Automated Manufacturing Delivery System

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Abstract

The goal for this project is to design a cost effective, off-the-shelf, sustainable control for a manufacturing system vehicle. The parts used in the original design are old, and they are becoming more expensive and difficult to replace. Two different designs are being implemented for prototyping. The first design utilizes a programmable logic controller (PLC) and is our primary design. The second design utilizes a microcontroller, and will be implemented as a backup design.

The first design option is to use a small PLC to control the vehicle. We are using the Siemens Simatic S7-1200 for its compact size. It is robust and ideal for industrial operation. This option would feature highly intuitive and usable software, but the software is proprietary and would add cost to the final control system. This option would also fail to meet the open-architecture design requirement. This option is being considered mainly due to its reliability in industrial environments and its ease of programming. The S7-1200 supports open-loop speed and position control of stepper motors and servo drives. It also supports up to 16 PID control loops for simple process control applications.

The second design will utilize the Mosaic Industries PDQ Board, which utilizes a HCS12 microcontroller for instrument control. This microcontroller is fast, has low power consumption, and small size, making it ideal for industrial control and automation. The board features dozens of analog and digital I/O ports, along with serial communications links. It is programmable in C or Forth, comes with a full featured integrated development environment (IDE), the Mosaic IDE Plus, and requires no software license. The IDE features a terminal from which functions can be called, making the IDE ideal for software testing. The IDE also provides full APIs for both the C and Forth languages, simplifying the use of the board's I/O ports. The board also features several "wild card" ports when additional I/O is needed.

The design team will provide drawings for any brackets or mounting fixture designs to be added onto the existing system. Mechanical designs will ensure structural stability and provide protection from environmental factors such as vibration, dust, and hydraulic fluid atmosphere. The power requirements for the control system and motor are compatible with existing machine voltages. New components used in the design, such as power converters and relays, will be easily replaceable and affordable off-the-shelf components. A backup power supply for the controller will be incorporated so that the vehicle can continue operating during momentary interruptions of the power supply.

This project will result in a prototype unit and a workable solution accompanied by test results. The design team will provide a completed bill of materials, assembly drawings, source code, and schematics. We will provide a detailed test plan for the unit, incorporating a new test fixture interface.

Electrical Design

The electrical design of this system revolves around designing two different control systems, one of which utilizes a microcontroller and one of which utilizes a programmable logic controller. The advantages and disadvantages of each design are listed as follows:

Mosaic PDQ Board Microcontroller

- Utilizes HCS12 microcontroller
- Fast, low power consumption, small
- Digital and analog I/O ports, serial communications links
- Programmable in C and Forth
- Includes free Integrated Development Environment (IDE) with interactive terminal from which functions can be called during debugging
- Full APIs for both C and Forth
- Lots of documentation provided on website
- Dimensions: 2.5"x4"

Siemens Simatic S7-1200

- Compact Programmable Logic Controller
- Robust and ideal for industrial operation
- Intuitive and usable software incorporating block coding
- However, software is proprietary, adding to cost
- Supports open-loop speed and position control of stepper motors and servo drives
- Up to 16 PID control loops
- Dimensions: 3.5"x4"x3", plus additional 25mm (~1 inch) clearance for cooling on all sides (except the side being mounted)

We are currently at the programming phase of the design cycle. We are programming each controller to follow the same basic logic control flow, shown in Figure 1.

