Da Vinci Robot Haptic Feedback Glove

Team

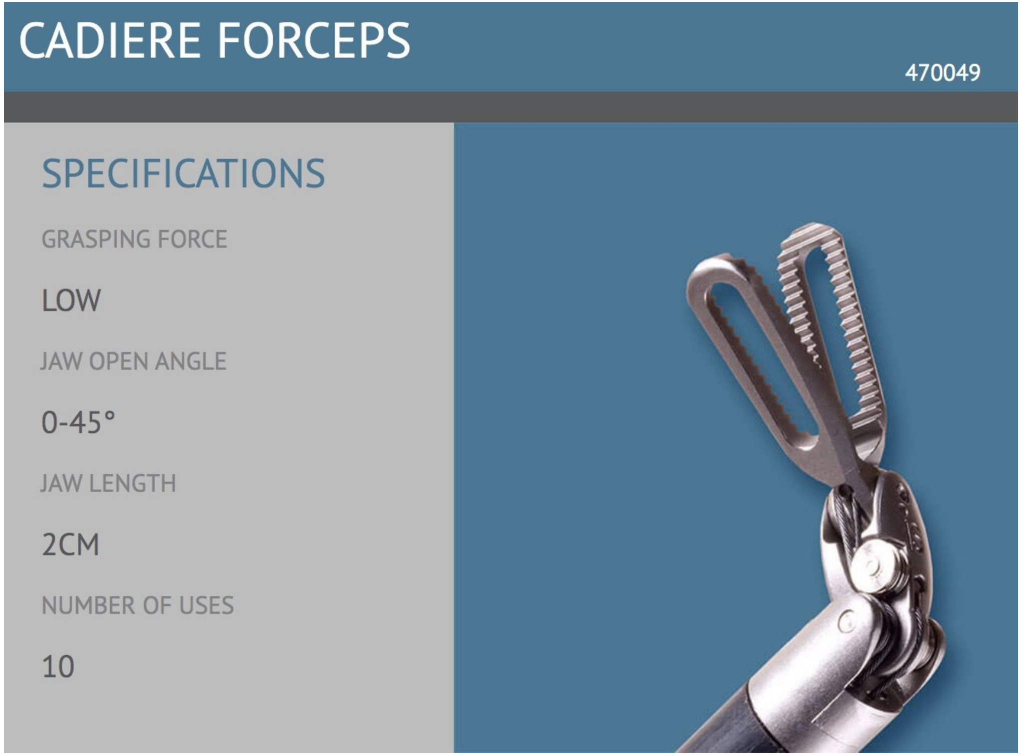
Paloma Laso, Michael Luchini, Julio Membreño, Sara Perez, Jenna Saiontz

Problem Statement

Although Minimally Invasive Surgical (MIS) robots, such as the da Vinci Surgical System, have reduced post-op care and recovery time, the robot does not provide haptic feedback to surgeons.

