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(54) Title: CALIBRATION TOOL FOR A DELTA ROBOT

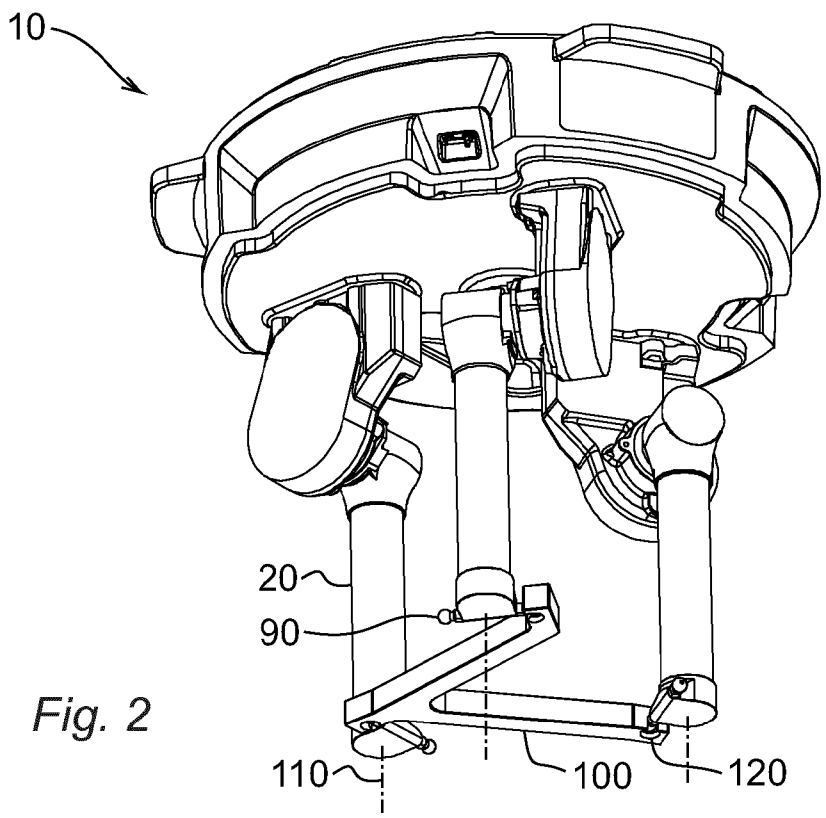


Fig. 2

(57) Abstract: A jig (100) for calibrating a Delta robot (10) fixes the longitudinal axes (110) of drive arms (20) to be parallel. With this configuration, the jig (100) always fixes the drive arms (20) at the same reference angle no matter what the drive arm length is.

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Calibration tool for a Delta robot

TECHNICAL FIELD

The present invention relates to a device for calibrating a robot comprising at least three parallel drive arms.

BACKGROUND ART

Referring to figure 1, a Delta robot 10 comprises a plurality of parallel drive arms 20 connected to an end effector 30 by means of rods 40. The rods 40 constitute together with the drive arms 20 and the end effector 30 parallelograms which restrict the movement of the end effector 30 to pure translation. Each drive arm 20 is driven by a servo motor through a gearbox, and the movement is transmitted to the rods 40 and ultimately to the end effector 30 via kinematic chains comprising ball joints 50 between the drive arms 20 and the rods 40, and the rods 40 and the end effector 30, respectively. A traditional Delta robot 10 has three drive arms 20 and three degrees of freedom, but variants of a Delta robot 10 may have four or more drive arms 20, and also more than three degrees of freedom. In the Delta robot 10 according to figure 1 a fourth degree of freedom is provided by a central shaft 60 transmitting rotating movement to the end effector 30.

