Gore Stent Crimper Capstone

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Abstract

The Heart Bytes team was an electrical engineering capstone team that was working together with a mechanical engineering team in order to create a stent crimping machine for the sponsor W.L. Gore & Associates. The Heart Bytes team was responsible for designing the electrical components of the stent crimping machine. The engineering requirements for the project included that there must be a set of user inputs to control the machine, a graphical user interface to display data, a high-torque motor to control the crimping process, and a couple of sensors to determine the radial force and diameter of the stent. In order to control all of these various components, the team decided to use an Arduino Mega microcontroller.

Stent crimping machines are medical tools that are used to contract a stent to the correct size prior to surgery. Stents are metal tubes that are inserted into a patient's blood vessels to maintain blood flow. Since stent crimping machines are medical devices, the team had to follow increased safety standards.

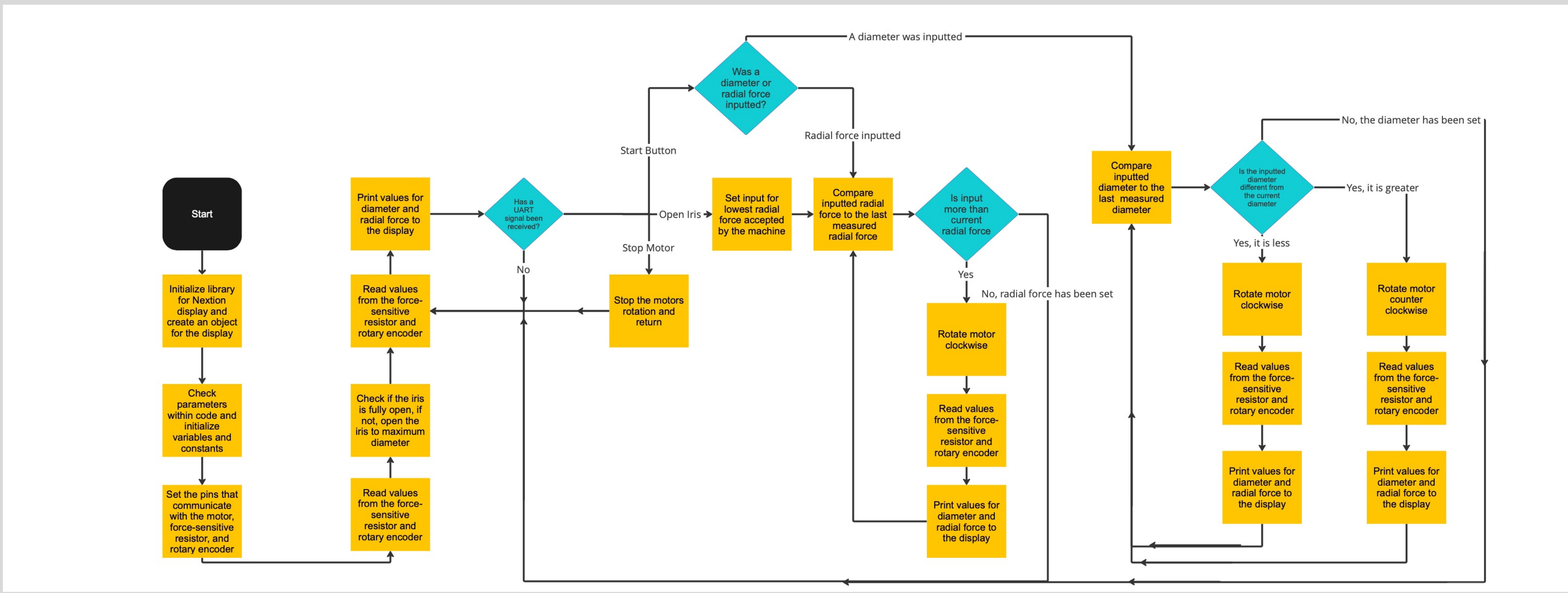
Requirements

Customer Requirements	Engineering Requirements
1. The stent crimper must utilize an iris-shaped crushing mechanism	1. The device will use an iris crusher designed by the ME team
2. Radial force and diameter readouts after crimping	2. The team will use a touchscreen display to show measurements
3. User inputs to control the diameter and radial force of the stent	3. The touchscreen display will take user inputs for setting measurements
4. The machine must meet relevant OSHA and ANSI standards	4. Include an emergency stop button, warning labels, and an iterative design process
5. A working model of an Endovascular stent crimper	5. Iris crimping range from 5mm to 50mm and exert a max force of 132.94N
6. A reliable and precise design	6. Will use precise sensors to determine the measurements for diameter and radial force

