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Innovative and cost-effective Measurement Setup to determine Robot Accuracy

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Summary

Established robot manufacturers have developed methods to determine and optimize the accuracy of their robots. These methods vary from robot manufacturers to their competitors. Due to the lack of published data, a comparison of robot performance is difficult. The aim of this article is to find methods to evaluate important characteristics of a robot with an accurate and cost-effective setup. A laser triangulation sensor and geometric referenced spheres were used as a base to compare the robot performance.

Keywords: accuracy, laser triangulation, measurement, repeatability, robotics

Introduction

Robot accuracy is crucial in current industrial applications with needed deviations smaller than 0.2 mm [1]. Beneath the pose accuracy often stated by manufacturers, other criteria are far more essential for many applications, e.g. the path accuracy or the distance for relative programming [2]. These are listed in ISO 9283 among several other criteria for pose and path accuracy [3]. A complete set of the characteristics needed for comparison between robots are often not given. For accuracy critical processes such as assembly or laser related operations it is essential to have the robot performance in advance.

In the beginning theodolites were used for measurement and calibration of robotic kinematics [4]. Nowadays camera-based units and laser interferometer are preferred [5]. A disadvantage of all systems is the effort in use and the costs.

This work provides a solution to derive with simple equipment two criteria of the above mentioned ISO 9283 in order to estimate the performance of the robot for individual use in one's own production.

Methods

The path accuracy and the pose repeatability were measured as a feasibility test for the setup. An edge is used to derive the path accuracy which is measured while the robot is moving along a given linear path. A board with four spheres and a diameter of 32 mm was used for the pose repeatability test. This board is a geometric reference with defined positions to each other as seen in **Figure 1**. The center of one sphere is used to trace back the position of the robot. The setup was a laser triangulation sensor (ECCO75.100, SmartRay) mounted at a 6-DoF robot (RA605-710-K, HIWIN) and the setup board. The sensor data were given as distances of a 2D-line measured between sensor and board.

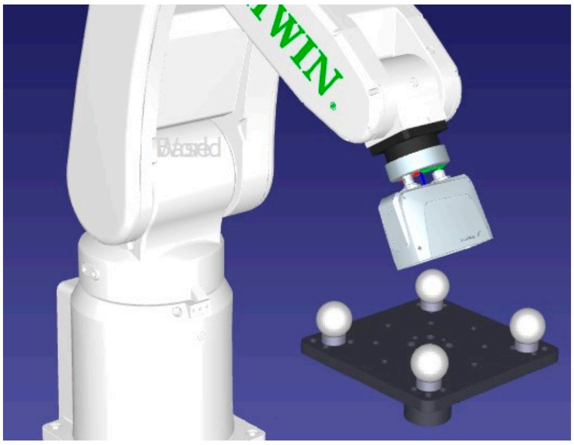

Figure 1 Robot and geometric setup (example), Picture was generated with RoboDK library [6].

As stated in ISO 9283 thirty measurements were repeated to evaluate the repeatability of pose. One data set was recorded for the path accuracy. The measured circle section was used to calculate x- and y-coordinates of the center. The radius was determined with a circle fit method [7]. The resulting errors were calculated as stated in ISO 9283.

Results

The data sheet specifies the pose repeatability as ±0,02 mm. The calculated robot pose repeatability results in ±0,031 mm. **Figure 2** shows the distribution of the pose repeatability according to Reinhart et al. [1]. The distribution results in measurement standard deviation of 6.5 µm.

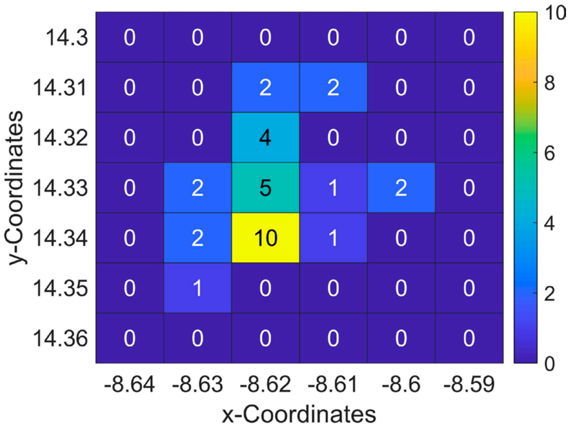

Figure 2 Distribution of sphere centers in pose repeatability measurements. The numbers show the distribution of the respective calculated coordinates.

The robot movement was parallel to a metal edge. While moving with 32 mm/s, the sensor measured with a sample rate of 50 Hz.

The base level of the start and end position was estimated by using the average of ten samples at the beginning and end of the predefined trajectory. The calculated nominal values of the line were used to derive the error along the 415 mm path resulting in maximum errors of 66 µm in x-, 656 µm in y- and 1.610 mm in z-direction (data in sensor coordinate system). This is shown in **Figure 3**.

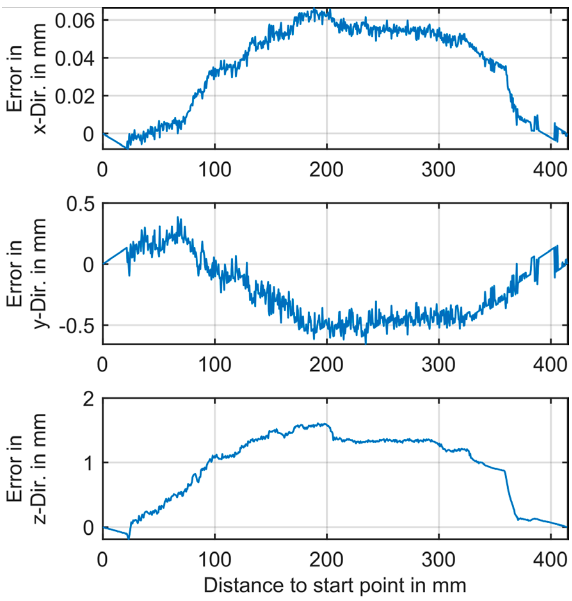

Figure 3 Path error, x, y and z error are shown separately.

Discussion

The setup is an accurate and low-cost solution to measure a robot on self-defined tasks. It is hypothesized that the exceeding errors occur due to inhomogeneous reflections on the spheres. The errors in z-direction are partly caused by shifts in x-direction since the 2-dimensional measurement is not capable to distinguish these errors.

On the path there can be reflections due to disturbances on the surface seen as peaks in **Figure 3**. These may have an influence in the maximum values. Also, the angle needs to be considered between the surface and the sensor. It has to be in the range of 40° to 60° in order the get a signal from both sides of the edge.

Conclusion

It has been shown that both characteristics, pose repeatability and path accuracy, could be derived with the inexpensive ECCO75.100 sensor. This setup can help to compare different robots in order to estimate the usability in certain applications, especially for the small size robot series up to 10 kg load.

Investigations need to be done in filtering the data, angle (object to sensor) optimization and implementing further criteria.

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