# Software-Driven Approach to Calibrating a Pick-and-Place Process

This thesis demonstrates that, by utilizing existing sensors, it is possible to measure errors in positions and rotations in a pick-and-place process within a few millimeters.

All industrial processes have to be calibrated to function properly. For example, calibration is crucial in a pick-and-place process where a camera inputs position data to a robot that manipulates objects with millimeter precision. Unfortunately for industries, this can be a complex practice, as this most likely means that a human will manually measure errors in the positioning and orientations of machines. Not only is it complex, but it can be time-consuming and require skilled service technicians as well. However, it is still unavoidable, as disregarding precision issues can negatively impact both products and machines. This is why this project aimed to reduce the need for human interaction by instead relying on the already integrated sensors to measure the errors. Thus reducing the complexity of performing the calibration.

The implemented method can be summarized in the following manner. A camera measures where an object is physically situated, which is also done by a robot. Comparing these measurements, and the devices' perspectives of where the object is, one can derive the difference between the error. Once the difference is identified, it is possible to subtract the difference from the robot's perspective. Consequently, the camera and the robot can, theoretically, communicate perfectly since the robot navigates according to the camera's perspective. As with most things, the calibration is not perfect. However, it does find errors within a few millimeters, an acceptable range for several industrial applications. For example, the apple industry is rather forgiving in terms of its pick-and-place processes. This is because apples are rather big and difficult to miss in the picking sequence.

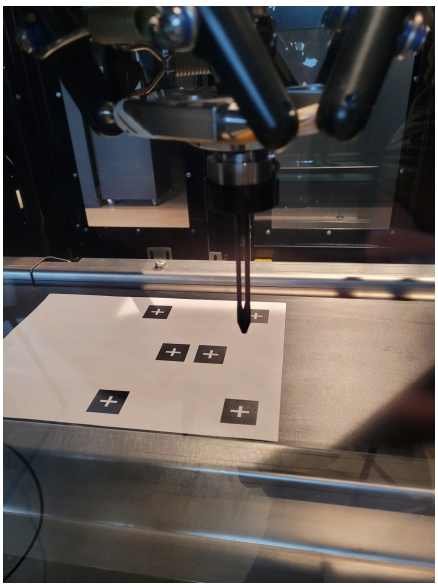

Figure 1: The robot is positioned over a point and is about to mark it for measurement.

To conclude, the implemented process is simple, allowing operators to calibrate the machines with little training and without complex instructions. It is also cheap and easy to implement since it relies on already integrated sensors. Although this accuracy is sufficient for several industries, many industries require even greater precision. Nonetheless, several proposed improvements can improve the accuracy.

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