Automated Syringe Mixer for Aneurysm Treatment

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Abstract

Purpose: This project, is to automate a mixing process of liquid-polymers in syringes for the purpose of treating aneurysms. The goal is to create a machine to replace the manual human mixing process, done so by technicians, which is the only method until now. By doing so, it will eliminate the time, stress, and errors in consistency that is unavoidable in mixing by hand.

Method: Aneurysms themselves have a number of ways to be treated, but the most effective way to date is the "liquid embolic method". The liquid embolic method is simply a method of mixing liquids together which will soon after solidify in the aneurism. According to Dr. Becker, the client, "the amount of liquid and the mixing rate must be consistent to successfully implement the liquid embolic method." As such the machine mixing the liquids, will be adaptable to different mixing rates, liquid polymers, and mixing strengths. Our project takes user inputs that defines mixing strength and mixing times for the purpose of outputting reproducible liquid polymers each time.

Requirements

Mechanical
- T Formation
- Linear Motion
- Sturdy Syringes and Actuators
- Provide a minimal force of 25 lbs

Electrical
- Automatic Actuating System
- User input interface
- LCD display
- Console Programming
- Mixing Rate User Control
- Mixing Time User Control

General
- Mix at a minimal speed of 2 inches per second
- Adaptable to various syringe sizes

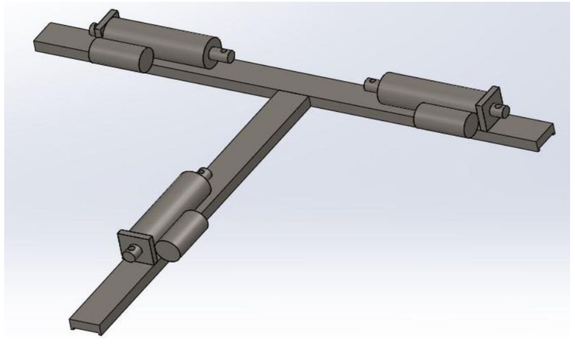

Figure 1: T frame model.

Engineering Design

Design Overview

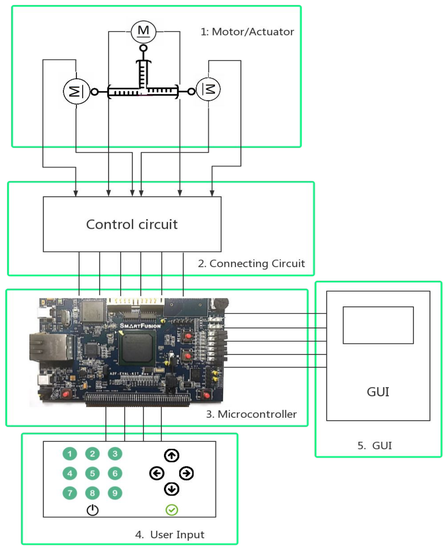

Figure 2: System Design Breakdown.

- **Actuators:**

Each syringe will have an actuator that will push and pull to mix the liquids inside.

- **Microprocessor:**

The SmartFusion Eval 2 was the chosen microcontroller for the project due to its system on chip design. Meaning, it has peripherals already mounted on the board. Peripheral used include GPIO, Timers, FPGA

- **Control Circuit:**

A second board made by the team, will be attached to our microprocessor for the purpose of sending current to actuators, interfacing the display to board, and button pad to board. For the Actuator subsystem, current will be passed through a MUX to select syringe to move and the direction it will move in (forward and back).

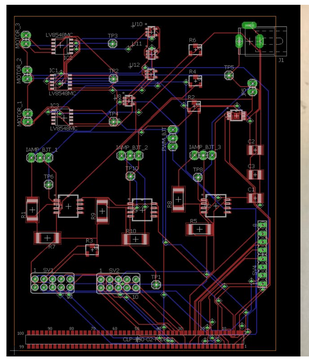

Figure 3: PCB Layout in Eagle

Figure 4: PCB Board

- **User Interface:**

A simple button interface and a LCD display was implemented to accomplish the user interface. Considering this machine will be used inside of hospitals, it is important to not have any type of interface which can house excessive bacteria.

Mixing Process

User confirms that they want to start a mix
User defines the mix length desired
The device starts by mixing the linear syringes together
Then the hardening agent is added into the mixture
The device mixes the linear syringes once more
After mixing the fluids are retracted from the initial syringe holding the hardening agent
Finally, the mixed fluids are able to be used for aneurysm treatment

Note: At any point during the mixing process the mix can be stopped, using an emergency shut off button.

Final Design

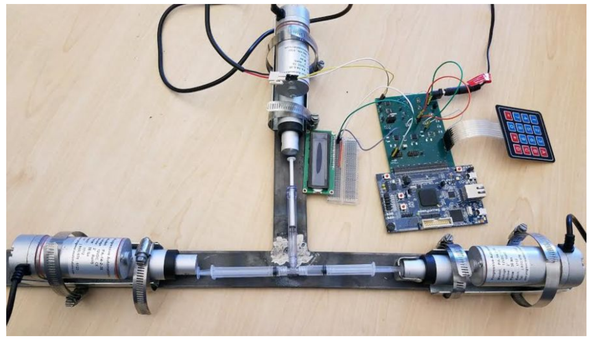

Figure 5: Design's Final Iteration

Future Improvements

Improvement 1: Circuit Redesign
While the board was effective for this project it was only rated to output a maximum of 2 amps. In the original design this was an acceptable current, but was found to not be enough to run the actuators at higher loads. The structure of the circuit is still useable, but may require parts which have the capabilities to output 4 to 6 amps of current to the actuators.

Improvement 2: User Input Range
Currently the system has a discrete set of values that the user can select as the run time for the syringe mixing process. In the next iteration of this design the user may appreciate the ability to set the exact time of the system with a precision of half a second, for higher accuracy testing.

Improvement 3: Expand Display
The current display that is being used has limited uses. Improvements beyond what was already done would have meant being able display information about the mixing process. The mixing of polymers to the optimum state is based on energy put into the system, given the amounts of liquid put into the syringes the device could have calculated the energy provided.

Improvement 4: Mixing Base
Stability and portability are key features of this design, but they can still be improved upon. Additionally, premade distances could be implemented into the connection between actuator and base, to allow for more variability in syringe sizes.

Acknowledgments

We would like to thank Dr. Timothy Becker and Anuevas Technologies for sponsoring this project and giving us this opportunity to work with them, as well as automate this system and help in the advancement of the PPODA-QT liquid embolic method. We would also like to thank Travis Byakeddy, Chris Settanni, Drew Shumway who greatly helped with the designing and creation of the base used in this project. And finally we would like to Thank Dr. Bertrand Cambou for letting us use his lab.