Pneumatic Actuations: From Simulation to Experiment

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Objective & Impact of Professor's Research

Professor Neda's research centers on investigating the mechanics of soft materials and structures, which have wide-ranging applications in both biology and engineering.

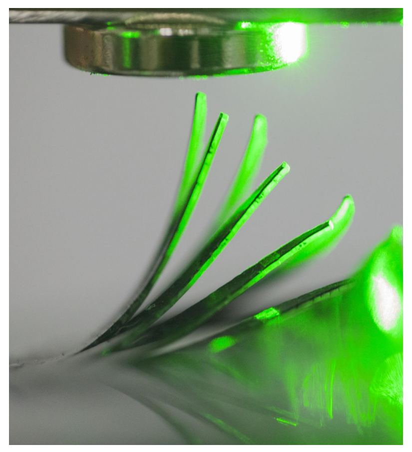
Fig 1: Photomechanical actuator

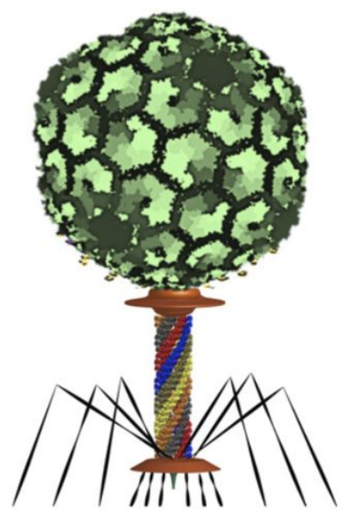
Fig 2: Bacteriophage T4

Introduction

Soft robotics is an emerging field of engineering which focuses on using hyperelastic materials to create robots that are more compatible with humans, have higher versatility than classical robots, and have infinite degrees of freedom. Rigid robotics, on the other hand, have defined degrees of freedom and are less compatible with humans.


Fig 3: Soft gripper


Fig 4: Solid gripper

Ways of Actuating Soft Robots

There are a variety of ways to make soft robots move. For our lab this summer, we decided to use pressure as an actuation force.

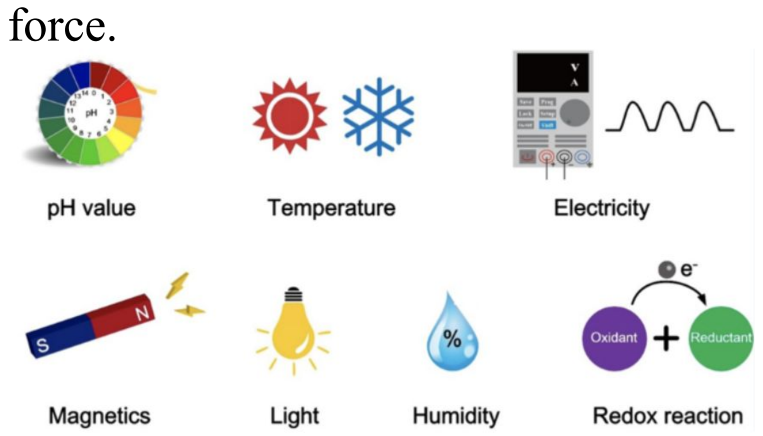

Fig 5: Different types of soft robotic actuation

Pressure Actuation

Applying pressure to an asymmetric multi chambered arm makes the arm bend due to the stress and strain forces acting upon the hyperelastic silicone.

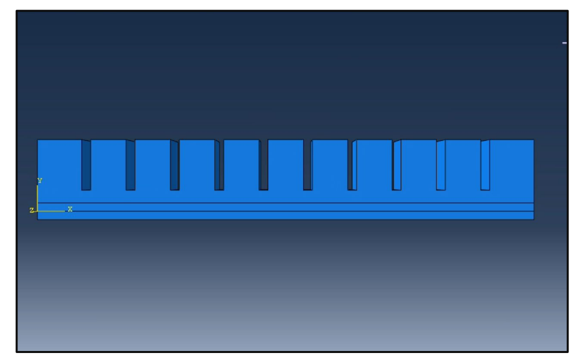
Fig 6: CAD Model of actuator

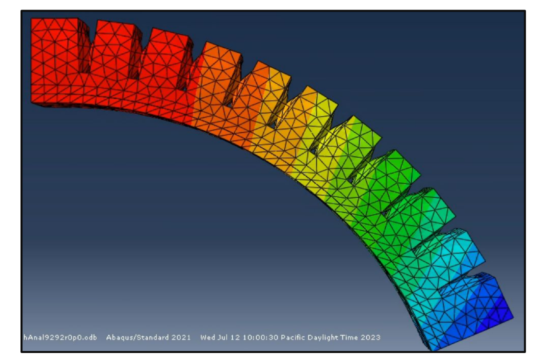
Fig 7: Abaqus simulation of actuator

Simulating Soft Robots

Using the finite element analysis (FEM) software Abaqus, we are able to simulate how a soft robot would deform when certain loads are applied to it. FEM works by breaking a model into thousands of parts and doing calculations on how they all interact.