Website

Heart Bytes Team Website
https://www.ceias.nau.edu/capstone/projects/EE/2022/GoreStent/

Flowchart



Parts and Testing Processes

The touchscreen display used for the project was the Nextion 7" intelligent series display. The display uses a 4-pin UART connector for power and serial communication. RX and TX wires are connected to the Arduino and the 5V and ground wires were connected to a micro USB cable that provided 5V at 1A. The wiring and GUI can be seen in figure 1.

The sensor used to determine the radial force was a Pololu 1.5 in^2 force-sensitive resistor. The resistor has a range from 0.2 N to 20 N. It is an analog sensor with a 10 kiloOhm pulldown resistor.
To determine the diameter of the stent, a Taiss rotary encoder with 600 pulses per rotation was used. The rotary encoder was a digital sensor Both of the sensors and their wiring can be seen in figure 2.

The motor that was used was a NEMA 23 stepper motor from StepperOnline. The motor was driven by a StepperOnline DM542 stepper motor driver board. The stepper motor is powered by a 24-volt power supply. The wiring for the stepper motor can be seen in figure 3.

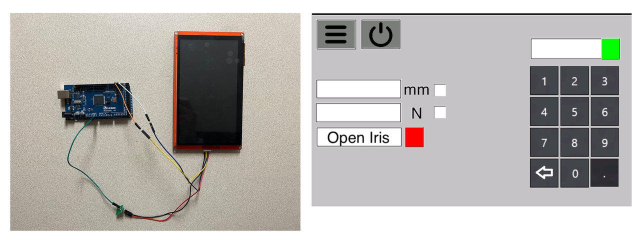


Figure 1: Wiring of Display and GUI

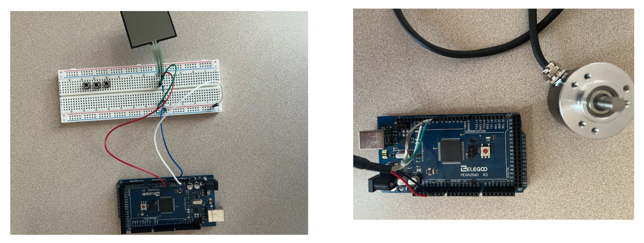


Figure 2: Wiring of FSR and rotary encoder

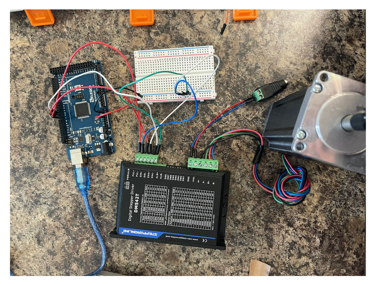
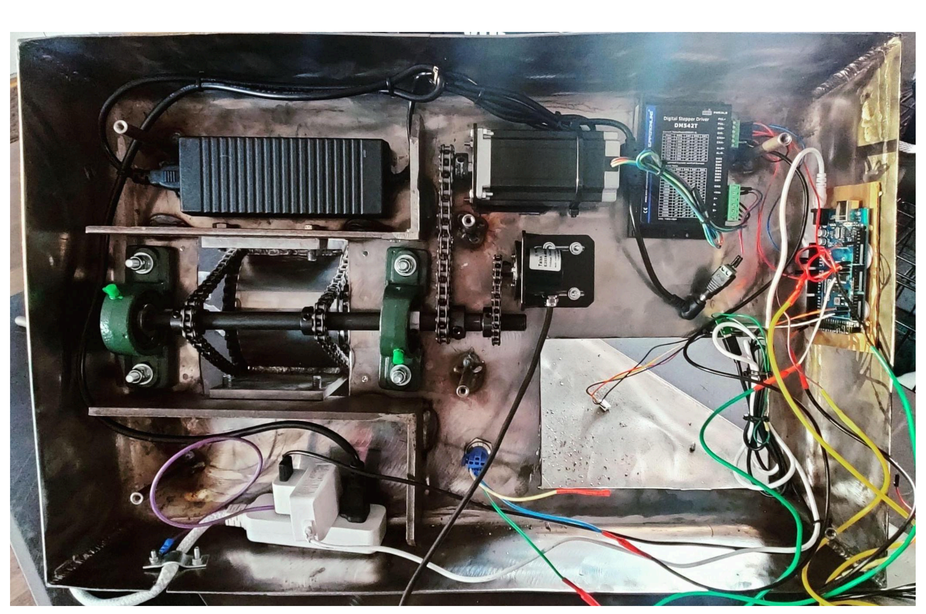
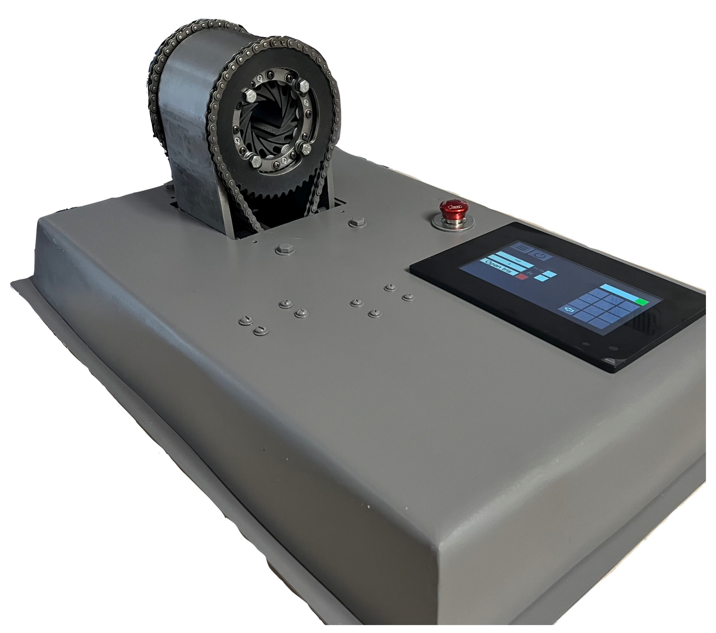


Figure 3: Wiring of the stepper motor

Final Design





Conclusion

The team was able to create a functional stent crimping machine. The stent crimping machine was constructed of a stainless steel base designed by the mechanical engineering team that contained various mechanical and electrical components. All of the electrical components were connected to an Arduino Mega board. In order to rotate the crimping mechanism designed by the mechanical engineering