Using Robots to Teach Manufacturing Automation

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Abstract

The Manufacturing Automation course is offered as part of the Electrical Engineering Technology curriculum. This course covers computer integrated manufacturing systems primarily from a hardware and control point of views. It also covers robotic applications to Computer Integrated Manufacturing (CIM) cells. The course includes lab experiments utilizing a robot and Computer Numerical Control (CNC) machines. The robot was designed to emulate an industrial robot. The open structure of the robot arm allows students to observe and learn about its internal mechanisms. The robot is a vertical articulated robot, with five revolute joints. With a gripper attached, the robot has six degrees of freedom. This design permits the end effector to be positioned and oriented arbitrarily within a large workspace. This paper describes the Manufacturing Automation course as well as the use of the robot to teach the course.

Introduction

Robots are different from any industrial machine, and the potential of the robot as an agent of change in manufacturing has not been fully realized yet. The International Standard Organization (ISO) defines an industrial robot as an automatically controlled, reprogrammable, multipurpose, manipulative machine with several programmable axes, which may be either fixed in place or mobile for use in industrial automation applications[1]. Integrating robots into manufacturing systems requires knowledge of both the manufacturing and robot systems. Furthermore, a robot system is more than the hardware; it includes all devices interfaced to the robot for control of the work cell.

The Manufacturing Automation course is offered as part of the Electrical Engineering Technology curriculum[2]. This course covers computer integrated manufacturing systems primarily from a hardware and control point of view. The course also covers robotic applications to Computer Integrated Manufacturing (CIM) cells. The CIM cell is a group of computer controlled machines located in the Science and Technology lab. The cell consists of an automatic storage and retrieval system (AS/RS), a programmable logic controller (PLC), a conveyor, a vision system, two robots and a mill. As part of the set-up, each machine is also connected to at least one computer.

At successful completion of this course the student will be able to:

- Understand the characteristics of robots
- Understand the interrelationships of material handling to the manufacturing process
- Understand the characteristics of other automated equipment
- Use a logical approach to problem solving
- Perform a detailed analysis of manufacturing cells
- Critique designs and recommend improvements.

The course also included lectures by two guest speakers and a field trip to a local electronic chip manufacturing facility. These activities were designed to give students a chance to interact with practicing engineers in the field and also to see practical implementation of robotics and automation.

Robot Description

The SCORBOT-ER 4pc was designed to emulate an industrial robot[3]. The open structure of the robot arm allows students to observe and learn about its internal mechanisms. The robot is a vertical articulated robot, with five revolute joints. With gripper attached, the robot has six degrees of freedom. Figure 1 illustrates the robot arm. This design permits the end effector to be positioned and oriented arbitrarily within a large workspace. The length of the links and the degree of rotation of the joints determine the robot's work envelope.

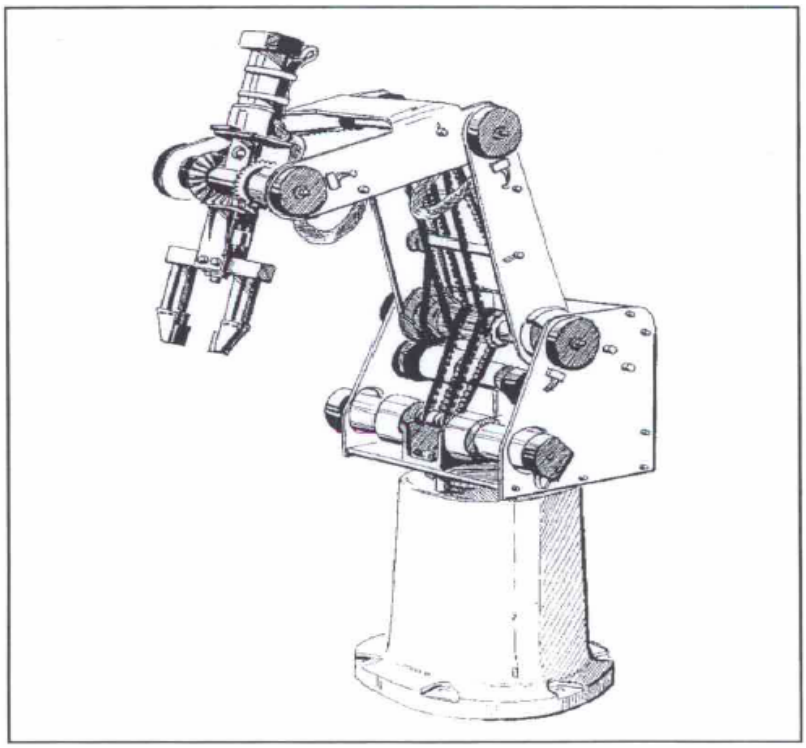

Figure 1. Robot Arm.

