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Using machine vision for flexible automatic assembly system

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Abstract

Flexible automatic assembly systems become the useful automation system for high mixed production lines of manufacturing processes. This research was aimed to design the primary prototype of the flexible automatic pick and place assembly system. We integrated the machine vision system with the robotic system to conduct a pick and place process. The product models consisted of a main part and an assembly part. The main parts were transferred to the mechanical system through a conveyor belt. When the main parts were held at the specific location, the images of the main parts were captured. Using the image processing of LabVIEW NI vision software and NI vision builder and image calibration method, we could obtain the shape, and orientation of assemble space in the main part which were used to control selective compliance articulated robot arm (SCARA). The SCARA was used to pick the assembly parts from the storage station and place them into the assembly spaces on the main parts. As the results of the prototyping, we evaluated the coordinate conversion factors from the image calibration and used them to control the movement of the SCARA. We finally obtained the reliable flexible automatic assembly system that could detect and identify the shape, and orientation of the assembly space correctly. The SCARA could also pick the correct assembly parts and place them into the assembly space perfectly.

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Keywords: flexible manufacturing system; machine vision systems; pick and place process; LabVIEW

1. Introduction

Nowadays, customer wishes push demands on variety of individual product features, and shorter delivery time in manufacturing industry[1]. With a high degree of complexity of manufacturing processes, the automation systems have been applied to production and final assembly systems. In the high mix production, product models may have various sizes, shapes, and orientations which require a higher flexibility of the automatic assembly process. When the product models are changed in the conventional assembly process, the production line needs to be stopped and then new configuration and commands of the automatic assembly system need to be set up. This conventional assembly process can increase the production lead time, whereas it can decrease the systems efficiency. Consequently, the production costs are raised by investing in labor cost, machine and equipment cost. To improve the conventional automatic assembly system, the flexible automatic systems have been utilized in the high mix assembly process. This flexible automatic system can modify its working pattern and automatically responds to the new models. In this case, the production line does not need to be stopped remarkably improving the assembly process performance.

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One way to accomplish the flexible automatic system is to integrate machine vision systems with the automation systems. The computer vision techniques have been used to provide product data which assists decision-making of the production systems[2]. In cutting tool process using CNC machine, the vision sensor have been used to monitor cutting tool conditions, including tool wear, and surface texture. In this case, the information on tool wear state obtained from the vision sensor was used to estimate wear parameters which were used as feedback control for CNC controllers[3]. An automated vision system has also been used to inspect defects on printed circuit boards using reference comparison approach. This automated visual inspection system was considered to be efficient for defect detection and defect classification[4]. In the automatic assembly process, the machine vision system is also feasible to inspect the characteristics, size, shape, orientation, and defects of the product models. This inspection assists the automatic assembly system to distinguish the models and respond to those models correctly. The vision system basically based on image classification. First, the object image is captured using camera. Next, the search area of the image is specified to set the environment for image processing. In the image processing step, the classification is identified by comparing the significant features of the captured image to those of the standard image. Two major classifiers are generally used for the image processing: object classifier, and color classifier. The object classifier identifies the object based on its shape while the color classifier distinguishes the object based on its color[5].

Meanwhile, industrial robots have been also implemented in the automatic assembly process to reduce human errors, lead time, and labor cost. The robots can achieve better performance using novel control methods. Chen and Liu have remarkably succeeded in implementing the robust impedance control algorithm with a selective compliance articulated robot arm (SCARA) to perform a printed circuit board (PCB) assembly[6].

This research paper focuses on the pick and place process, a sub process of assembly process which requires a precise configuration and position to assemble parts of products. The integration system of machine vision system and SCARA robot has been designed to assemble the parts with various shapes, configurations, and orientation in a single production line.

2. Experiment

In this experiment, model components were consisted of main parts and assembly parts. We had three assembly models which were square, triangle, and circle to be placed into the corresponding main parts in various positions. The main parts and assembly parts are presented in Fig. 1(a), and Fig. 1(b), respectively. The main parts were moved along the conveyor belt, while the assemble parts had been stored on the storage station. The assembly process must be done by putting the right assembly part into correct position on the main part. To complete the task, vision system was integrated to identify the geometry and the orientation of the assembly space.

a b

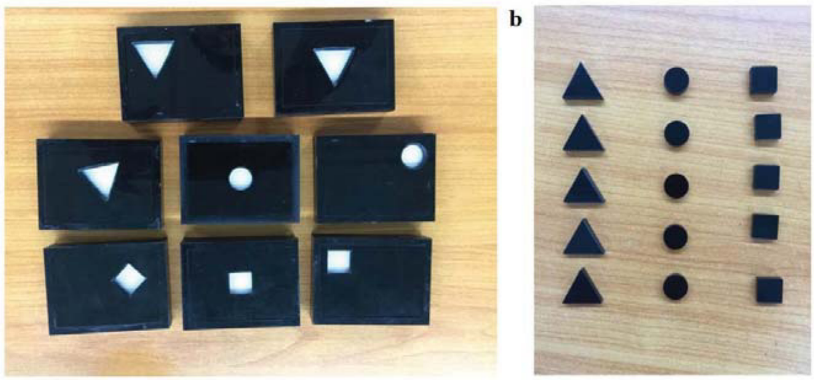

Fig.1. (a) Main parts; (b) Assembly parts.

This chapter is divided into two sections which are hardware design, and software design. The hardware system composed of camera, robot, and end effecter of robot. We also used SCARA model IX-NNC6020-5L-T1-SP to receive processing information. The end effecter of the robot, a 10 mm diameter vacuum suction head, was used to hold the assembly part in the assembly step. Then the SCARA was programmed to move to the desired location in pick and place process.

For the vision module, we used the USB CCD camera with the resolution of 640 X 840 pixels to capture the image of the main part on the conveyor belt. The brightness of the backlight at 700 Lux makes it was easier to create image processing software of LabVIEW. The system used the LabVIEW NI vision software and NI vision builder to develop computer programs for image processing. The program was designed for identifying the position and orientation of the parts. LabVIEW was also used to communicate to the robot controllers by sending the location of the assembly part and the location of the assembly space to the SCARA. NI Vision Builder program was brought in to define the characteristics of the parts such as the configuration of the main part that needed to be searched, color, brightness, searching area, etc. This vision builder helped the program work easily.