MEASUREMENT AND POSITIONING SYSTEM BASED ON MACHINE VISION AND LASER TRIANGULATION

FIELD OF THE INVENTION

The invention relates to the field of machine vision measurement and three-dimensional spatial positioning, in particular relates to a three-dimensional measurement and positioning system designed based on machine vision and laser triangulation.

BACKGROUND OF THE INVENTION

The robot recognises and tracks objects through machine vision to determine the spatial coordinate position of the work object corresponding to the robot, and carry out various tasks such as grasping, placing or processing.

At present, robot vision positioning methods mainly include stereo vision method, structured light method and laser scanning method. Stereo vision method imitates the distance estimation and 3D reconstruction of the human visual system for 3D spatial measurement. The measurement accuracy varies according to the measurement baseline length. It is bulky and not suitable for mounting on a robotic arm.

Structured light measurement is a three-dimensional measurement technology composed of a controllable light source and a camera. A light source with a specific structure and pattern is projected onto the surface of the work object to generate light fringes. The three-dimensional information of the object surface is obtained according to the pattern deformation of the light fringes on the object surface captured by the camera. It is mainly suitable for obtaining the position of various structural objects on the surface of the object.

The laser triangulation sensor is a precision measurement sensor, but its one-dimensional measurement system can only measure the height or distance of a point. The laser flying spot measurement method is also a one-dimensional measurement

system, which measures the straight-line distance by measuring the time of flight of the laser, and its measurement accuracy is low.

INVENTION SUMMARY

The technology of the present invention provides a measuring and three-dimensional positioning system designed based on machine vision and laser triangulation, which can realize rapid measurement and precise positioning of the three-dimensional coordinate position of a work object.

The technical solution adopted by the present invention to solve the technical problem is: a measuring and positioning system designed based on machine vision and laser triangulation, including a machine vision system, a laser ranging system and a standard positioning target installed on the workpiece that needs to be positioned.

The laser ranging system is used for projecting laser beam onto a standard positioning target.

The machine vision system is used for imaging the positioning target and the laser image projected on the standard positioning target.

Next: the machine vision system includes a detection camera and a first optical imaging lens connected with the detection camera. The first optical imaging lens is equipped with an adjustable aperture. The bottom of the detection camera is equipped with a lighting system.

Next: the laser ranging system includes a laser projection component and a laser imaging component. The laser projection component consists of a laser, a laser collimating lens and a beam splitter. The laser imaging component consists of a second imaging lens and an imaging camera.

The beam splitter is set at a 90-degree oblique angle below the detection camera. The laser is set on one side of the beam splitter. The laser collimating lens is placed between the laser and the beam splitter.

The imaging camera is set on one side of the detection camera, and the imaging camera is set at an angle to the optical axis of the surface of the standard positioning target.

The laser beam of the laser is deflected by 90 degrees through the laser collimating lens and the reflector. It is then vertically projected toward the surface of the standard positioning target. The scattered light of the laser is imaged by the laser imaging component.

Next: the standard positioning target is a two-dimensional or three-dimensional structure with a central figure.

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Next: the three-dimensional figure is a truncated cone, and is distributed around the standard positioning target in a circularly symmetrical manner.

Next: there are at least three standard positioning targets (200), three of which are mounted on the positioning workpiece. The three positions are not in a line.

Next: the laser ranging system includes a laser and a laser collimating lens equipped at the front end of the laser. The laser is equipped on one side of the detection camera. The imaging camera is set at an angle to the optical axis of the surface of the standard positioning target.

The laser beam emitted by the laser is obliquely projected to the standard positioning target through the laser collimating lens, and is imaged by the machine vision system.

Next: the laser ranging system includes a laser projection component and a laser imaging component. The laser projection component includes a laser and a laser collimating lens. The laser imaging component consists of a second imaging lens and an imaging camera.

The laser and the imaging camera are respectively located on both sides of the detection camera. Both the imaging camera and the laser are set at an angle to the optical axis directed towards the surface of the standard positioning target.

The laser beam of the laser is deflected by 90 degrees through the laser collimating lens and the reflector. It is then vertically projected toward the surface of the standard positioning target. The scattered light of the laser is imaged by the laser imaging component.