team, a StepperOnline NEMA23 stepper was chosen driven by a DM542T stepper motor driver board purchased from the same company. The stepper motor is able to provide 3Nm of torque. A 7" Nextion Intelligent Series touchscreen display handled the graphical user interface and inputs. The Nextion display has an integrated microcontroller built in that processed the GUI and communicated to the Arduino via UART commands. To determine the radial force applied to the stent, the team had planned to install a Pololu 1.5 in^2 force-sensitive resistor to the fins of the crimping mechanism which can be seen in the bottom right of the results. To determine the diameter of the stent, the team installed a Taiss rotary encoder with 600 pulses per rotation to correlate the rotation of the motor shaft to a known diameter. Due to time constraints, the team was not able to get either of the sensors fully functional for the final build. The team is still working on these components, so this may change.

After further research, the force-sensitive resistor proved it would not work for the use case for which it was needed. The resistor was determined to be too thin to be placed between the fins of the iris so it would not accurately read the force applied to the stent. The team also faced trouble converting this force value to an accurate radial force. The rotary encoder worked, but the motor's vibrations occasionally caused the encoder to register pulses that did not occur, causing a notable error that increases over time.

Overall, the team is proud of the stent crimping machine they created; it was a valuable learning experience. The team had not anticipated the complexities that come along with implementing and calibrating sensors and due to time constraints, the requirement for the sensors was not met.

Works Referenced During Design

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