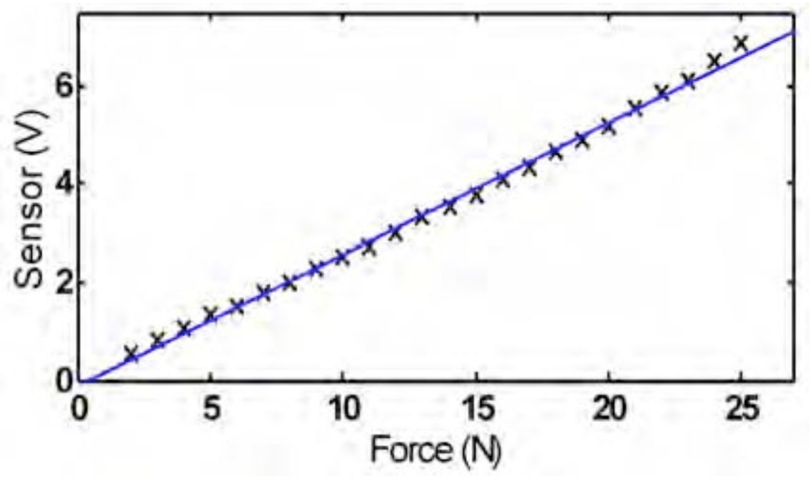
Project Description

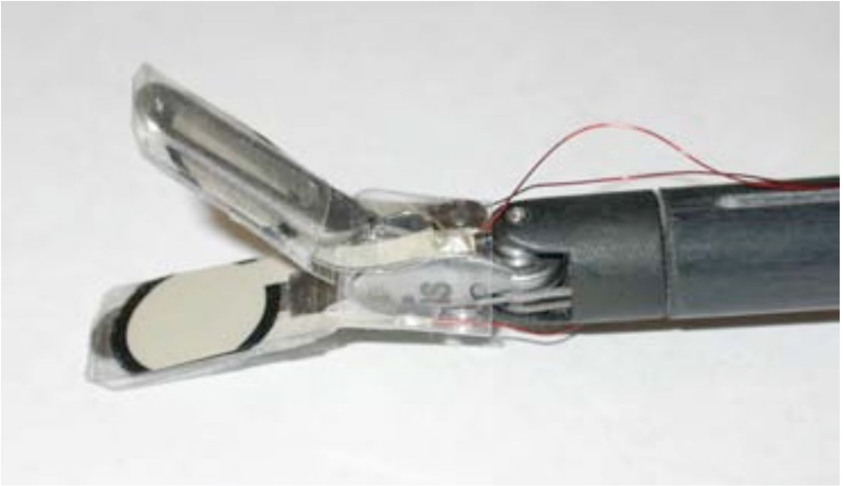
Our goal is to design soft robotic gloves that provide haptic feedback when the pressure applied by the Da Vinci's Cadiere Forceps approaches the maximum pressure that human tissue can safely withstand.



Benchmarking – Pressure Sensors

Drawing Inspiration from the Literature

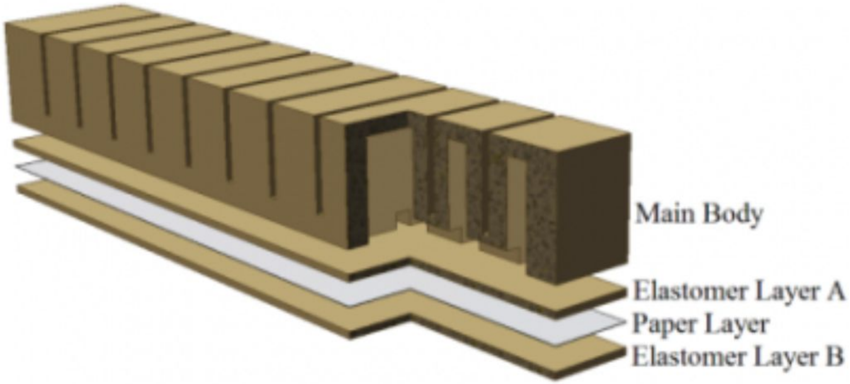


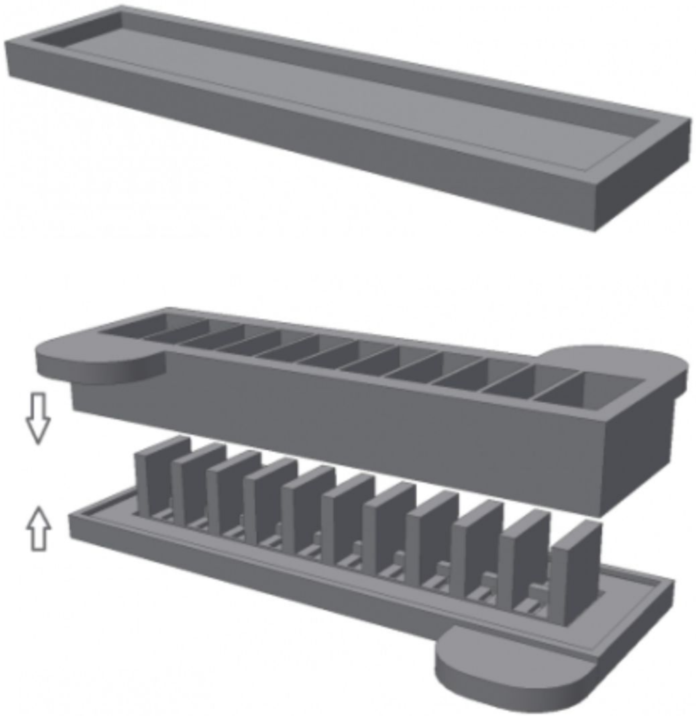


"A Tactile Feedback System for Robotic Surgery" by Martin O. Cultaj, et al.

