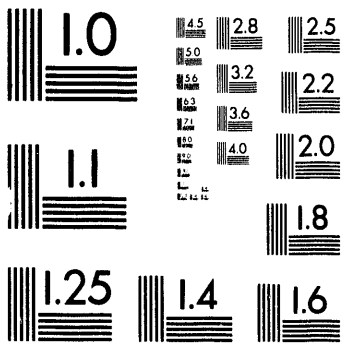
1.0
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OFF-LINE PROGRAMMING AND SIMULATION IN HANDLING NUCLEAR COMPONENTS

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Off-line Programming and Simulation in Handling Nuclear Components

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Summary

IGRIP was used to create a simulation of the robotic workcell design for handling components at the PANTEX nuclear arms facility. This initial simulation identified problems with the customer's proposed workcell layout, and allowed a correction to be proposed. Refinement of the IGRIP simulation allowed the design and construction of a workcell mock-up and accurate off-line programming of the system. IGRIP's off-line programming capabilities are being used to develop the motion control code for the workcell. PNL's success in this area suggests that simulation and off-line programming may be valuable tools for developing robotics in some automation resistant industries.

Problem Statement

PANTEX approached PNL (and other labs) with a request to develop an automated (robotic) system to perform a simple pick and place operation. The PANTEX request for proposal (RFP) included elevation and plan views of the proposed robot workcell, a desired sequence of events, and a specific robot to be used for the task. The sequence of events was approximately as follows: An operator pushes a cart containing the item to be handled (a "pit assembly") into a floor chock, which automatically latches onto the chock. In response to serial port commands, the manipulator then removes the lid from the cart, lifts the pit assembly from the cart, puts the assembly on an input table and puts the lid back on the cart. The cart may be removed at this point. After the part is processed, it is replaced (by the processing system) on the input table, from which it is removed by the robot, which places it back in the cart. This system is used instead of manual handling because the pit assembly is slightly radioactive; the automated handling system reduces personnel exposure to radiation.

Since the pit assembly is a sensitive and expensive device, it was of particular concern that a system be used to detect collisions and to sense that appropriate forces were generated as payloads were picked and placed.

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1. PNL is Operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

Solution

As part of the proposal preparation, PNL developed an IGRIP simulation based on the PANTEX provided information. The information provided included workcell layouts and elevations and the type of robot to be used. The simulation showed that PANTEX would have to alter the layout to include a pedestal to lift the robot approximately 27 inches above the floor, or they would have to select a different manipulator.

In order to monitor the loads and detect collisions, PNL proposed to use a force/torque sensor (FTS) monitored by the robot controller during all motions.

Results

Having been awarded the contract, PNL is continuing to use IGRIP to support the development of the workcell. Once PANTEX elected to design a mounting pedestal for the manipulator (allowing them to maintain compatibility of mechanical units across their facility), the simulation was further enhanced. The auto-positioning feature of IGRIP was used to place the robot in the workcell, thereby determining the pedestal dimensions and locations of related tooling which the robot needed to reach. At present, the prototype workcell is being assembled in a PNL facility using tooling which was developed from the simulated workcell.

As the motion control code for the project is developed, it will be simulated and tested in IGRIP before being transferred to the mocked-up workcell. The entire project requires that accurate, reliable code be generated. This code is subject to the highest Q/A standards, as the product being handled forms the core of a nuclear device.

At this writing, some difficulties remain in dealing with certain issues. In particular, under the new Fanuc R-Model J controller, the $HOME position variable has been removed (as compared to the R-Model H). This makes it difficult to end a motion sequence by tidily returning to the $HOME position. In addition, addressing the issue of robot configurations (elbow up, elbow down, wrist flip/no–flip, etc.) is not straightforward.

Simulation Benefits

It would have been very difficult (if not impossible) to lay out this workcell by hand, as the selected robot was hard pressed to reach the required target points in the workcell. Use of IGRIP and IGRIP's auto-place function was critical to project success. Use of the simulation was very important in receiving the contract award and in completing work on schedule, despite a substantial delay in receiving robots with which to work.

In the case of this work, the simulation allowed the early discovery of a potentially serious problem. In addition, the tools provided (particularly the automatic placement facility) allowed a solution to be developed early.

The off-line programming was valuable in allowing the code to be partly developed and evaluated prior to delivery of the hardware. The translation facility was tested and found to work reasonably well.

Our success in this area, and the usefulness of the simulation in early problem detection, suggests that simulation may be useful in developing projects in industries previously resistant to automation.

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