A Clinical Device to Treat Brain Aneurysms: The 3-Way Syringe Mixing Team

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3-Way Syringe Mixing Team

Abstract

Aneuvas Technologies, a commercial biotechnical research company local to Flagstaff Arizona, has reached out to NAU's electrical engineering department with the request to help build an electromechanical system capable of mixing separate medication component gels with reliable and reproducible mixing results. When mixed, the amount of energy imposed on these medication component gels has a direct correlation with the efficacy of the medication when administered into the body to treat cerebral aneurysms. Effects of theses abnormal enlargements from weakened blood vessel segments within the brain have the potential to burst without warning usually resulting in disabilities or death. The goal of this design project is to build a system to replace the company's old method of mixing these research samples by hand. The estimated cost of this system is to be $1,317.92.

Future goals of this project aim to develop the device blueprints which could be subject to the creation of multiple devices and clinical trials as well as cutting down on manufacturing costs.

Criteria

This project is a continuation of a previous year's capstone team project which failed to produce a working prototype up to the standards prescribed by our client, Tim Becker. Dr. Tim Becker has established a number of criteria for the the project's development including, maneuverability/portability of the system for a hospital setting, minimal difficulty to remove components for the purposes of cleaning, a minimum motor stroke rate of 2"/sec, the capability of a minimum stroke rate under realistic motor-load conditions, an adjustability measure for compatibility with different sized 'T'-junction syringe connectors, minimized dead volume of medication through system tubing, and an intuitive interface with user-defined variables including mixing duration, mixing speed, and period of delay for programming.

References/Acknowledgement

-"LPPS-22 Series Linear Potentiometer Position Sensor with Rod Ends," Bloomfield Hills, MI, rep., 2019.
-PA-15 Data Sheet," Progressive Automations, rep.
-Sunfounder.com. (2019). *Lesson 1 Display by I2C LCD1602*. [online] Available at: https://www.sunfounder.com/learn/sensor-kit-v2-0-for-arduino/lesson-1-display-by-i2c-lcd1602-sensor-kit-v2-0-for-arduino.html [Accessed 18 Apr. 2019].

Note: All funding has come from Aneuvas Technologies

Problem Statement

Lab researchers at our client's laboratory, Aneuvas Technologies, have no efficient means to mix three separate medication gels with consistent variables regarding speed, duration, and delay. Their current method consists of manually pumping these gels with their hands which is not persistent and widely dependent the person doing the procedure.

The Developed System

Pictured to the right in Figure 1.1 is our collapsible design for our syringe pump system. As you can see the three motors and fourth Graphic User Interface (GUI) panel fold up to minimize the space during storage.

Figure 1.1

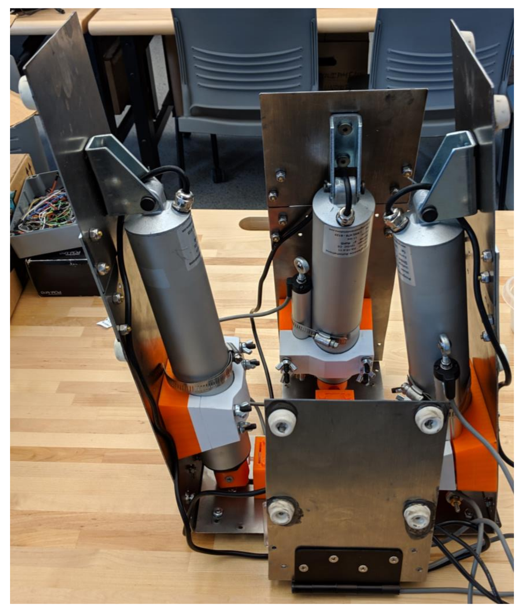
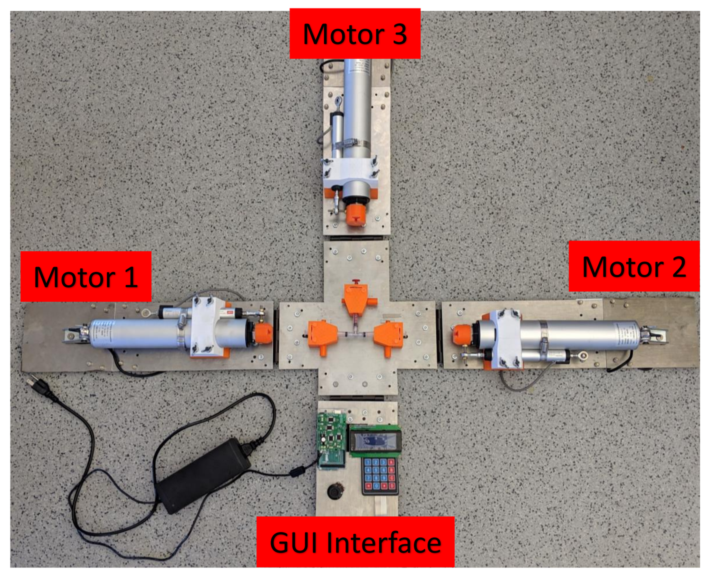