When calibrating a drive arm 20 of a Delta robot 10, the respective drive arm 20 needs to be moved to a known position that is used as a reference position for the calibration. A conventional way of fixing a drive arm 20 into a reference position is to push the drive arm 20 all the way up until it comes into contact with a calibration pin 70 positioned at a robot base 80. While this reference position is accurate enough for many applications, for other applications it is not. The position of the calibration pin 70 in relation to the drive arm 20 depends on a chain of

tolerances between the two components, and consequently the reference position is not as accurate as desired.

JP2009255197 discloses a jig that is configured to fix the drive arms of a Delta robot into a reference position. The jig is attached between a robot base and an end effector, and the reference position is transmitted to the drive arms via rods.

In practice a certain type of Delta robot has several configurations with different drive arm lengths and rod lengths (all the drive arms in a certain configuration having, of course, the same length, and all the rods in a certain configuration likewise having the same length). A drawback with the jig according to JP2009255197 is that when the drive arm length or the rod length changes, a use of the same jig results in a different reference angle value. There is therefore a desire to improve the existing methods of fixing a drive arm of a Delta robot into a reference position.

SUMMARY OF THE INVENTION

One object of the invention is to provide a Delta robot calibration tool that provides an improved accuracy for a reference position, and that always results in the same reference position despite of the length of the drive arms.

A further object of the invention is to provide an improved method for calibrating a Delta robot.

These objects are achieved by the device according to appended claim 1 and the method according to appended claim 6.

The invention is based on the realization that there is only one drive arm position where the relative positions of two distal drive arm ends remain unchanged when the drive arm length is changed, this drive arm position being the one

where the longitudinal axes of the two drive arms are parallel i.e. the angular position of each drive arm is +90°.

According to a first aspect of the invention, there is provided a jig for calibrating a robot comprising at least three parallel drive arms. The jig is configured to fix the longitudinal axes of at least two drive arms to be parallel. With this configuration, the jig always fixes the drive arms at the same reference angle no matter what the drive arm length is.

According to one embodiment of the invention, the jig is configured to fix the longitudinal axes of at least three drive arms to be parallel. The reference position becomes more precise when at least three drive arms are attached to the jig.

According to one embodiment of the invention, the jig comprises an attachment element configured to interact directly with a drive arm. The reference position becomes more precise when the jig is attached directly to the drive arms.

According to one embodiment of the invention, the attachment element is a jig socket configured to interact with a ball. The balls belonging to ball joints at the drive arms are found to be suitable attachment elements for the jig.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in greater detail with reference to the accompanying drawings, wherein

figure 1 shows a conventional Delta robot, and

figure 2 shows a jig according to one embodiment of the invention attached to a Delta robot.

DESCRIPTION OF PREFERRED EMBODIMENTS

A Delta robot 10 shown in figure 2 corresponds to that of figure 1 with some components, among other things the rods 40 and the end effector 30, removed. Each of the three drive arms 20 comprises two studs with a ball 90, the balls 90 being configured to constitute ball joints 50 together with rod sockets at the ends of the rods 40. According to one embodiment of the invention, one ball 90 at each drive arm 20 is instead attached to a jig 100 that fixes the drive arms 20 into a reference position during calibration. More precisely, the jig 100 fixes the drive arms 20 into a position where the longitudinal axes 110 of all the drive arms 20 are parallel i.e. a position where the angular position of each drive arm 20 is +90°. In this reference position the relative positions of the balls 90 remain unchanged when the drive arm length is changed, and consequently usage of the jig 100 results in an identical reference angle value for robot configurations with different drive arm lengths. The jig 100 comprises jig sockets 120 interacting with the balls 90 for the attachment.

In theory, it is sufficient to attach the jig 100 to only two of the drive arms 20 to fix the longitudinal axes 110 of the two drive arms 20 to be parallel. Because of clearings between the balls 90 and the jig sockets 120, and at the bearings of the drive arms 20, respectively, the reference position becomes much more precise when all the three drive arms 20 are attached to the jig 100. In the case of a Delta robot 10 with more than three drive arms 20 it is advantageous to attach all the drive arms 20 to a corresponding jig 100 during calibration.