The beneficial effect of the invention is: the structure enables rapid measurement and precise positioning of the coordinate position of the object through the design of the standard positioning target.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of the first positioning system designed based on machine vision and laser triangulation.

Figure 2 is a schematic diagram of a standard positioning target and laser beam projected on the standard positioning target.

Figure 3 is a schematic diagram of a three-dimensional standard positioning target.

Figure 4 is a schematic diagram of a standard positioning target installed on the object that needs to be measured and positioned.

Figure 5 is a schematic diagram of the second positioning system designed based on machine vision and laser triangulation.

Figure 6 is a schematic diagram of the geometric relationship of laser triangulation positioning in the second positioning system.

Figure 7 is a schematic diagram for the laser beam and the centre of the target. Its spacing is used for height measurement.

Figure 8 is a schematic diagram of the third positioning system designed based on machine vision and laser triangulation.

Labels in the figures are as follow:

Machine vision system 100, detection camera 101, adjustable aperture 102, first optical imaging lens 103, and lighting system 104.

Standard positioning target 200, central figure 201.

Laser ranging system 300, laser 301, laser collimating lens 302, beam splitter 303, second imaging lens 304, imaging camera 305, imaging straight line 306.

Three-dimensional stereo standard positioning target 400, three-dimensional truncated cone 401.

Workpiece that needs to be positioned 501.

DETAILED EMBODIMENTS OF THE INVENTION

To make the abovementioned objective, features and advantages of the invention more clearly understood, the specific embodiment of the invention is described in detail below with reference to the attached drawings. In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, the invention can be applied in many other ways apart from those described herein, and those skilled in the art can make similar improvements without deviating from the connotation of the invention. Therefore, the invention is not limited by the specific embodiments disclosed below.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by the ordinary skilled technician in the art to which this invention belongs. The terms used herein in the description of the invention are for the purpose of describing specific embodiments only, and are not intended to limit the invention. The term "and/or" as used herein includes any and all combinations of one or more of the associated listed items

As shown in Figure 1, the invention discloses a measuring and positioning system designed based on machine vision and laser triangulation, including a machine vision system 100, a laser ranging system 300 and a standard positioning target 200 installed on a workpiece that needs to be positioned 501.

The laser ranging system 300 is used to project the laser onto the standard positioning target 200.

The machine vision system 100 is used for imaging the positioning target and the laser image projected on the standard positioning target 200.

When operating, the standard positioning target 200 is used to achieve centre positioning, and the machine vision system 100 is used to locate the XY-axis coordinates, thereby determining the XY-axis position. The laser ranging system 300

determines the vertical coordinate position, Z through the position of the laser beam on the standard positioning target 200. There are three specific embodiments as follow:

Embodiment 1:

As shown in Figure 1, the machine vision system 100 includes a detection camera 101 and a first optical imaging lens 103 which is connected to the detection camera 101. The first optical imaging lens 103 is equipped with an adjustable aperture 102. The bottom of the detection camera 101 is equipped with a lighting system 104.

The laser ranging system 300 includes a laser projection component and a laser imaging component. The laser projection component consists of a laser 301, a laser collimating lens 302 and a beam splitter 303. The laser imaging component consists of a second imaging lens 304 and an imaging camera 305.

The beam splitter 303 is set at a 90-degree oblique angle below the detection camera 101. The laser 301 is set on one side of the beam splitter 303. The laser collimating lens 302 is placed between the laser 301 and the beam splitter 303.

The imaging camera 305 is set on one side of the detection camera 101, and the imaging camera 305 is set at an angle to the optical axis of the surface of the standard positioning target 200.

The laser beam of the laser 301 is deflected by 90 degrees through the laser collimating lens and the reflector. It is then vertically projected toward the surface of the standard positioning target 200. The scattered light of the laser is imaged by the laser imaging component.

When measuring and positioning, the machine vision system 100 and the laser ranging system 300 can be integrated and installed on the robotic arm.

The standard positioning target 200 is installed on the workpiece 501 that needs to be positioned in advance. When the standard positioning target 200 installed on the object is illuminated by the lighting system 104, the standard positioning target 200 is imaged on the photoelectric sensor of the detection camera 101 by the first optical imaging lens 103. During use, the adjustable aperture 102 and the brightness of the lighting system can be adjusted to ensure that the machine vision imaging system has sufficient brightness and depth of field.