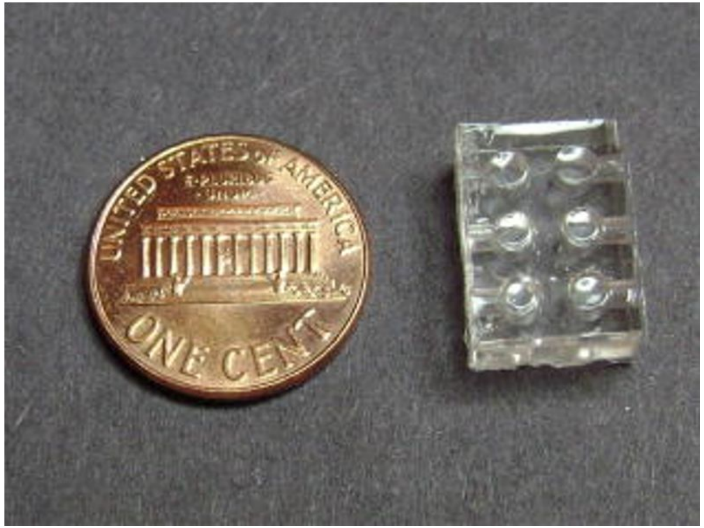
Benchmarking - Actuator

Existing Research & Design Inspiration

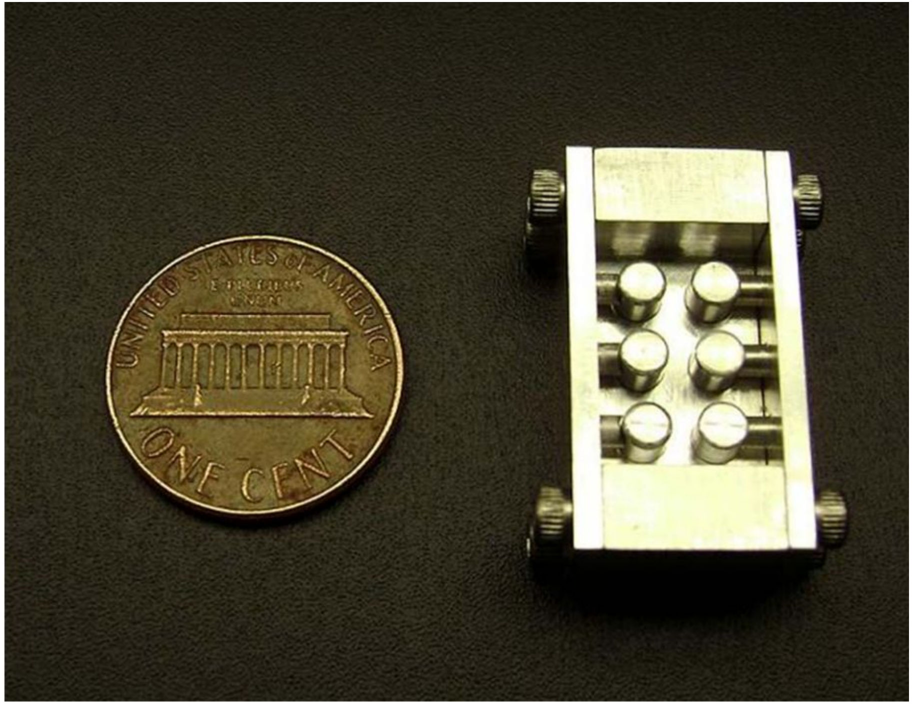




Existing Research & Design Inspiration



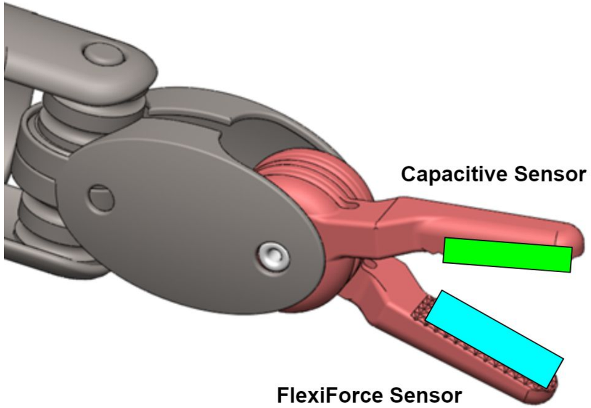
King, C. et. al. ASME Digital Collection