Figure 1.2



In Figure 1.2, the syringe pump system is portrayed open as it would be during the use by a researcher. The panel for the GUI has all the operation controls localized and readily accessible to the user.

A close-up of the GUI, Figure 1.3, reveals all the controls accessible from its panel with the LCD screen displaying the options and feedback to the user in real-time.

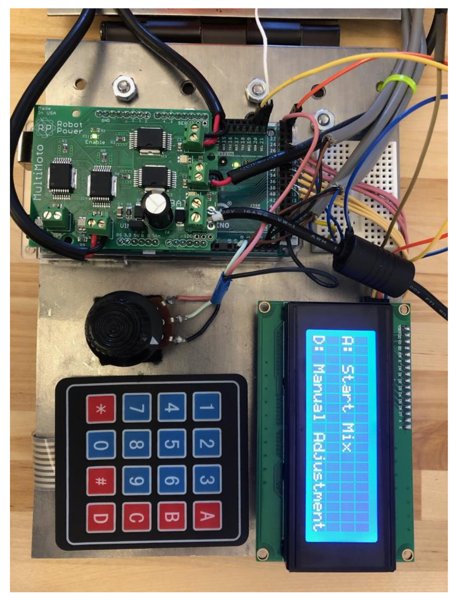


Figure 1.3

Our Challenges

Throughout this project our team ran into a number of challenges including: the changing of criteria for the design by our client, coding communication between software shells, and learning to use the fabrication systems to build our structure from the Mechanical Engineering department. The team went through three platform redesigns as well as 3D component resizing/adjustments, and various component swaps for the motors LCD screen, and power supply. The constraint of time also played a significant role in the development of this project. Given more time some optimization efforts could be made to sand the sharp edges of the panels, 3D print a GUI cover and mount, and reduce programming logic for an overall faster system.

Methods

This project uses an Arduino Mega microcontroller, three PA-15 linear actuators, a MultiMoto 4-channel motor driver shield, three linear potentiometers with positional feedback, several 3D printed components, and a LCD screen with keypad to prompt the user for desired speed, duration, and delay to specify a perfected protocol and yield a finalized medication gel from three syringes. With the use of the MultiMoto shield, the device is able to reverse the actuation movement in unison with another motor in order to push and pull the liquid properly.

The use of 3D printing through Solidworks was necessary for holding the syringes in place, the motor-to-syringe connectors, and the bases for the motor/actuator pairs. The components went through numerous reprints and redesigns due to excess heat during the printing causing warped regions, generalized redesigns, and after some components were deemed to loose to handle the demands of the motors. Preliminary 3D components were also printed at lesser densities as trials. Figures 2.1-2.3 display 3D CAD models of our motor-to-syringe connector, and syringe mount.