The invention is not limited to the embodiments shown above, but the person skilled in the art may modify them in a plurality of ways within the scope of the invention as

defined by the claims.

CLAIMS

1. A jig (100) for calibrating a robot (10) comprising at least three parallel drive arms (20), **characterized in that** the jig (100) is configured to fix the longitudinal axes (110) of at least two drive arms (20) to be parallel.

2. A jig (100) according to claim 1, wherein the jig (100) is configured to fix the longitudinal axes (110) of at least three drive arms (20) to be parallel.

3. A jig (100) according to any of the preceding claims, wherein the jig (100) comprises an attachment element configured to interact directly with a drive arm (20).

4. A jig (100) according to claim 3, wherein the attachment element is a jig socket (120) configured to interact with a ball (90).

5. A Delta robot (10) comprising at least three parallel drive arms (20) and a jig (100) according to any of the preceding claims attached to the Delta robot (10).

6. A method for calibrating a robot (10) comprising at least three parallel drive arms (20), the method comprising the steps of:
- fixing the longitudinal axes (110) of at least two drive arms (20) to be parallel; and
- using the corresponding position of the at least two drive arms (20) as a reference position for the calibration.

7. A method according to claim 6, wherein the method further comprises the step of:
- fixing the longitudinal axes (110) of at least three drive arms (20) to be parallel.

8. A method according to any of claims 6 or 7, wherein the jig (100) is attached directly to the at least two or at least three drive arms (20).