King, C. et. al. ASME Digital Collection

Preliminary Design Concept

Preliminary Design Concept Overview



Arduino Uno with Relay Shield

Electronics & Circuitry

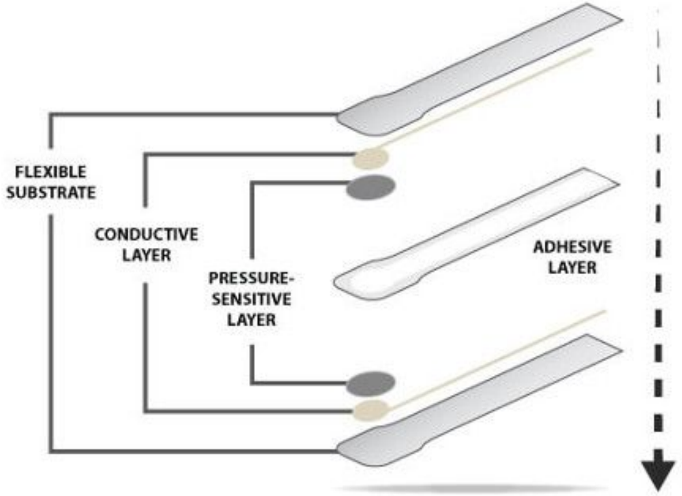
Pneumatics

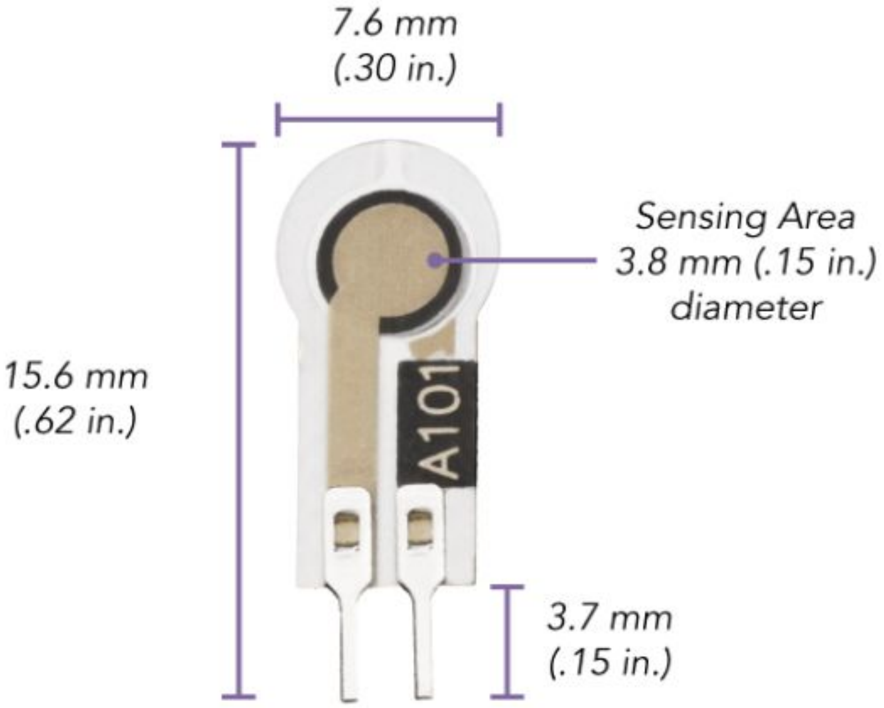
Fingerless Gloves with embedded silicone actuators

Preliminary Pressure Sensor Design

FlexiForce A101 Sensor

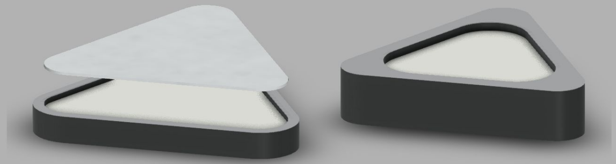
- Easy to use with Arduino
- Acts as a resistor in the circuit
    - When unloaded → Very High R
    - When loaded → Decrease in R



