Multidisciplinary Senior Design
Project Readiness Package

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Project Title	Robot Controller
Project Number	P19611
Primary Customer	Jonathan Caves
Sponsor	Jonathan Caves
Faculty Champion	
Other Support	
Project Guide	
IP Considerations	

(CNC Machine)

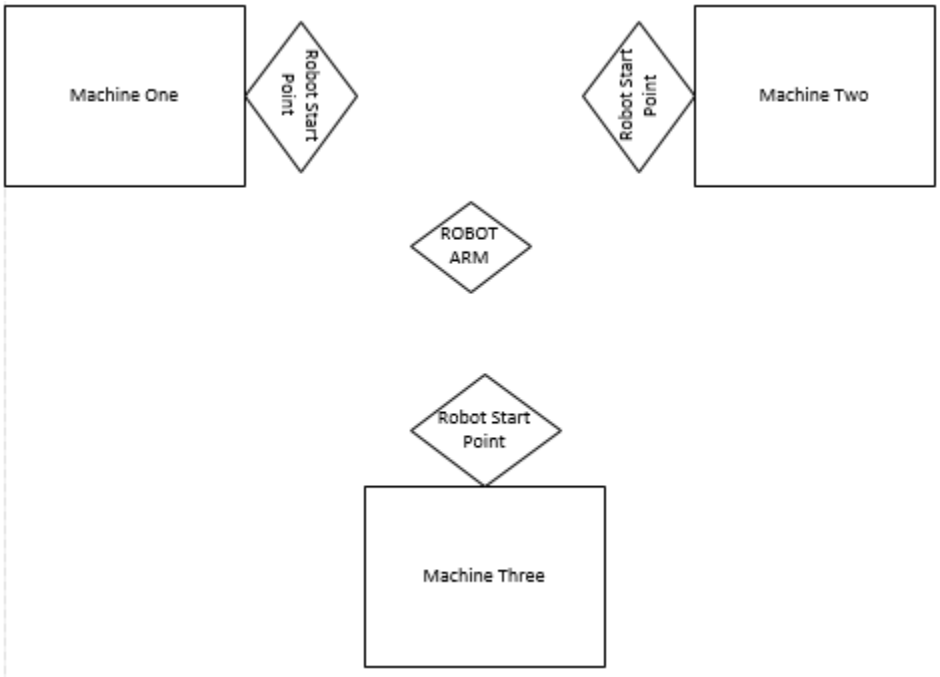
(Horizontal SCARA Robot)


(Vertical SCARA Robot)

Project Information

Overview

In a manufacturing environment there are many areas that could benefit from the automatic loading and unloading of machines by Robotic arms. One example is the unloading of milled parts from a CNC machine. Another example is the movement of parts from the outfeed of a large sanding machine back to the infeed area. It is important to note that at times these machines may sit unused for one or two weeks. Because of this, if each machine had a designated robotic arm for loading and or unloading they too would sit unused. A way to avoid a robotic system from sitting dormant while its assigned machine is not in use is to have one portable robotic arm that could be pre-programed to load and or unload three machines. The user of this arm would simply need to place the arm next to a machine, load the program for that machine, and hit go.



(Figure 1)

Next to each machine there will be a marked area that will outline the position the robotic arm will need to be placed to operate correctly in respect to a pre-made unloading/loading program. Note, the body of the robot may be somehow bolted to the floor to keep it stable.

For this senior design project, the main objective will be to develop and build a SCARA robotic arm controller and design the arm itself for the CNC unloading situation referenced above. This arm will be used to unload a CNC table after the cutting of parts is completed. When a CNC has finished cutting wooden pieces out of a 4' by 8' sheet of plywood, the object's location on the cutting table will be sent somehow to the controller's application located on a PC, and in turn to the robot's controller. Unlike other controllers in the Robotics industry, the calculations behind "how to" and "why to" move for a given robotic project will be done on a desktop application rather than within the internal firmware of the controller. We will be investigating using Autodesk Fusion 360 as this PC application.

The primary goal for this project is to have a controller get instructions from a desktop application to control a robotic arm with stepper motors. Also note that although the focus of this project is to build a robotic arm controller and the PC application to achieve the unloading of a CNC table, when designing the arm itself keep in mind the need for portability to other machines and ability to be loaded with different tasks.

Useful links to understand idea:

Vertical SCARAS
https://www.youtube.com/watch?v=u7cBzMtEB1g

Horizontal SCARAS
https://www.youtube.com/watch?v=y96-_RLiZu8
https://www.youtube.com/watch?v=2xkdcUAWaVY

This is What is Really Wanted, a heavy weight lifting portable SCARA robotic arm
https://www.youtube.com/watch?v=dxEZPBWVl18
Ours will not be this nice

Preliminary Customer Requirements (CR)

Design the robotic arm system to fit the requirements seen below and **design/build** a simpler system scaled down as a prototype specifically for testing the controller.