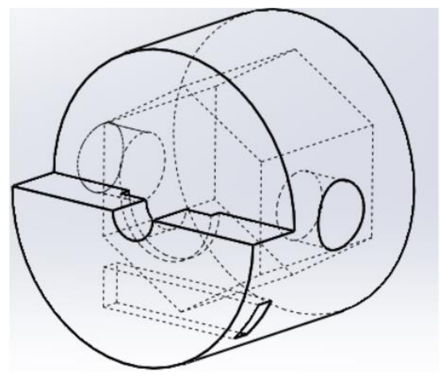


Figure 2.1

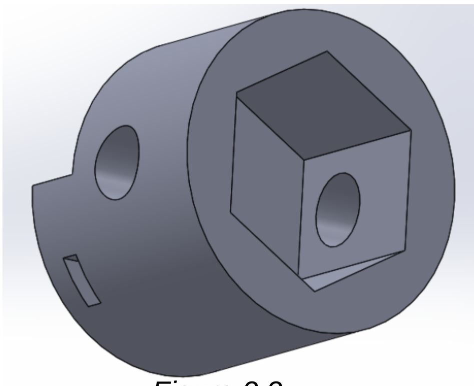


Figure 2.2

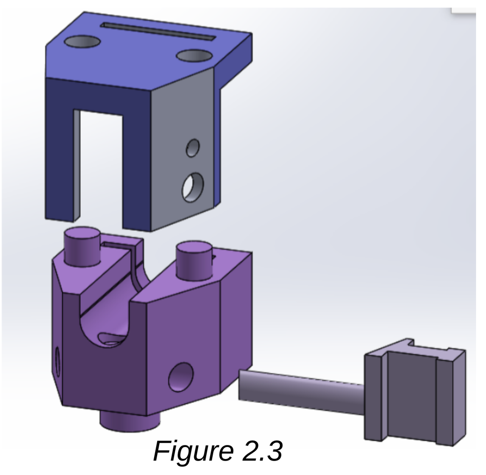


Figure 2.3

The User Interface was constructed using the Arduino Wiring Language. Figure 3 shows a block diagram of the interface of the GUI as the program runs. This program consists of a step by step user input of shells where it prompts the user for the different mixing options as well as values for the duration or number of mixes, and mixing speed storing the value which will be called upon during the mixing protocol.

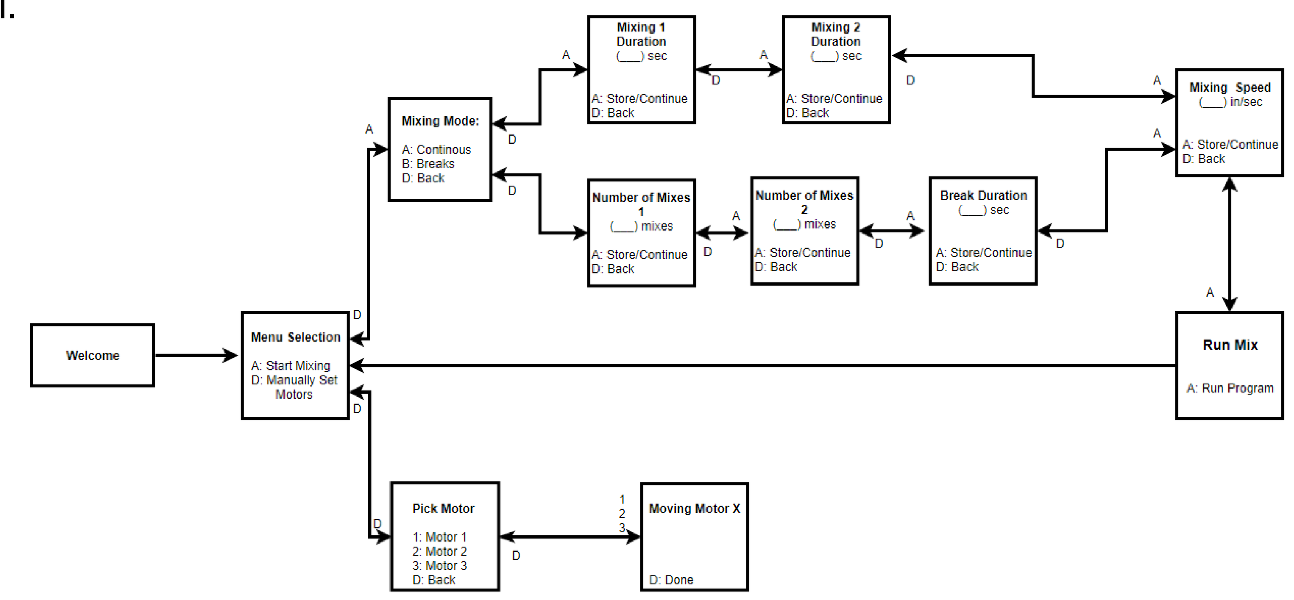


Figure 3

Conclusion

In summary, our device fully enables the researchers at Aneuvas Technologies to specifically dictate the duration, speed, and mixing period for full control over mixing results. In accordance, with the prescribed criteria, we have also made this system usable by persons who have little to know technical knowledge with an intuitive design. The device's folding platform allows for minimal storage space and protection of the components of the device during periods of inactivity.