Popular abstract

As a high-wage country, Denmark relies on automation to maintain an economically feasible production industry. However, small-batch manufacturing of products, which either have high variability or experience rapid design changes, is difficult to automate using traditional techniques. For this reason, there is an increasing interest in developing flexible automation solutions. One of the major challenges of flexible automation is to get the workpieces into the system. This is referred to as *part feeding*. Part feeding is done by first aligning a part to a desired orientation and position. When the orientation and position of the part is known, a robot can be used to pick up the part and insert it into the automation system. Traditionally the alignment is performed using specialized equipment known as mechanical part feeders. However, mechanical part feeders are generally designed for a single part, which makes them infeasible to use in a flexible automation system which must be able to handle a large variety of parts. An alternative method for determining the orientation and position of a part is to use a vision sensor system. Such a system relies on cameras to “see” where the parts are and how they are oriented. However, in order for the vision system to perform reliably, it needs to be properly configured. In other words the type of camera must be chosen, the placement of camera and light must be determined, and the software, which is used to automatically analyze the camera images, must be configured properly. At present, the configuration process is both costly and time-consuming since it relies on expert knowledge and is often guided by intuition and trial and error.

This Ph.D. project investigates how the configuration of a vision sensor system for flexible part feeding can be automated, such that the implementation and change-over time and cost can be reduced and thereby increase the feasibility of using vision-based flexible feeding solutions in the production industry. The project focuses on the part of vision system configuration that is the determination of sensor placement. Furthermore, the project primarily focuses on vision sensors which are similar to the Microsoft Kinect which was originally developed for the Xbox.

In essence, the goal of the project is to develop a piece of software which can replace the engineer’s ability to estimate system performance based on intuition. If the software can predict if a given sensor placement will lead to good vision system performance, it is possible to test a large number of configurations on a computer and output the optimal one. Good performance of the vision system simply means that the orientation and position of a part is estimated accurately enough that the robot can pick up the object. Since the robot is robust to small errors on the estimated orientation and position of a part, the vision system just needs to have an accuracy which corresponds to the error tolerance of the robot.

Prediction of the vision system performance is done by simulating the vision sensor using realistic 3D computer graphics. The vision software can then be run on simulated images instead of real images. By running a large number of tests on simulated images it is possible to predict how the system would perform in the real world. To conclude, this Ph.D. project has investigated how sensor simulation can be used to predict the performance of a vision sensor system such that it can be automatically configured. This approach has been used to automatically determine the optimal placement of a Kinect-like vision sensor for part feeding.