Specifically, the standard positioning target 200 is a two-dimensional or three-dimensional structure with a central figure 201. A two-dimensional view of the standard positioning target 200 is illustrated in Figure 2. There are two concentric circles on it. After the standard positioning target 200 is imaged in the centre of the detection camera 101, the plane coordinate positions X and Y of the standard positioning target 200 relative to the robotic arm can be accurately calculated and determined. The laser beam projected by the laser is near the centre of the standard positioning target 200, and the image can be a straight line 306 or a point.

The height of the robotic hand relative to the work object is determined by using the laser ranging system 300. The laser beam of the laser 301 passes through the laser collimating lens or cylindrical lens, and then passes through the semi-transparent and semi-reflective beam splitter 303. The reflected light is deflected by 90 degrees and then vertically projected towards the surface of the standard positioning target 200. The surface of the standard positioning target 200 is an optically rough surface, and the scattered light of the laser beam is imaged on the imaging camera 305 by the second imaging lens 304. When the height of the standard positioning target 200 is at the middle position P0, the laser spot is also at the middle position of the imaging camera 305. The highest position of the standard positioning target 200 is P1. Its lowest position is P2, and the height L between P1 and P2 is the measurement positioning range of the positioning system. No matter whether the standard positioning target 200 is raised or lowered, the laser beam is always projected at the same position, but because the optical axis of the imaging camera 305 and the optical axis of the laser beam have an included angle, the position of the laser beam on the camera changes in a nonlinear functional relationship. Before use, test calibration will be performed to obtain the nonlinear relationship, so that the calibrated nonlinear functional relationship can be used to measure the height of the standard positioning target 200, i.e., the vertical coordinate position, Z.

Based on the above, the standard positioning target 200 is a two-dimensional or three-dimensional structure with a central figure 201. Multiple three-dimensional figures surround the standard positioning target 200. The central figure can be concentric circles, concentric squares, concentric triangles, etc. The 3D figure can be various symmetrical 3D geometric figures, such as cone, truncated cone, cylinder,

pyramid, truncated pyramid, etc. Using this two-dimensional standard positioning target 200 for measurement positioning cannot determine the perpendicularity of the machine vision system 100 to the standard positioning target 200, and may generate measurement positioning errors. A three-dimensional standard positioning target 400 is illustrated in Figure 3. The centre of the standard positioning target 200 is a two-dimensional concentric circle, and there are four three-dimensional truncated cones 401 at its four corners. When the machine vision system 100 and the standard positioning target 200 have eccentricity and verticality errors, the image of the three-dimensional standard positioning target 200 is asymmetrical. The magnitude of the eccentricity and the angular error can be processed and computed with the image of the standard positioning target 200. When the optical axis of the machine vision system 100 passes through the centre of the concentric circles and is perpendicular to the surface of the standard positioning target 200, then the image of the large three-dimensional standard positioning target 400 obtained by the machine vision is symmetrical. With that, the accurate spatial point position can be obtained to ensure the measuring and positioning accuracy.

Based on the above, there are at least three standard positioning targets 200, three of which are mounted on the workpiece 501 that needs to be positioned. The three positions are not placed in a line.

For an object, only measuring the three-dimensional coordinate position of a point is not enough to determine its spatial object position. To determine the spatial position of a known object, it is necessary to measure at least three points that are not placed on a straight line. As shown in Figure 4, three standard positioning targets 200 are installed at three different places on the workpiece 501 that needs to be positioned, and three positioning measurements are performed, and their spatial positions are obtained through three spatial points.

Embodiment 2:

As shown in Figure 5, the machine vision system 100 includes a detection camera 101 and a first optical imaging lens 103 which is connected to the detection camera 101. The first optical imaging lens 103 is equipped with an adjustable aperture 102.

The bottom of the detection camera 101 is equipped with a lighting system 104. The machine vision system 100 can be integrated with the laser ranging system 300 and installed on the robotic arm.

The laser ranging system 300 includes a laser 301 and a laser collimating lens 302 set at the front end of the laser 301. The laser 301 is set on one side of the detection camera 101, and the imaging camera 305 is set at an angle to the optical axis of the surface of the standard positioning target 200.

