Improved Robot Accuracy with Motion Capturing

Degree programme : Master of Science in Engineering | Specialisation : Mechatronics and Automation
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Collaborative robots are built to have good repeatability. But for the use in an agile production environment the robots also need to have good absolute accuracy. The position error of a Universal Robot UR5e can be in the magnitude of a few millimetres. The goal of this project was to improve the accuracy of the robot with the help of an optical motion tracking system. A closed loop position controller and a static error correction approach were implemented in ROS2.

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Context

Collaborative robots became very popular over the last years because they can be easily installed with a minimum of safety equipment and also easily programmed in an offline mode with teach-in methods. For that, of course, the repeatability is the important design factor. For more flexible applications where the robot receives the goal position at runtime the absolute accuracy of the robot is important.

Goal

The goal of this project is to improve the absolute accuracy of the robot with the help of a optical motion capturing system. A motion capturing system consists of multiple infrared cameras which track reflective markers in the three-dimensional space. A closed loop controller for the tool flange of the robot is implemented. The controller is implemented in ROS2 so it can be used in other research projects of the institute.

Method

The test setup consists of six Qualisys motion capturing cameras mounted on the ceiling of the laboratory and a collaborative UR5e robot. On the tool flange and at the base of the robot multiple markers are mounted to track the pose of the flange and the robot base. The black support to be mounted on the flange with the reflective markers can be seen in figure 1.

The cameras are connected to a Windows PC on which the software of the motion capturing system is running. The capturing software sends the poses of the robot flange and base over TCP/IP to a Linux PC and ROS2. The controller is composed of six separate P-Controllers to control all degrees of freedom and outputs the robot flange velocity in cartesian coordinates. ROS2 then calculates the joint positions of the robot and sends them over TCP/IP to the robot.

Results

To compare the implemented controller with the normal movements the robot was moved to multiple points in its workspace and the position error were measured with the motion capturing system. If the robot is operated in its normal mode, the positioning error has a median of 5 mm. The errors can be seen in figure 2, they show a dependency on the pose of the robot. The errors for different poses are indicated by a dot in the figure. Smallest errors (around 0.5 mm) are shown in blue and largest errors (around 10 mm) are shown in red. With the closed loop controller, the median error was reduced to 0.8 mm.
With the new controller the movements of the robot are way slower than with the normal mode. Furthermore, the cost of a motion capturing system is not negligible. Prices are in the same range as the robot itself.

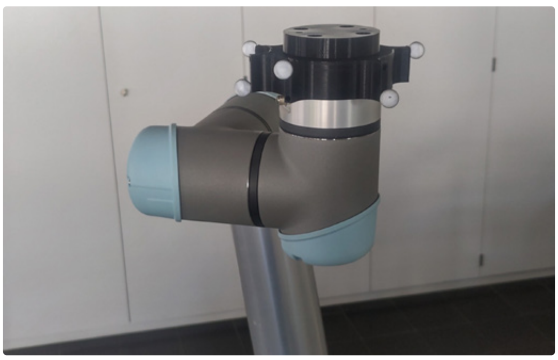

Figure 1: Markers for Robot Flange

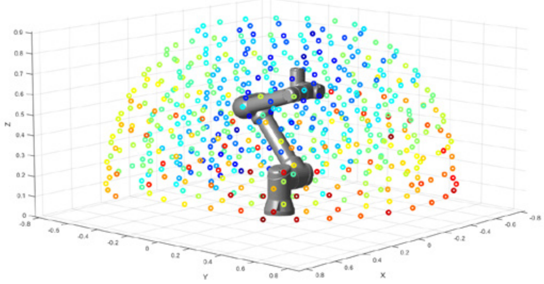

Figure 2: Position Errors normal Robot Movement