Simulation and Fabrication of Soft Pneumatic Actuators

Regan Song | songregan@gmail.com
Diamond Bar High School | Class of 2024
USC Viterbi Department of Mechanical Engineering | SHINE 2023

Objective & Impact of Professor's Research

Professor Neda's research focuses on the dynamics of soft materials and structures with broad applications in biology and engineering.

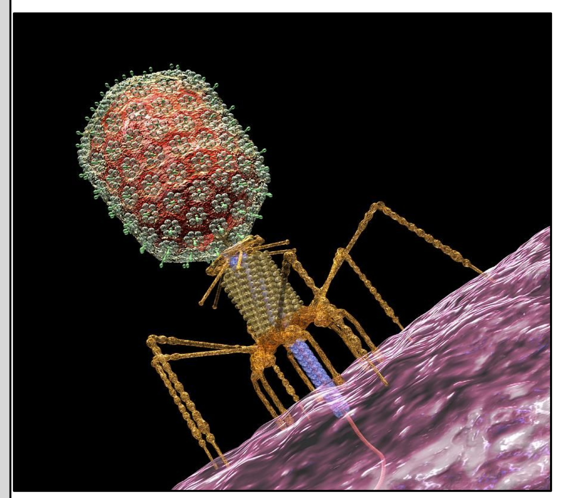

Fig. 1: T4 Bacteriophage

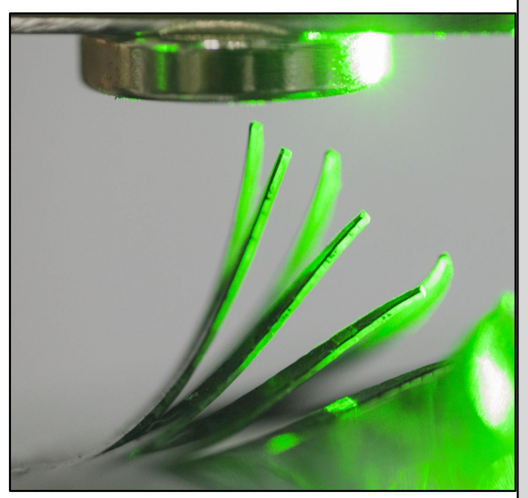

Fig 2: Photomechanical material

Introduction

Soft robotics focuses on the design of deformable robotic systems using elastomers and flexible materials. They offer more versatility and maneuverability, but lack structural strength.

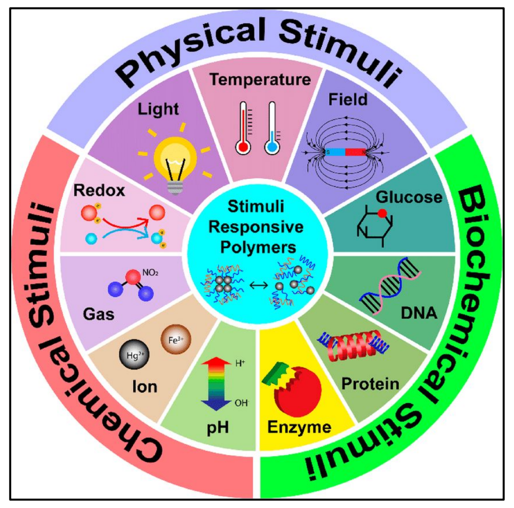

Fig. 3: types of soft material

Fig 4: Soft Robotic Gripper

This study focuses on the pneumatic arm, and how changing parameters can affect the behavior of the arm with pressure.

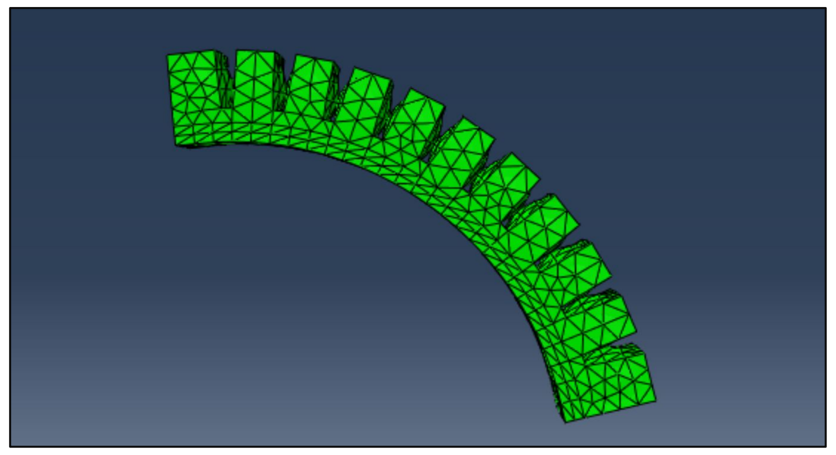

Fig. 5: Bent Pneumatic Arm

Materials and Methods

The pneumatic arm model was created in CAD (Solidworks), specifically designed to bend when a pressure is inputted.