The laser beam emitted by the laser 301 is projected obliquely to the standard positioning target through the laser collimating lens 302, and is imaged by the machine vision system 100. The machine vision system 100 enables the dual functions of imaging the standard positioning target and laser projection imaging.

During the detection, the standard positioning target 200 is installed on the workpiece 501 that needs to be positioned in advance. When the standard positioning target 200 installed on the object is illuminated by the lighting system 104, the standard positioning target 200 is imaged on the photoelectric sensor of the detection camera 101 by the first optical imaging lens 103. During use, the adjustable aperture 102 and the brightness of the lighting system can be adjusted to ensure that the machine vision imaging system has sufficient brightness and depth of field.

During operation, the laser beam of the laser 301 passes through the laser collimating lens 302, where a cylindrical mirror is used to project it onto the standard positioning target 200, and a laser beam is formed when the cylindrical mirror projects it onto the surface of the standard positioning target.

Figure 6 illustrates the geometrical relationship between the laser beam and the height. Figure 7 shows the positional relationship between the image of the laser beam and the standard positioning target. When the standard positioning target 200 is at the middle position P0 of the measurement range, the laser beam is projected at the centre position D0, and the laser beam is imaged at the centre of the detection camera 101. When the height of the object that needs to be measured rises to position P1, the laser beam is projected at position D1, and its distance from the standard positioning target is A. At this time, the laser beam is also imaged on the camera, but it is deviated from the centre of the camera, and the image is to the left of the centre. The distance from the centre of the camera is E. In the same way, when the height of the object that

needs to be measured is lowered to position P2, the laser beam is projected at position D2, and the laser beam is also imaged on the detection camera 101 at this time, but is deviated from the centre of the camera and is imaged to the right of the centre. In this design scheme, by changing the included angle α and the working distance between the laser projection system and the machine vision system 100, the sensitivity of the measuring and positioning system and the working range of measuring and positioning can be changed. The size of the offset of the laser beam to the centre is linearly proportional to the height of the object position. It needs to be measured and calibrated before the instrument is used. The height position of the object can then be measured by measuring how far the laser beam is from the centre.

The determination of the specific coordinate positions X and Y, and the selection of the standard positioning target 200 are the same as those described in the first embodiment above.

Embodiment 3:

As shown in Figure 8, it includes two independent optical systems: machine vision 100 and laser triangulation 300. The function of the machine vision system has not changed, and it is still responsible for illuminating and imaging the standard positioning target.

The machine vision system 100 includes a detection camera 101 and a first optical imaging lens 103 connected with the detection camera. The first optical imaging lens 103 is equipped with an adjustable aperture 102. The bottom of the detection camera 101 is equipped with a lighting system 104. The machine vision system 100 can be integrated with the laser ranging system 300 and installed on the robotic arm.

The laser ranging system 300 includes a laser projection component and a laser imaging component. The laser projection component includes a laser 301 and a laser collimating lens 302 located at the front end of the laser 301. The laser imaging component includes a second imaging lens 304 and an imaging camera 305.

The laser 301, the laser collimating lens 302, the second imaging lens 304 and the imaging camera 305 are respectively arranged on both sides of the optical axis of the machine vision system 100. It is in a symmetrical position, and its configuration

can also be installed in other positions. Both the imaging camera 305 and the laser 301 are arranged at an angle to the optical axis emitting to the surface of the standard positioning target 200.

The laser beam of the laser 301 is deflected by 90 degrees through the laser collimating lens and the deflection lens, and then vertically project toward the surface of the standard positioning target 200. The projection of the laser beam is imaged by the laser imaging component.

During the detection, the standard positioning target 200 is installed on the workpiece 501 that needs to be positioned in advance. When the standard positioning target 200 installed on the object is illuminated by the lighting system 104, the standard positioning target 200 is imaged on the photoelectric sensor of the detection camera 101 by the first optical imaging lens 103. During use, the adjustable aperture 102 and the brightness of the lighting system can be adjusted to ensure that the machine vision imaging system has sufficient brightness and depth of field.