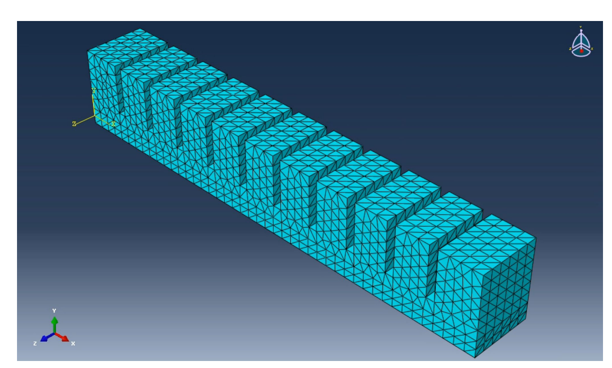
Fig 8: Actuator cut into different pieces

Casting Soft Robots

Using 3D printing molds made both at home and at the Baum Family Makerspace, we were able to cast two types of silicone. We used a more elastic Ecoflex 00-30 and a more rigid hobbyist casting silicone to create two separate robots. One is a simple linear actuator that bends. The other is a three armed gripper designed to hold objects of different sizes.


Fig 9: Simple Actuator


Fig 10: Gripper

Pressure Simulation

The more pressure we apply to the actuator, the more it deforms. Using Abaqus I studies the effect that pressure has on the deformation of the arm.

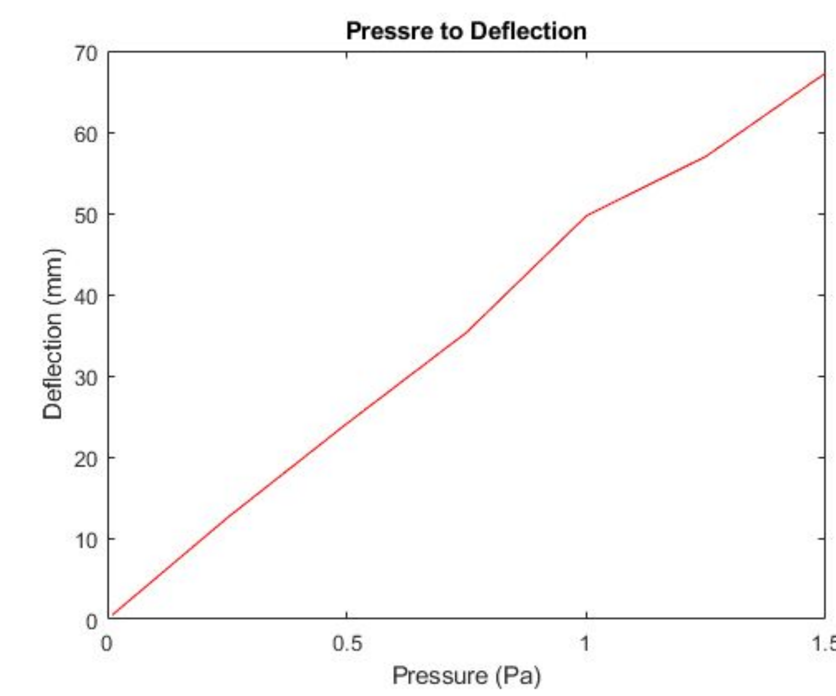

Fig 11: Pressure to Deflection Graph

This graph makes apparent how increasing the pressure in the arm chambers makes it deflect further.

Material Simulation

The type of material used to construct the robot highly affects how the robot works because of how its elastic properties react to the pressure of the inner chambers. In this series of simulations, I looked at how the different materials would work with different robots.

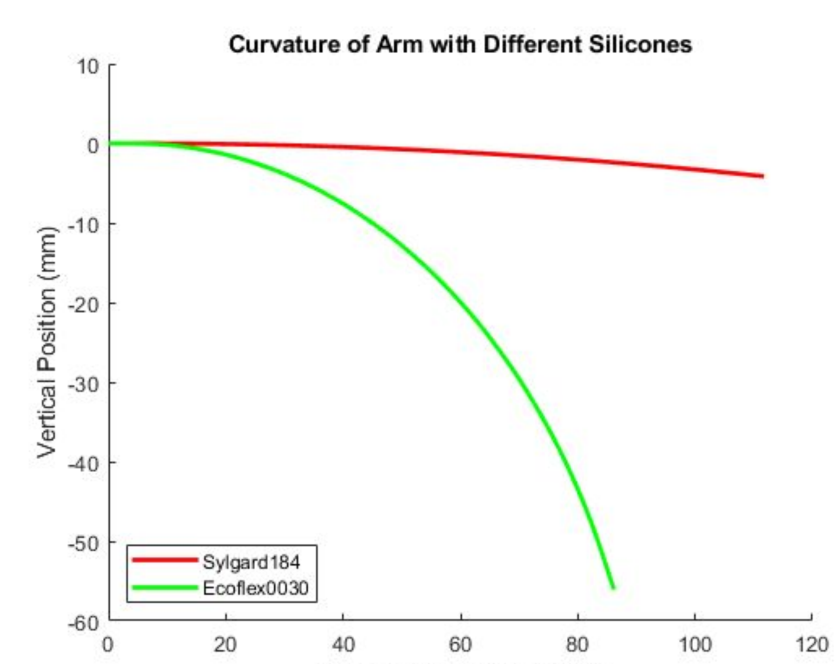

Fig 12: Silicone Simulation Graph

This graph illustrates how the the stiffer silicone (Sylgard 184) bends less than the more flexible silicone (Ecoflex 00-30).

Software Learned

MATLAB, Excel, ABAQUS, onshape, cura, SOLIDWORKS

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Citations

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