining the feature image which corresponds to the plurality of local contour points;

restoring a plurality of feature images according to the preset pixel scaling rule;

comparing the plurality of feature images with the reference image to acquire a plurality of matching values; and

taking the feature image with the highest matching value as the feature image having the highest matching degree with the reference image in the image to be compared.

8. The automatic calibration method according to claim 1, wherein determining a target position according to the target image further comprises:

generating a grid according to the target image;

acquiring a deviation value of the target image according to the grid and the target image;

adjusting a current position of the manipulator to the target position which corresponds to the deviation value which is less than a first preset offset threshold, if

the deviation value is greater than or equal to the first preset offset threshold but less than a second preset offset threshold; or

moving the manipulator to a preset recovery position and sending out alarm information, if the deviation value is greater than or equal to the second preset offset threshold, wherein the second preset offset threshold is greater than the first offset threshold.

9. An automatic calibration method which is applied to a manipulator and comprises:

moving from a current position to an initial position according to a movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position;

taking a set of the primary image and the secondary image as a plurality of images to be compared;

comparing the image to be compared with a reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared;

taking the image to be compared which corresponds to the feature image having the highest matching degree as a target image;

determining an image coordinate range which corresponds to the feature image having the highest matching degree in the target image;

determining a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information;

determining the target position according to the midpoint coordinate and the relative position information; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

10. An automatic calibration method which is applied to a manipulator and comprises:

moving from a current position to an initial position according to a movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position;

taking a set of the primary image and the secondary image as a plurality of images to be compared;

acquiring a contour point to be compared in the image to be compared;

comparing the contour point to be compared with a reference feature point set of a reference image to obtain a plurality of similarity values;

determining a plurality of local contour points in the contour point to be compared whose similarity value is greater than a preset similarity threshold;

determining a feature image having a highest matching degree with the reference image in the image to be compared, according to the plurality of local contour points;

taking the image to be compared which corresponds to the feature image having the highest matching degree as a target image;

determining an image coordinate range which corresponds to the feature image having the highest matching degree in the target image;

determining a midpoint coordinate which corresponds to the image coordinate range and a preset relative position information;

determining the target position according to the midpoint coordinate and the relative position information; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

11. An automatic calibration method which is applied to a manipulator and comprises:

moving from a current position to an initial position according to a movement instruction and acquiring a primary image which corresponds to the initial position, when receiving the movement instruction;

moving from the initial position to at least one secondary position according to a preset swing rule, and acquiring a secondary image which corresponds to each secondary position;

taking a set of the primary image and the secondary image as the plurality of images to be compared;

comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared;

taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image;

comparing the image to be compared with the reference image to determine a feature image having a highest matching degree with the reference image in the image to be compared;

taking the image to be compared which corresponds to the feature image having the highest matching degree as the target image;

determining a target position according to the target image; and

determining an adjustment signal according to the target position, wherein the adjustment signal is configured to adjust a movement path of the manipulator.

12. The automatic calibration method according to any one of claims 1, 9-11, wherein the movement instruction is generated when the manipulator traverses storage grooves.

13. The automatic calibration method according to any one of claims 1, 9-11, wherein a generation process of the movement instruction comprises:

determining the movement path from a recovery position of the manipulator to a storage position of the manipulator corresponding to a storage groove according to the recovery position and the storage position, so as to generate the movement instruction.

14. The automatic calibration method according to any one of claims 1, 9-11, wherein the reference image is an image of a convex part which is arranged at a surface of a storage groove.

15. The automatic calibration method according to any one of claims 1, 9-11, wherein the reference image is arranged as images of four convex part which are arranged at a surface of a storage groove.

16. A manipulator comprising a memory, a processor and an automatic calibration program which is stored in the memory and capable of being implemented by the processor, wherein when the automatic calibration program is implemented by the processor, the automatic calibration method according to any one of claims 1-15 is implemented.

17. A computer-readable storage medium, on which an automatic calibration program is stored, wherein when the automatic calibration program is implemented by a processor, the automatic calibration method according to any one of claims 1-15 is implemented.