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Experimental Investigation of Pose Repeatability of Manipulating Robots

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Main characteristics, which define abilities of implementation of manipulating industrial robots are [1]:

– pose accuracy and repeatability
– pose stabilization time
– pose overshoot
– minimum positioning time
– drift of pose accuracy
– path accuracy and repeatability
– path velocity accuracy and repeatability

In implementations where the path accuracy and repeatability is not so important, the sufficient characteristics are pose accuracy and repeatability.

In this publication the object is experimental investigation of pose repeatability of manipulating robot SCARA type.

Pose Repeatability

Parameters, which characterize manipulating robots in positioning the end effector into working space are definited from the deviations between task and achieved position, due to mechanical mistakes., friction, chisteresis, programming mistakes depending by the methods of control, and other environmental influences.

Pose repeatability shows the degree of deviation of coordinates and angles after *n* times positioning in the same point and in the same order of changing of coordinates .i.e. executing of the trajectory in the same way.

Pose repeatability for given point is defined from the value of the parameter *r*, which is the radius of sphere into which the end effector goes, and it is calculated from the equation:

(1) $$r = \bar{D} + 3S_D ,$$

where

(2) $$\bar{D} = \frac{1}{n}\sum_{j=1}^{n} D_j ,$$

(3) $$D_j = \sqrt{(x_j - \bar{x})^2 + (y_j - \bar{y})^2 + (z_j - \bar{z})^2} ,$$

(4) $$S_D = \sqrt{\frac{\sum_{j=1}^{n}(D_j - \bar{D})^2}{n-1}} ,$$

(5) $$\bar{x} = \frac{1}{n}\sum_{j=1}^{n} x_j , \quad \bar{y} = \frac{1}{n}\sum_{j=1}^{n} y_j , \quad \bar{z} = \frac{1}{n}\sum_{j=1}^{n} z_j$$

are the coordinates of the center of the area, calculated after repeating the task pose ***n*** times, and x_j, y_j, z_j are the coordinates of j-th achieved pose; $j = 1, ..., n$ – number of cycles.

Investigation of pose repeatability of manipulating robots must be done in conditions given in [1], and shortly are:

– measures are made in 5 task poses, situated in a plane into a cube into working space that is used mostly.; sides of the cube must be parallel to basic coordinate system; when the robot executes variety of movements in one axis, which are small enough to the arcs, cube may be replaced with a right angled parallelepiped.. The first task point is the crossing point of its diagonals.

– measurements are made in 100% of the limited load

– measurements are made with maximal velocity of the robot

– minimal number of cycles of each point is 30.

Experimental Scheme

Experimental scheme for the investigation of the pose accuracy and repeatability of manipulating robot is given in Fig.1.

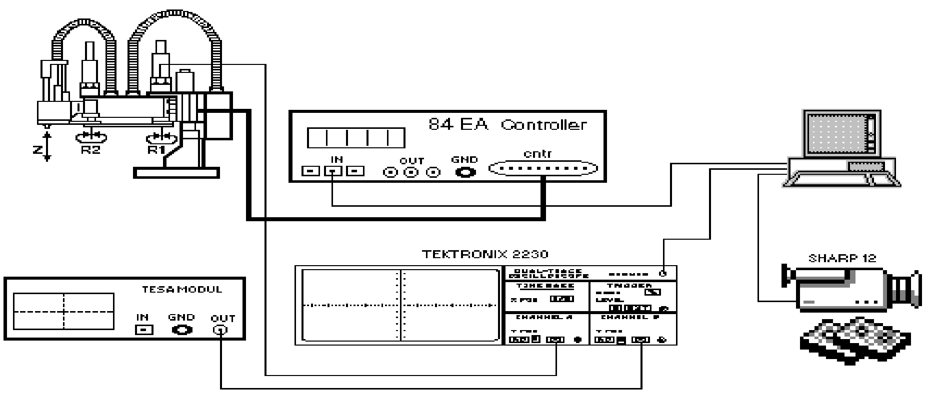

Fig.1. Experimental scheme

The object if investigation in this case is manipulating assembling robot PEM 10-01 SCARA type. D.C. motors are used for turning modules. Pneumatic cylinder is used for Z-axis and possible positions are 2 – up and down. Working space of the robot is restricted from the angles of rotation of turning modules: $R_1 - 200°$, $R_2 - 155°$. It is a part of a plane, perpendicular to the axes of the two turning cinematic pairs, which could be situated in two positions, distanced 150 mm each from the other due to the two fixed positions of the translation cinematic pair. The other elements from the experimental scheme are given in details in [2].

Experimental data

Having in mind the type of working space of the robot PEM 10-01 and experimental conditions given above, the measured poses are situated into a rectangular parallelepiped. The first pose is the crossing point of the diagonals and its sides are parallel to axes $O\vec{x}$, $O\vec{y}$ in the basic coordinate system.

Numerical data from the experimental investigation of pose repeatability of manipulating robot PEM 10–01 for poses P1–P5 are given in Appendix 1.

The results in Appendix 1 are calculated from the equations (3) and (4)

The results for the pose repeatability of the manipulating robot, calculated from the equations (1) and (2), (on the base of the data from Appendix 1 and Appendix 2 are given in Table 1.

All numerical values in the tables are in μm.

Table 1. Pose repeatability

Conclusion

The above mentioned method for investigation of pose repeatability of manipulating robots could be used both for experimental testing of pose repeatability of existing manipulating robots, and for new structures.

The results of testing the assembling robot PEM 10-01 are in the values, given in its technical characteristics.

References

1. ISO/DIS 9283.

2. D. Uzunova, T. Boiadjiev, I. Stoianov. Investigation of pose accuracy of manipulating robots. Scientific session "Mechatronica 96", 04-07.06.1996, Drianovo, Bulgaria.

Экспериментальное исследование позиционной повтаряемости манипуляционных роботов

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В работе показаны исследования позиционной повтаряемости манипуляционных роботов, которые могут применяться при экспериментальных тестах существующих манипуляционных роботов и новых структур. Представлены результаты манипуляционного робота РЕМ 10-01.