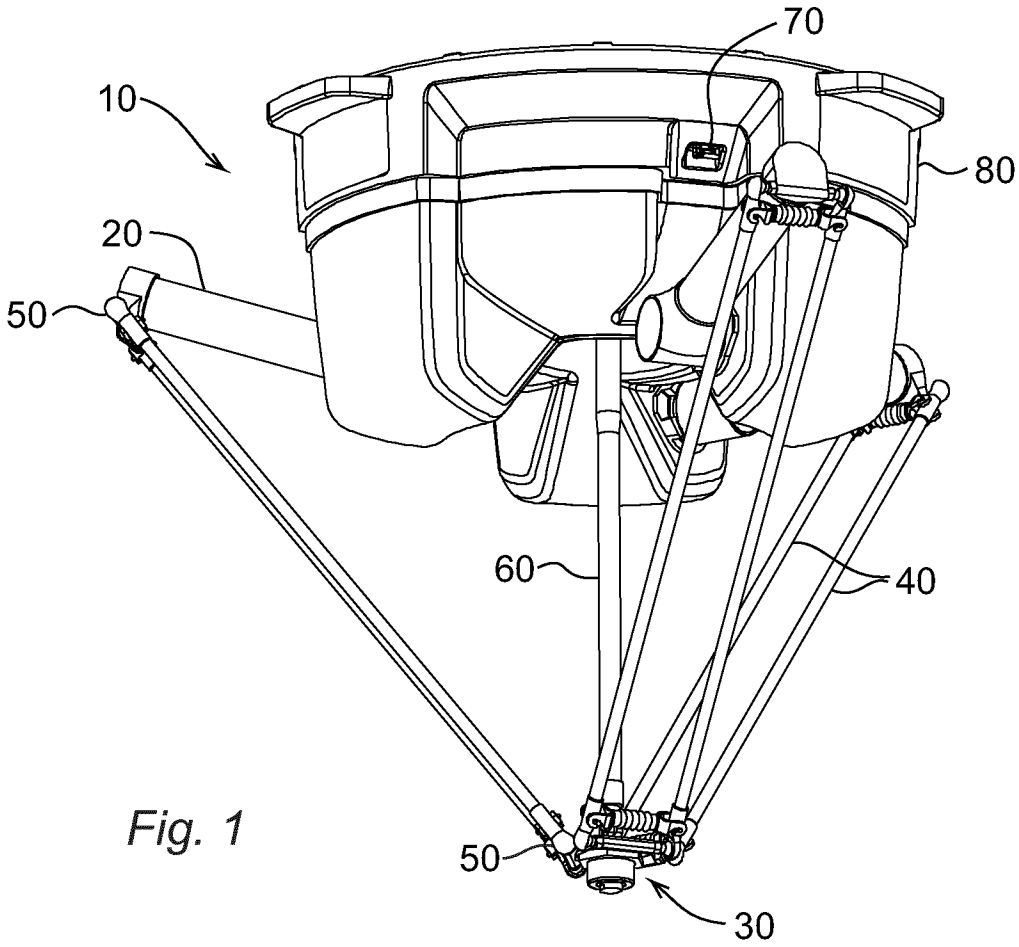


Fig. 1

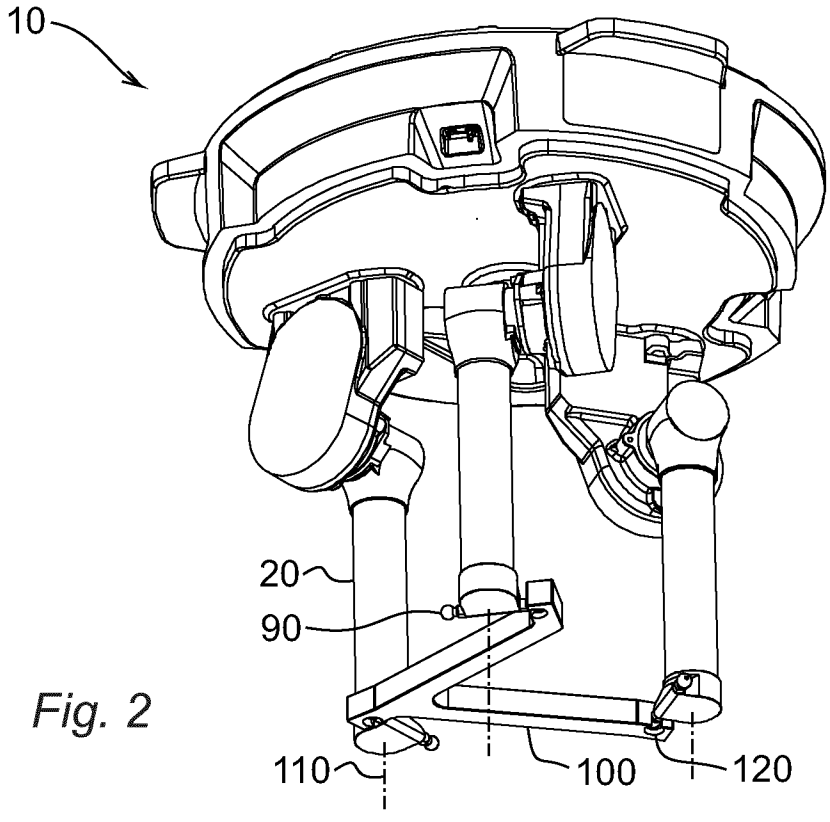


Fig. 2

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J9/00 B25J9/16
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009 255197 A (MURATA MACHINERY LTD; KYOTO SEISAKUSHO) 5 November 2009 (2009-11-05) cited in the application abstract; figure 1	1-8
A	EP 2 359 988 A1 (MULTIVAC HAGGENMUELLER GMBH [DE]) 24 August 2011 (2011-08-24) abstract; figure 3 paragraphs [0014], [0015]	1-8

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2013	06/06/2013

Name and mailing address of the ISA/	Authorized officer
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Peter Vischer ET AL: "Kinematic calibration of the parallel Delta robot", Robotica, 1 January 1998 (1998-01-01), pages 207-218, XP55063566, Retrieved from the Internet: URL:http://cats-fs.rpi.edu/~wenj/ECSE641S07/delta_calibration.pdf [retrieved on 2013-05-22] the whole document -----	1-8
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/066512

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