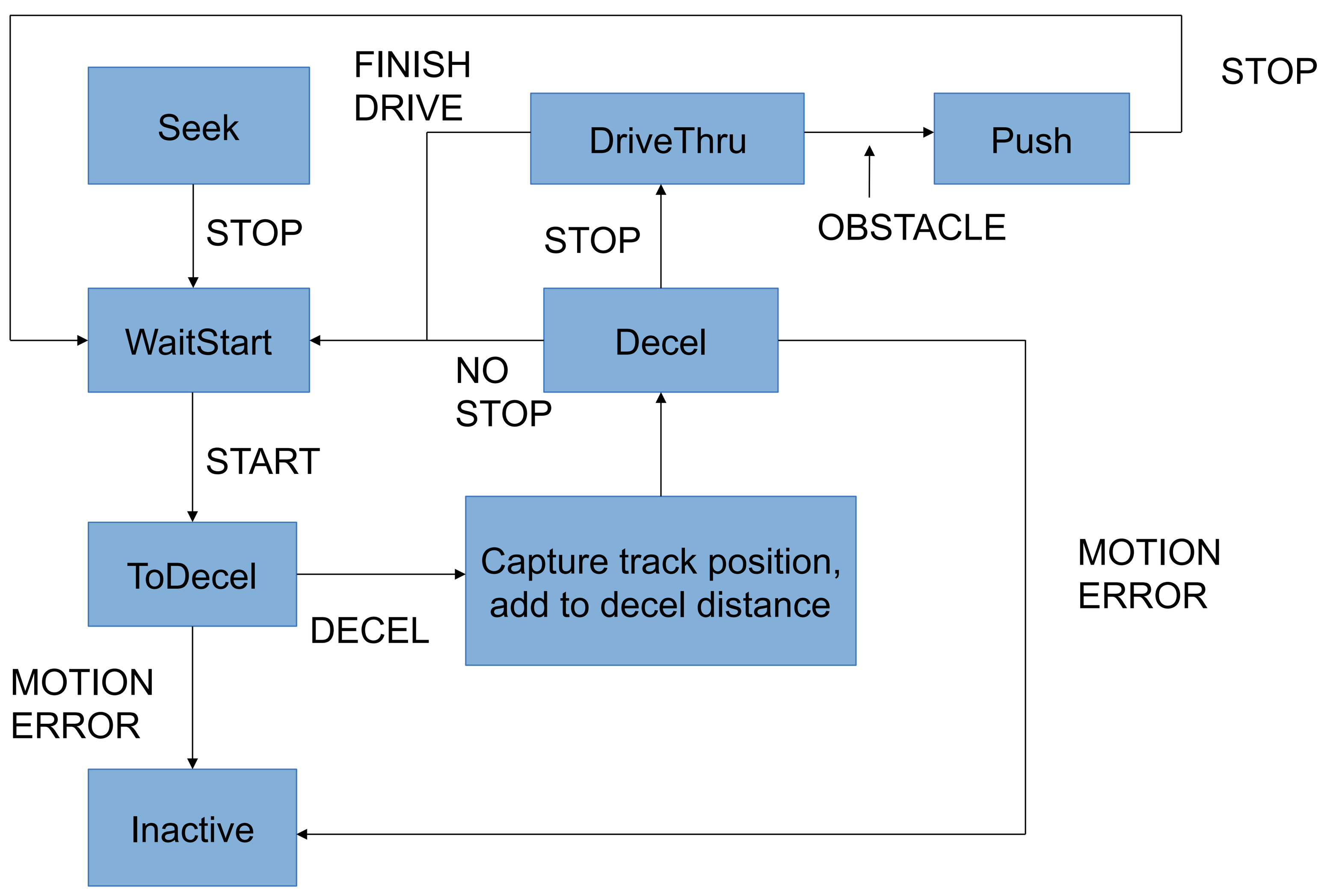

Figure 1: Program Control flow

Mechanical Design

The main tasks undertaken by our mechanical engineers are performing temperature and vibration analysis on the delivery vehicle and designing protective enclosures for each of the potential controller choices. These enclosures will mitigate damage to the controllers from high temperatures and shock. Since the Siemens Simatic S7-1200 comes with its own protective casing, we only needed to design casing for the Mosaic PDQ Board. Figure 2 shows the SolidWorks models of the casing, which will be fabricated in the next few weeks. Figure 3 shows the mounting bracket that will be used to mount the Siemens PLC to the vehicle.