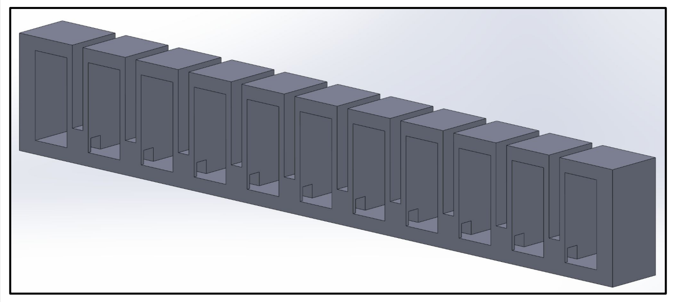

Fig. 6: Pneumatic Arm Section View

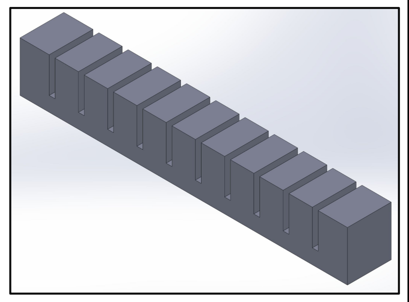

Fig. 7: Pneumatic Arm Iso View

The model is imported into Abaqus. The Neo-Hooke model describes material and Finite Element Method (FEM) simulates the arm under load.

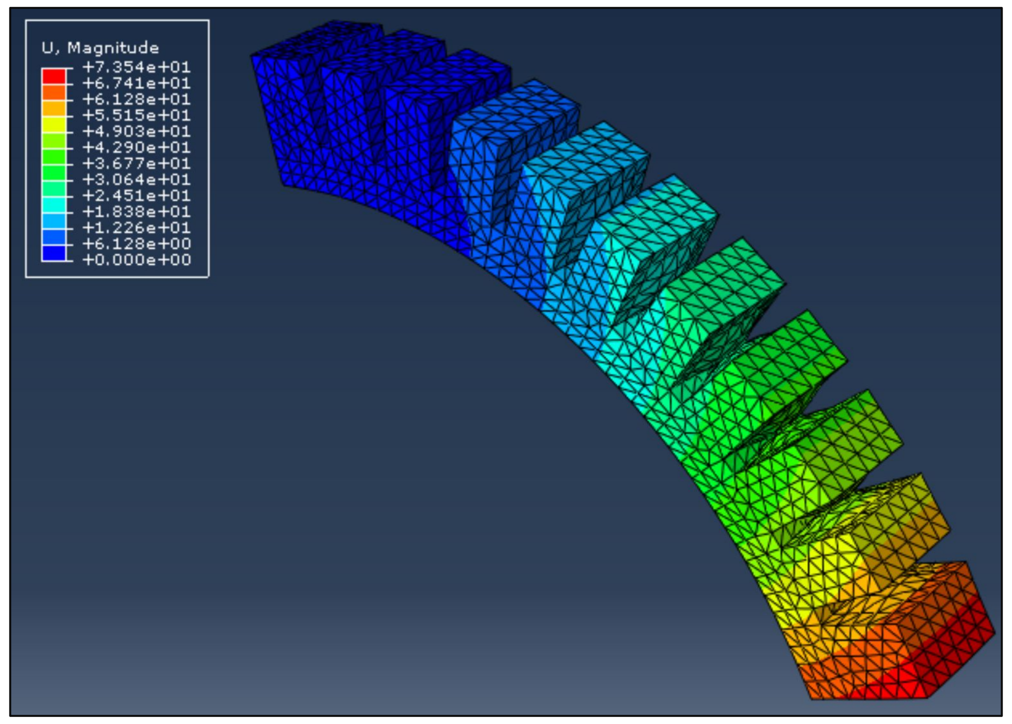

Fig. 8: Simulation of bent pneumatic arm using FEM, with gradient representing deformation

We found the change in deformation over pressure, and the change in deformation over air chamber size, then plotted it in MATLAB.