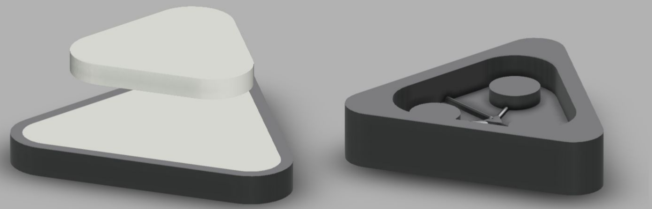


Preliminary Actuator Design

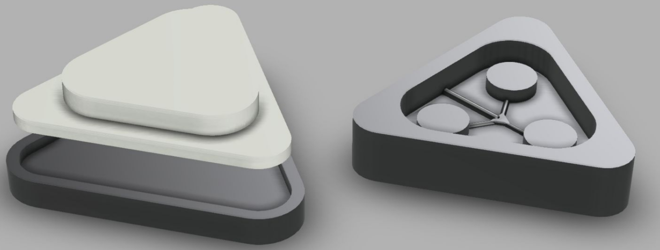
Molding Process



Step 1: Fill upper mold and half of bottom mold, apply paper layer to bottom mold

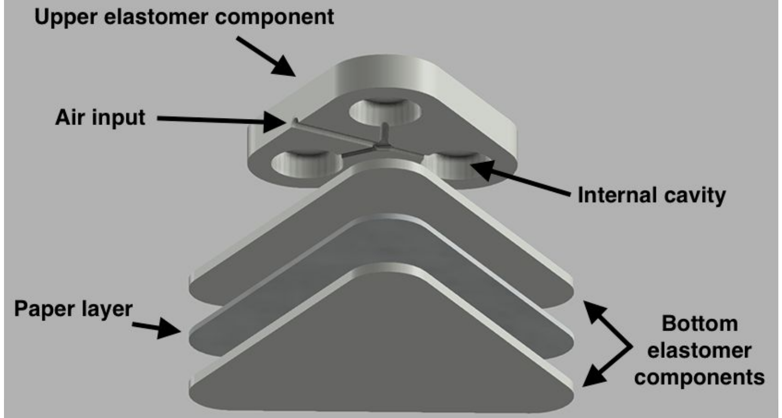


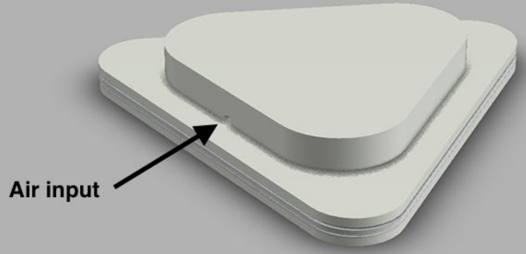
Step 2: Demold upper mold, fill remainder of bottom mold, using uncured elastomer in bottom mold as glue, bond the two cured components