In order to perform heat and vibration tests, we are programming an Arduino microcontroller and equipping it with an accelerometer and thermocouples so it can measure vibrations and temperature changes. Once the controller code is ready and has been shown to function properly, we will gather heat and vibration data from the vehicle during operation and plot the results using MATLAB.

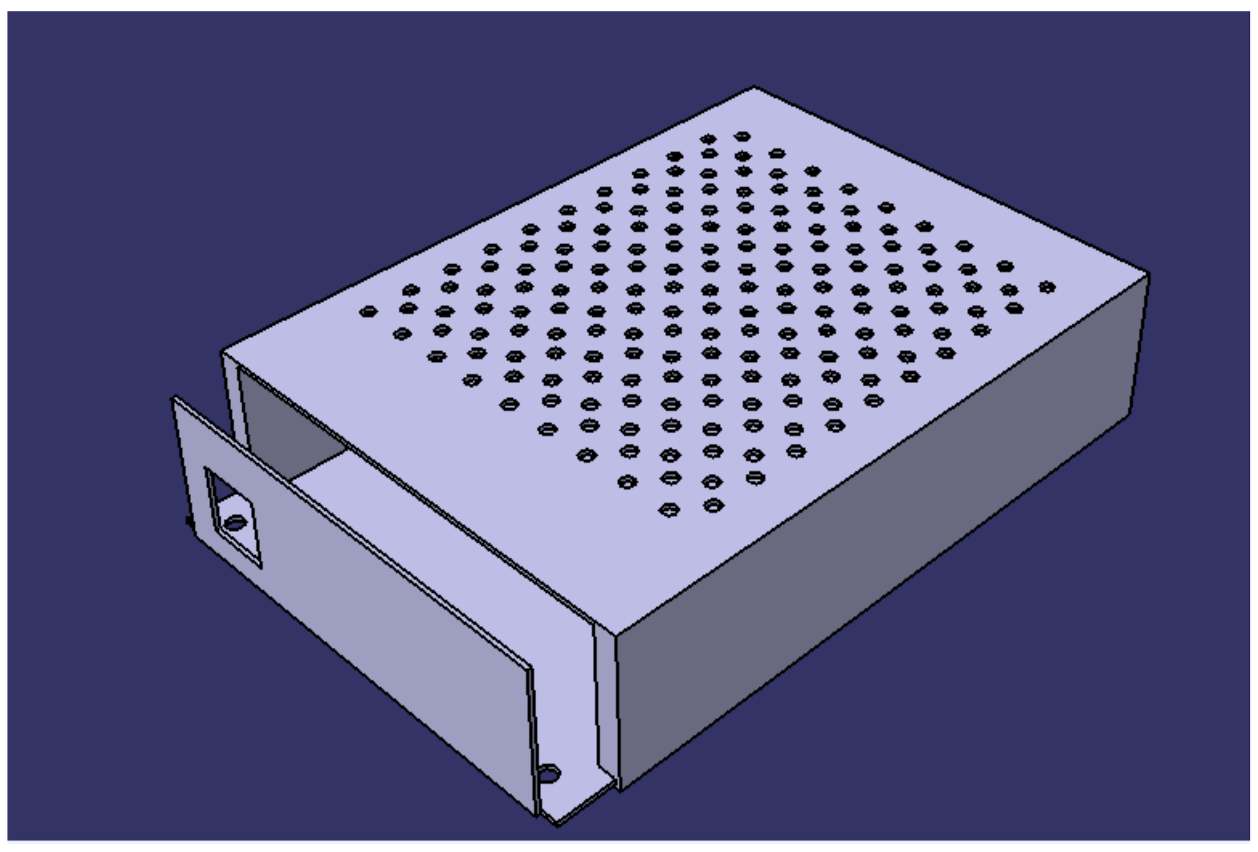

Figure 2: Protective casing for Mosaic PDQ Board

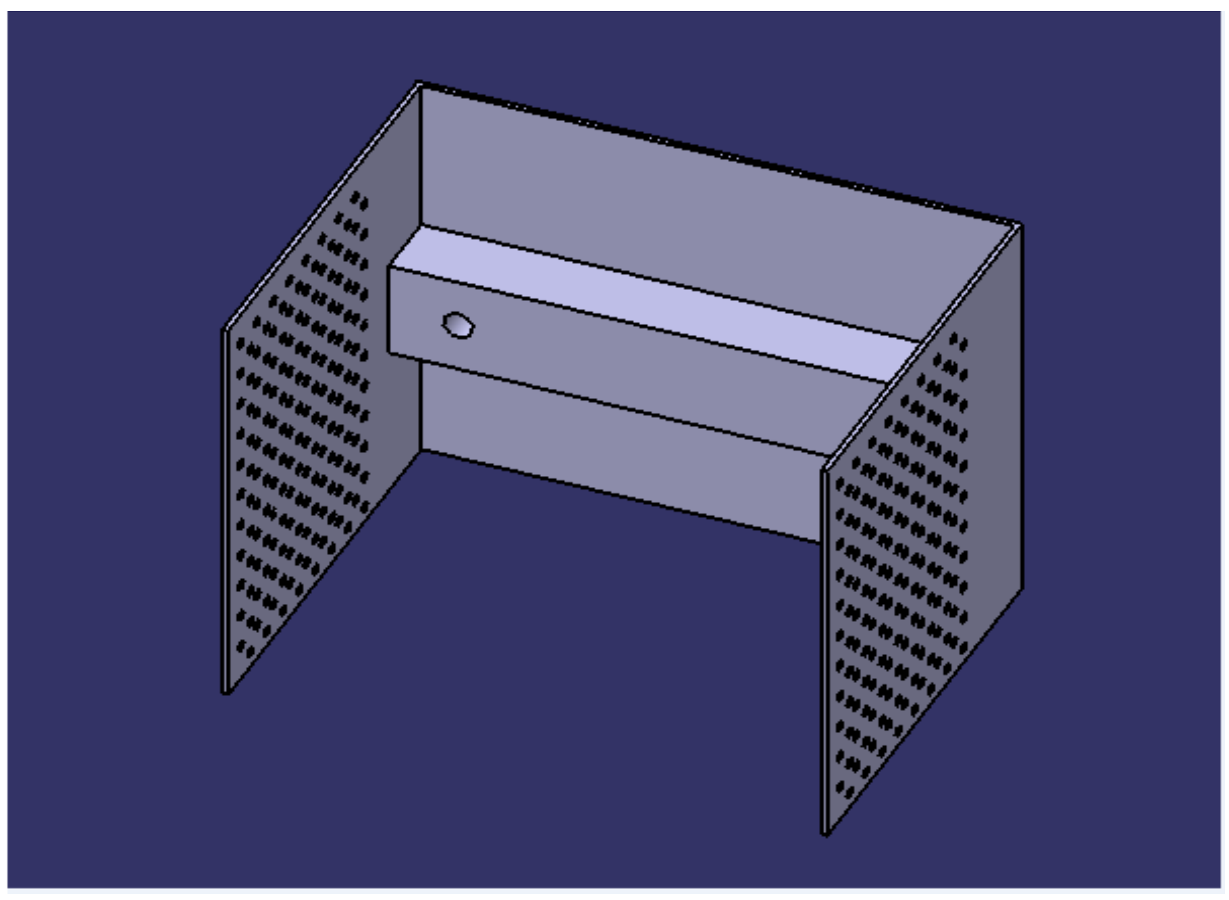

Figure 3: Mounting Bracket for Siemens Simatic S7-1200

Future Work

Potential future work on this project includes the following:

- Following testing at Fairfield University, integration into actual industrial automation system at factory
- Streamlining our original prototype in order to make it more efficient in terms of power and CPU usage
- Adding a backup power supply in case of power loss during operation
- Real-time temperature and vibration measurements during operation
- Collision detection/prevention mechanisms between vehicles using ultrasonic sensors
- Replace motor with more efficient/cost-effective solution