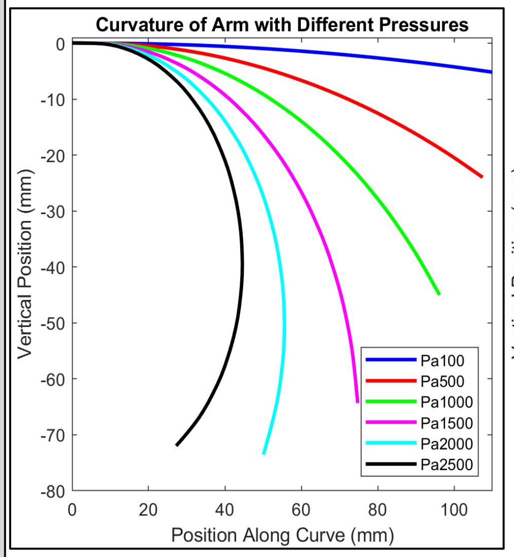

Fig. 9: Pressure Study Plot

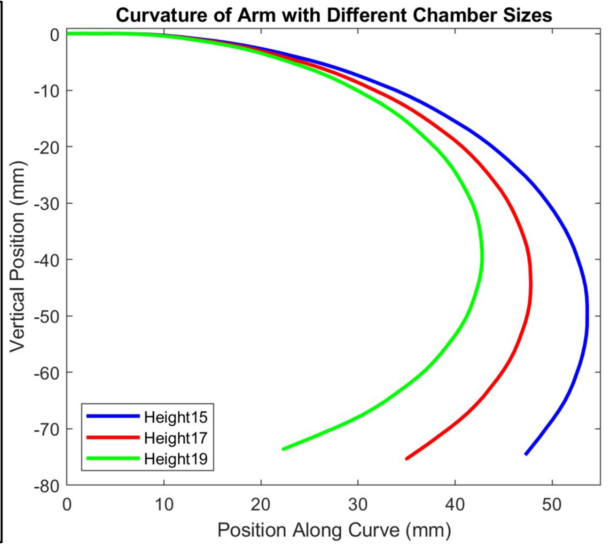

Fig. 10: Chamber Size Study Plot

Application of Findings

We created the mold for the pneumatic arm in Solidworks with simulation parameters, then 3D printed it at home and at the Baum Family Makerspace.

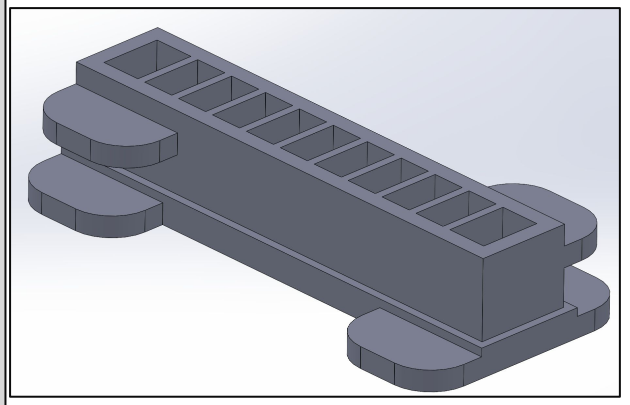

Fig. 11: Mold CAD Model

Fig. 12: 3D Printed Mold

We casted the silicon with the mold, and let it cure for two days before taking it out. A pump was inserted to exert pressure, bending the arm.

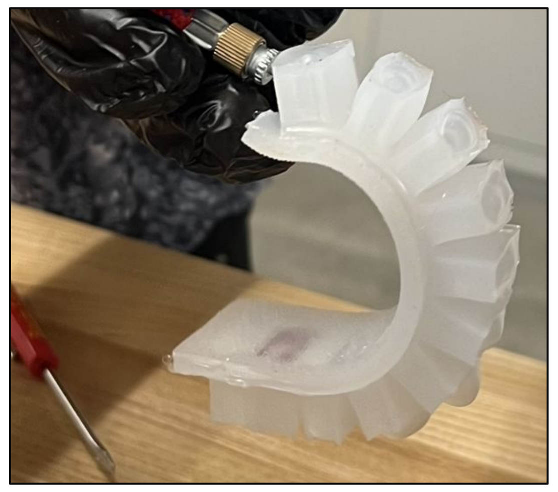

Fig. 13: Completed Pneumatic Arm

After the working proof of concept, we created a 3-arm gripper combining three pneumatic arms. We followed the same procedure with CAD, 3D printing, casting, and testing.

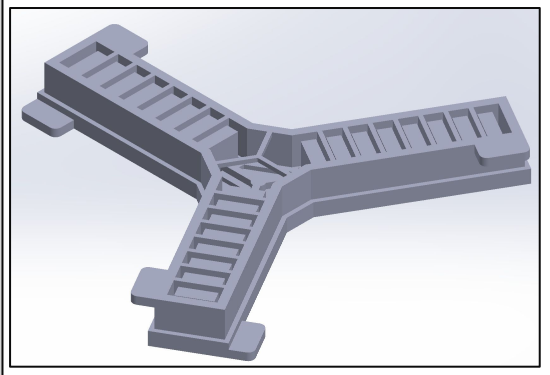

Fig. 14: Gripper Mold Model

Fig. 15: Casting Silicon

Fig. 16: Gripper Lifting a Roll of Tape (~1 lb)

Skills Learned

Conclusion

This lab allowed me to foray into the use of elastomers in robotics, and challenged my 3D printing and CAD skills. I hope the parameters I researched illustrates the behavior of the pneumatic arm and will help optimize their design in the future.

Acknowledgements

I would like to thank Professor Neda for giving me the opportunity to perform this research as well as my mentor Sungmo Park for guiding me through my project. Both of them were always supportive and very patient with me, and I greatly appreciate all of their support. I am also grateful for the Baum Family Maker Space for providing an incredible workspace as well as very kind and knowledgeable staff helping us with our 3D printing.

Citations

LIBRARY, R. K. P. (n.d.). Bacteriophage T4, artwork - Stock Image - C016/8972. Science Photo Library.

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