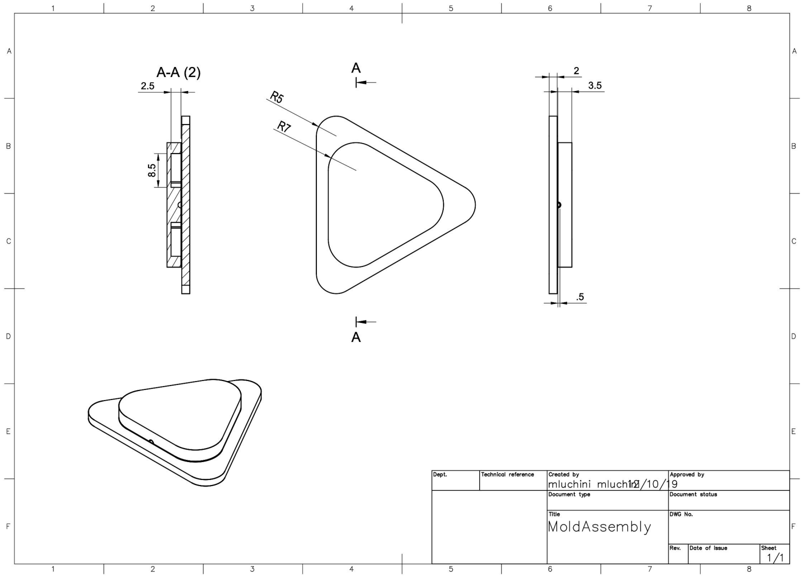
Step 3: Demold cured actuator

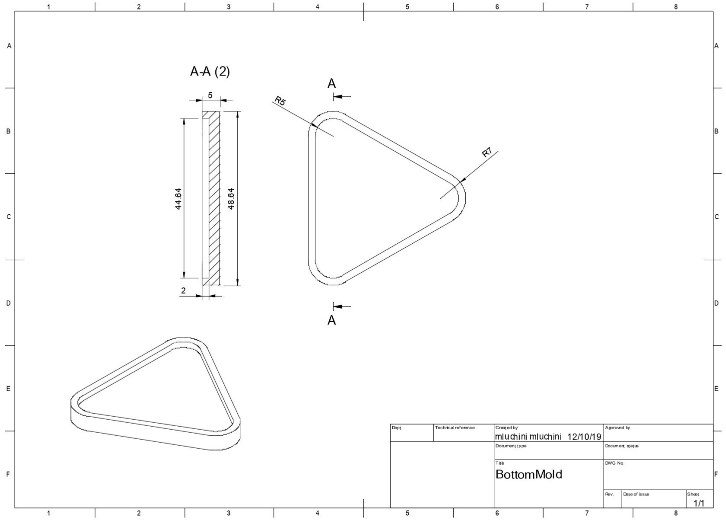
Design

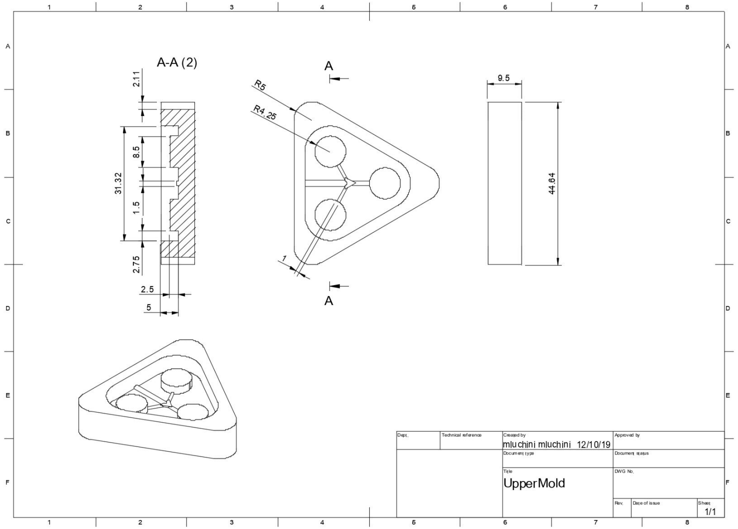




Preliminary Actuator Design







Feasibility Demonstration

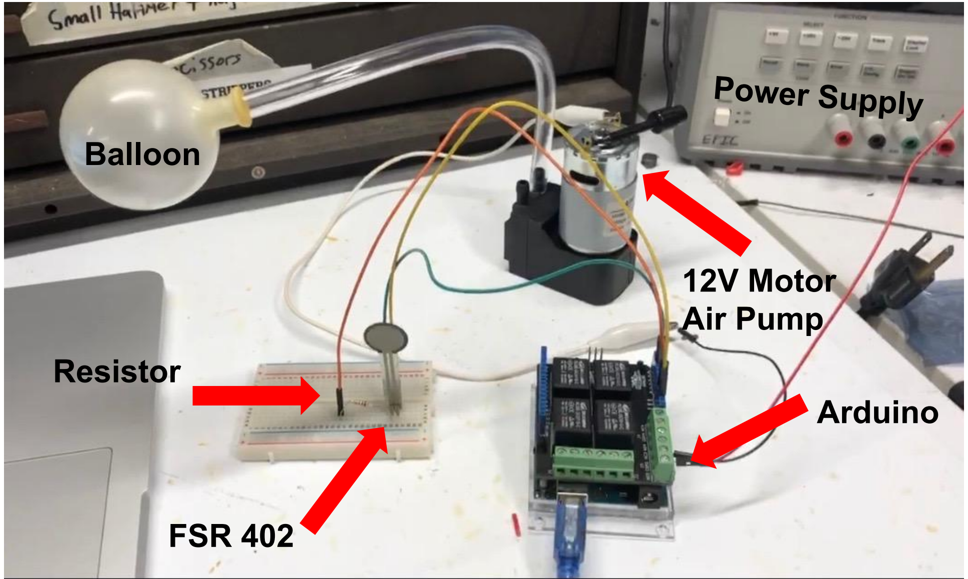
Selection of Feasibility

- **Two Functionalities:** Actuator & Sensor