The base of the robot is normally fixed to a stationary work surface. It may, however, be attached to a sliding base, resulting in an extended working range. The robot's five axes and gripper are operated by DC servo motors. The direction of the rotation is determined by the polarity of the operating voltage. Each motor is fitted with an encoder for closed-loop control. The robot has a servo jaw gripper fitted with rubber pads. These pads can be removed to allow the attachment of other end effector devices.

The robot can be programmed and operated by means of Windows-based software and by a teach pendant. The SCORBASE for Windows has a menu-driven structure and has off-line capabilities to facilitate robotic programming and operation[3]. The teach pendant is a hand-held terminal used for controlling the robot and peripheral equipment connected to the same robot controller. The teach pendant is most practical for moving the axes, recording positions, and sending the axes to recorded positions.

Laboratory Exercises

The goal of the laboratory sessions is to analyze and verify the theoretical ideas learned in the classroom. Some experiments require written reports. In such cases, the report is always due one week after the experiment is performed. Late reports are not normally accepted.

The robot was mounted to a 30 inch square plywood base to perform the laboratory assignments. A gravity feeder and two wooden fixtures that contain holes placed in different orientations were also attached to the base. This base is also indexed to the base of a table-top milling machine for integrated exercises.

The laboratory assignments are selected to show both the simplicity of concept and the complexity of implementing automation projects. A brief description of the assignments follows.

- **Introductory Assignment:** Students see various video tapes such as the Society of Manufacturing Engineers (SME) "Industrial Robotics" illustrating different types of robots and equipment used in automation applications.

- **Resource Identification Assignment:** Students search the Internet and report on vendors that sell automation products. Each student is assigned an automation component such as various types of robots, grippers, conveyors, parts feeders, vision systems, sensors, end of arm tooling, and controllers. The students prepare a written report on the web site, and briefly describe it orally to the class.

- **Robot Programming Assignment:** Students are introduced to robot programming by the task of stacking and un-stacking rectangular blocks.

- **Repeatability Assignment:** The student places dial indicators at certain points on the robot path. The student then executes a program and collects the measurement data. Various robot speeds and types of movement are assigned. The data is analyzed to determine the mean and

standard deviation from the programmed point. Any trends in variations with respect to time are noted.

- **Part Presentation Assignment:** Students program the robot to pick up and replace cylindrical objects using an end-effector with parallel jaws in a continuous cycling mode. When the cylinder "walks" away from the reach of the end-effector, the student discovers the importance of the presentation of the part to the robot and the design of the end-effector. In the second part of the assignment, the cylinders are removed from a parts-handling device and inserted into a hole. The student is also required to sketch a redesigned gripper that would better handle the cylinders. Students are required to design a parts-presentation system for a specific application by selecting a vibratory bowl or another device and designing the appropriate accessories.

- **Machine Vision Assignment:** Students program an Amatrol machine vision system that is based upon template matching and histograms to detect a pass/fail condition of a particular part. The students discover that changing the lighting greatly impacts the template matching.

- **Computer Numerical Control (CNC) Assignment:** Students take an existing CNC mill program that has been written to cut a simple design into a wax block and modify it to cut their initials or other simple designs.

- **Flexible Manufacturing Cell Assignment:** The students integrate the robot and the CNC milling machine to load and unload the milling machine and execute the above assignment.

- **System Control Assignment:** To demonstrate the control of an automated system, the students develop a ladder logic program for a programmable logic controller. Limit switches and LED outputs are used to simulate an automated process.

- **Economic Justification Assignment:** Students prepare an economic justification for a proposed automation project that considers current and proposed operating parameters, taxes, and the time value of money.

Conclusion

This paper described the Manufacturing Automation course as well as the use of a robot to teach the course. The Manufacturing Automation course is offered as part of the Electrical Engineering Technology curriculum. The course includes lab experiments utilizing a robot and CNC machines. The goal of the laboratory sessions is to analyze and verify the theoretical ideas learned in the classroom. The open structure of the robot arm allows students to observe and learn about its internal mechanisms. The laboratory assignments were selected to show both the simplicity of concept and the complexity of implementing automation projects.

References

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