- Prototype Arm Requirements
  - A reaching distance capable of traveling to all points of a 2' by 4' table
  - Capable of lifting and moving a weight of 5lbs when fully extended
  - Entire system capable of being moved to other locations/machines

- Full-sized Arm Requirements
  - A reaching distance capable of traveling to all points of a 4' by 8' table
  - Capable of lifting and moving a weight of 30 lbs when fully extended
  - Entire system capable of being moved to other locations/machines

Layout of Projects Steps:

- CNC finishes cutting
- Objects positional (X,Y) coordinates are sent to the controllers application, located on PC
- Application determines how to drive the arm to each location
- Commands are sent from PC to controller and in turn to the motors
- Arm moves to each location
- For each location the arm will lower a vacuum mechanism to acquire the object, move to a predetermined drop off location, and set it down
- This will continue until all objects on the CNC cutting area have been moved
- The arm will then go back to its home position away from the operations of the machine

- Safety buttons/sensors will have a direct connection to the controller. If a kill button or sensor are activated the controller will override the PC applications commands and stop power from going to all motors

Preliminary Engineering Requirements (ER)

May require 1 Mechanical Engineers and 2 or 3 Electrical Engineers for this project.

ME Goals:

- **Design** a robotic arm to fit criteria seen below
  - Reach every space on a 4' by 8' table
  - Move a 30lb weight when arm is fully extended
  - Have home position out of CNC machines working envelope
  - Arm system portable
- **Design and Built** a simple prototype of the robotic arm for testing the controller
  - A reaching distance capable of traveling to all points of a 2' by 4' table
  - Capable of lifting and moving a weight of 5lbs when fully extended
  - Entire system capable of being moved to other locations/machines

EE Goals:

- Program a microcontroller to receive serial communication from a PC application(Fusion 360) and send PWM signals to various motor drivers/amps to drive a robot arm with respect to the PC applications commands
- Select motors, drivers, and amplifiers to attach to the controller for both the designed system and the prototype
- Select kill switches to be directly connected to the control board

Constraints

There is limited space above the CNC table, due to a dust collection system and wiring to the machine. Because of this a robotic arm with its ability to reach across the 4' by 8' table while being able to fold up and stay out of the CNC's working envelope is required. Also, it is a dusty environment at times and will have people walking around. Because of people potentially being close to the machine safety systems must be put into place to prevent harming individuals. Input power to the machine is TBD. Budget TBD but working to be lower than $1200 for prototype.

Project Deliverables

Minimum requirements:

- A controller capable of operating stepper motor and pneumatic drivers/amplifiers
- An application capable of communicating to the controller through serial communication
- All design documents (e.g., concepts, analysis, detailed drawings/schematics, BOM, test results)
- Working prototype, of the scaled down SCARA arm
- Technical papers

Budget Information

TBD but wanting the cost of the prototype to be under $1200.

Intellectual Property

All participating students will have the right to share what they have done and how they fulfilled the problem given to them to any 3rd parties. However, all source code files, documentation, technical schematics/drawings, and any purchased hardware or software will belong to the customer. Exceptions, if RIT, students, or third parties donate anything to the project it will be returned to said person at the end of the project.

U.S. Citizenship

Not Applicable

Project Resources

Anticipated Student Staffing by Discipline

Department	Expected Activities
Electrical Engineering	● Program a microcontroller to receive serial communication from a PC application and send PWM signals to various motor drivers/amps to drive a robot arm with respect to the PC applications commands ● Select motors, drivers, and amplifiers to attach to the controller ● Select kill switches to be directly connected to the control board
Mechanical Engineering	● **Design** a robotic arm to fit criteria seen below o Reach every space on a 4’ by 8’ table o Move a 30lb weight when arm is fully extended o Have home position out of CNC machines working envelope o Arm system portable ● **Design and Built** a simple prototype of the robotic arm for testing the controller o A reaching distance capable of traveling to all points of a 2’ by 4’ table o Capable of lifting and moving a weight of 5lbs when fully extended o Entire system capable of being moved to other locations/machines

Required Resources

Faculty	Ferat Sahin, professor and researcher of Robotics Alan D. Raisanen, Developing micro-electro-mechanical (MEMS) devices for mechanical, fluidic, and optical applications.
Environment	The areas used by ME and EE students in their labs/classes
Equipment	The equipment/software used by ME and EE students in their labs/classes
Materials	● 3 - Stepper Motors ● 1- pneumatic cylinder ● 1 - pneumatic actuator ● 2 – air pumps (one for the pneumatic cylinder the other for the lifting vacuum system on the end of the cylinder) ● Unknown amount of aluminum metal for the body of the prototype ● Unknown amount of wires/connectors ● 1 – PC (Laptop or Desktop) ● 1 seat of Fusion 360 for everyone on the team