During the operation, the laser beam of the laser 301 is projected to the standard positioning target 200 through the laser collimating lens 302 or the cylindrical lens. When the cylindrical lens projects it onto the surface of the standard positioning target to form a laser beam or a point, the projected laser is imaged on the imaging camera 305 through the second imaging lens 304. However, since the optical axis of the imaging camera 305 has an included angle with the optical axis of the laser beam, the position of the laser beam on the camera changes in a nonlinear relationship. Before use, test calibration needs to be performed to obtain the nonlinear relationship, so that the calibrated nonlinear functional relationship can be used to measure the height of the standard positioning target 200, i.e., the vertical coordinate position, Z. Like the measuring device, the machine vision system 100 is placed in the middle position for measuring the plane coordinate positions (X, Y) of the standard positioning target.

The specific embodiments described above further describe the purpose, technical solutions and beneficial effects of the invention in detail. It should be understood that the above descriptions are only specific embodiments of the invention, and are not intended to limit the invention. Any modification, equivalent replacement, improvement, etc. made within the spirit and principle of the present invention shall be included within the protection scope of the invention.

CLAIMS

1. A measuring and positioning system designed based on machine vision and laser triangulation, the measuring and positioning system comprising:

a machine vision system,

a laser ranging system, and

a standard positioning target mounted on a positioning workpiece,

wherein:

the machine vision system is arranged to image the standard positioning target; and

the laser ranging system comprises:

a laser projection component arranged to project laser light onto the standard positioning target; and

a laser imaging component comprising an imaging camera arranged to image the projected laser light.

2. The measuring and positioning system as claimed in claim 1, wherein:

the machine vision system comprises a detection camera and a first optical imaging lens connected to the detection camera, and wherein the first optical imaging lens is equipped with an adjustable aperture, and a bottom of the detection camera is equipped with a lighting system.

3. The measuring and positioning system as claimed in claim 2, wherein:

the laser projection component consists of a laser, a laser collimating lens and a beam splitter;

the laser imaging component further comprises a second imaging lens;

wherein the beam splitter is arranged to be set at a 90-degree angle below the detection camera, the laser is arranged to be set on one side of the beam splitter, and the laser collimating lens is arranged between the laser and the beam splitter; and

wherein the imaging camera is arranged to be set on one side of the detection camera, and the imaging camera is arranged to be set at an angle with respect to an optical axis of the standard positioning target so that the laser light is deflected by 90

degrees through the laser collimating lens and the beam splitter and is then vertically projected toward a surface of the standard positioning target, for the laser imaging component to image the projected laser light .

4. The measuring and positioning system as claimed in claim 2, wherein:

the standard positioning target is a two-dimensional or three-dimensional structure with a central figure.

5. The measuring and positioning system as claimed in claim 2, wherein:

the standard positioning target is a two-dimensional or three-dimensional structure with a central figure with a plurality of three-dimensional figures surrounding the central figure.

6. The measuring and positioning system as claimed in claim 5, wherein:

the three-dimensional figure is a truncated cone, and is distributed around the standard positioning target in a circularly symmetrical manner.

7. The measuring and positioning system as claimed in claim 1, further comprising:

second and third standard positioning targets, wherein the three standard positioning targets are arranged to be mounted on the positioning workpiece, and are not positioned in a line.

8. The measuring and positioning system as claimed in claim 1, wherein:

the laser ranging system further includes a laser and a laser collimating lens equipped at a front end of the laser, the laser is equipped on one side of a detection camera; and

the imaging camera is arranged to be set at an angle with respect to an optical axis of the standard positioning target so that the laser light emitted by the laser is obliquely projected to the standard positioning target through the laser collimating lens for the machine vision system to image the projected laser light.

9. The measuring and positioning system as claimed in claim 1, wherein:

the laser projection component further includes a laser and a laser collimating lens, the laser imaging component further comprises a second imaging lens;

the laser and the laser collimation lens, the second imaging lens and the imaging camera are arranged to be respectively set on both sides with respect of an optical axis of the machine vision system where a detection camera is located;

the laser and the laser collimation lens are symmetrically arranged with respect to the second imaging lens and the imaging camera; and

the second imaging lens and the imaging camera are arranged to image the projected laser light after the laser and the laser collimating lens project the laser light on the standard positioning target.