MODELING OF SOFT ROBOTIC ARM

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Introduction

- Soft robotics has shown promise due to its safety, bio-adaptability, and flexibility compared to traditional rigid body manipulators.
- Modeling a soft robot is crucial to its usability and applicability in manufacturing, human interaction, and the medical field.
- However, modeling soft manipulators is complex and utilizes extensive testing and sensor implementation [1].
- Soft robots are challenging to model due to their non-linear nature [2].

Methodology

- A soft robotic arm made up of fabric pouches is used. Hardware to control it needs to be designed.
- Hardware needs to be capable of collecting accurate data from a variety of sensors including cameras, pressure sensors, and motor wire encoders.
- A transfer function relating pressure inputs to the output arc length will be estimated using the system identification toolbox.
- The transfer function model will be validated for accuracy with experimental data.

Hardware

- 8 Arduinos are connected to 8 Pressure Regulators all controlled by a laptop where the command signals are inputted. The soft robotic arm has 8 chambers and one Arduino controls one chamber.

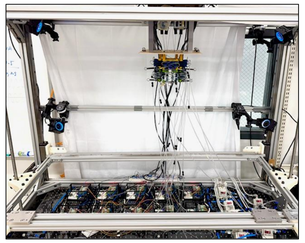

Figure 1

- A laptop is used for sending command signals to the Arduinos while the Arduinos control the pressure regulators and receive sensor data.

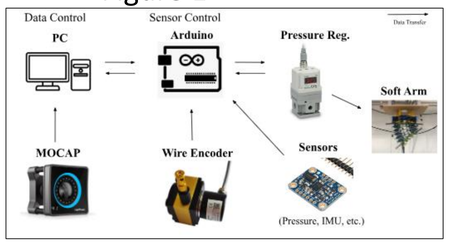

Figure 2

- Figure 2 shows the connections between the laptop, Arduinos, and sensors.

Model Creation

$$e^{-1.5s} * \frac{0.4646s^2 + 0.3522s + 0.0006993}{s^3 + 0.1378s^2 + 0.002588s + 0.0001055}$$

- Transfer function of 3 poles 2 zeroes with 1.5 second time delay. Fig 3 shows the model arc length vs actual arc length.

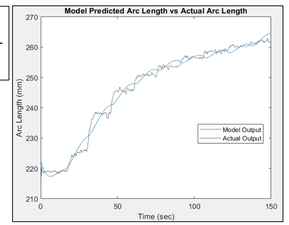

Fig 3. Model vs Actual

Experimental Results

- The Model was created by inflating a single chamber and recording the arc length. Data was collected in a text file and was analyzed in MATLAB.

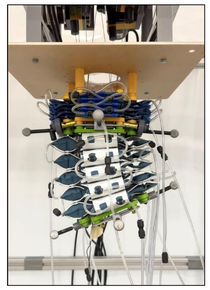

Figure 4

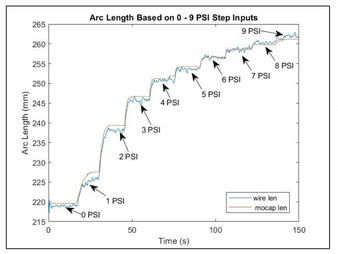

Figure 5

- Figure 5 shows the relationship between input pressure and arc length.
- A model was created using the data shown in figure 5. Figure 6 shows the experimental arc length inflating the chamber to 5 PSI. Figure 7 shows the arc length output of the created model when given an input of 5 PSI.
- The model simulated output successfully predicted the actual output.

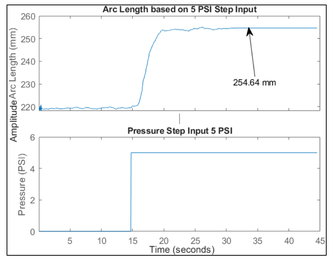

Fig 6. Experimental Trial

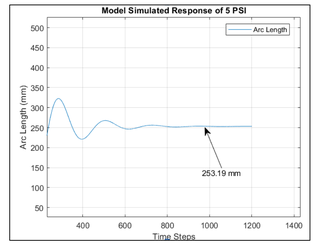

Fig 7. Simulated Trial

Future Work

- More complicated modeling algorithms such physics-based and neural-networks modeling techniques can be implemented.
- Controller algorithms can be applied to the soft robotic arm.

Conclusion

- The hardware setup can reliably collect data from the soft arm.
- The model created can accurately predict the arc length of the soft arm based on different inputs.

References

[1] Chen, X., Guo, Y., Duanmu, D., Zhou, J., Zhang, W., & Wang, Z. (2019). Design and modeling of an extensible soft robotic arm. *IEEE Robotics and Automation Letters*, *4*(4), 4208-4215.

[2] Armanini, C., Boyer, F., Mathew, A. T., Duriez, C., & Renda, F. (2023). Soft robots modeling: A structured overview. *IEEE Transactions on Robotics*.

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