- **Feasibility:** Combining the two systems
  - Tested with FSR402 Pressure Sensor
  - Need to prove that sensor could detect pressure, relay to Arduino, and activate pump to inflate actuator
  - **Proof-of-Concept**: Pressure from sensor relays to pressure in balloon

Demonstration Set-Up

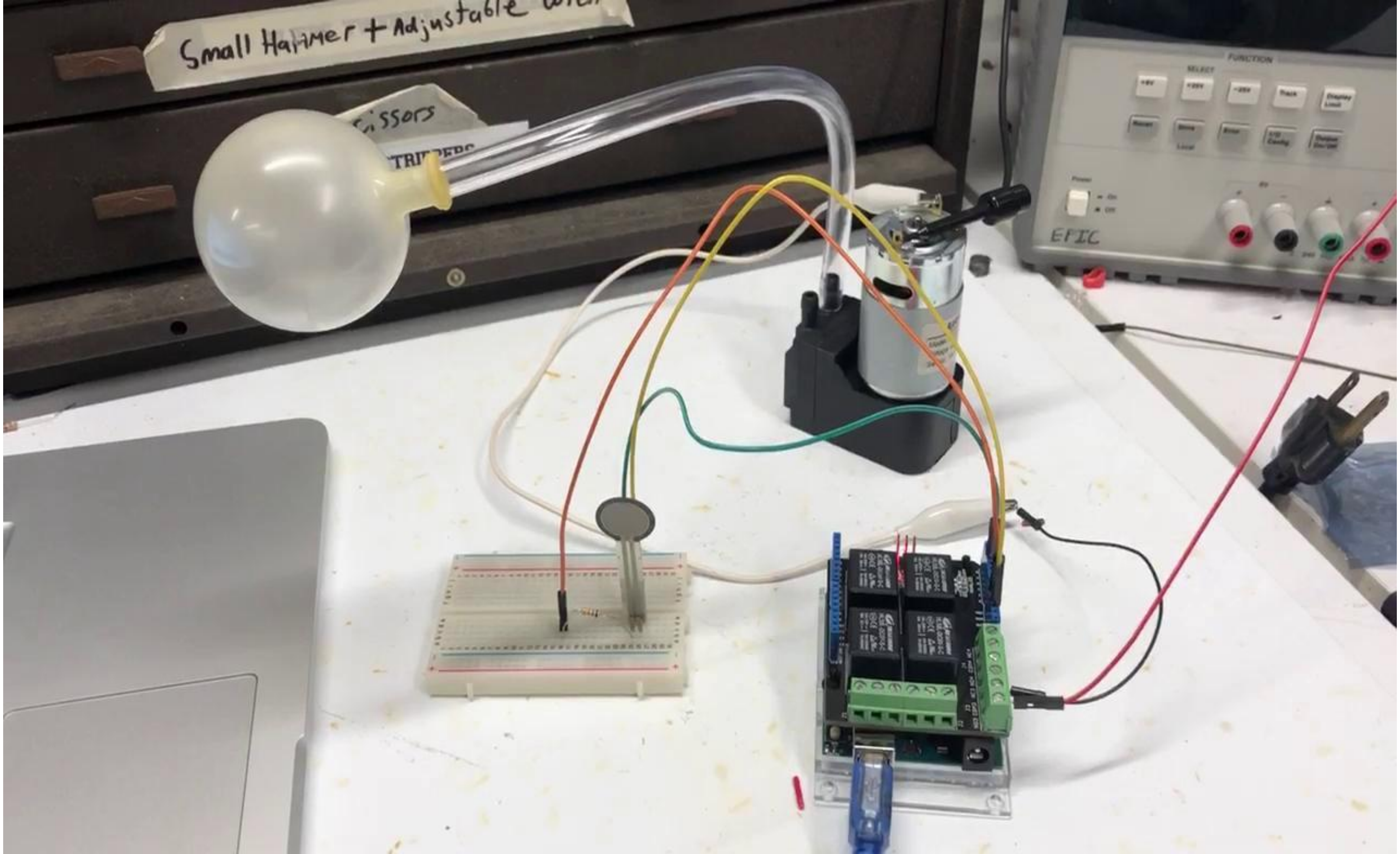
Goals:

1. Detect pressure in appropriate range and designate threshold pressure
2. Inflate/deflate balloon with sufficient air pressure when threshold pressure is applied to sensor



Equipment :

- Arduino
- FSR402 Sensor
- 12V Air pump
- 10kΩ resistor
- Balloon
- Tubing
- 12V battery


Small Hammer + Adjustable
EPIC

Results & Analysis

Progress

- FSR402 Sensor appropriately sensed threshold pressure
- Pump produced sufficient pressure to inflate balloon
- Successfully deflated balloon after pressure was relieved

Points of Improvement

- Implement the custom molded actuator
- Deflating the balloon
    - Implementation of a solenoid
- Addition of pulling force sensor
    - Capacitive sensor
- Calibrate sensors
    - Non-Inverting Op-Amp

Looking Ahead – Next Steps In 2020

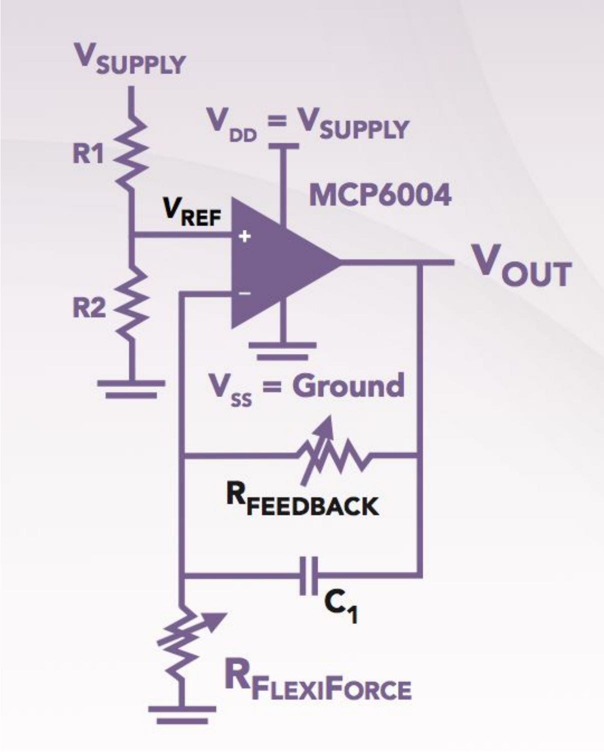
Non-Inverting Op-Amp Circuit

Progress

- Ordered MCP6004 op-amp and FlexiForce Sensor

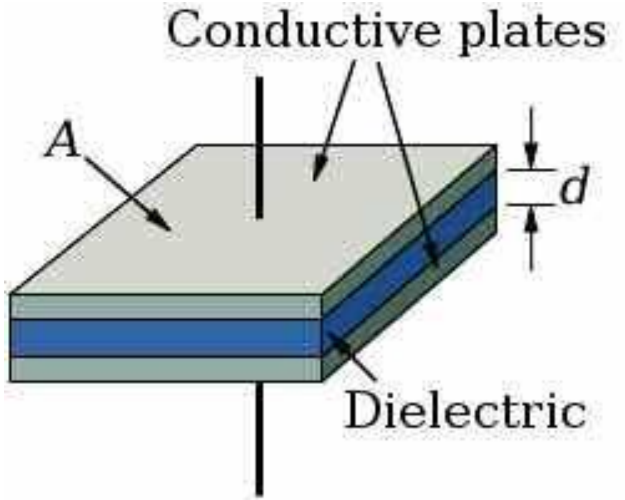
Why?

- To achieve excellent linearity in voltage output with respect to force applied
- Adjust the sensitivity to increase/decrease the max force that can be measured over the FS dynamic range



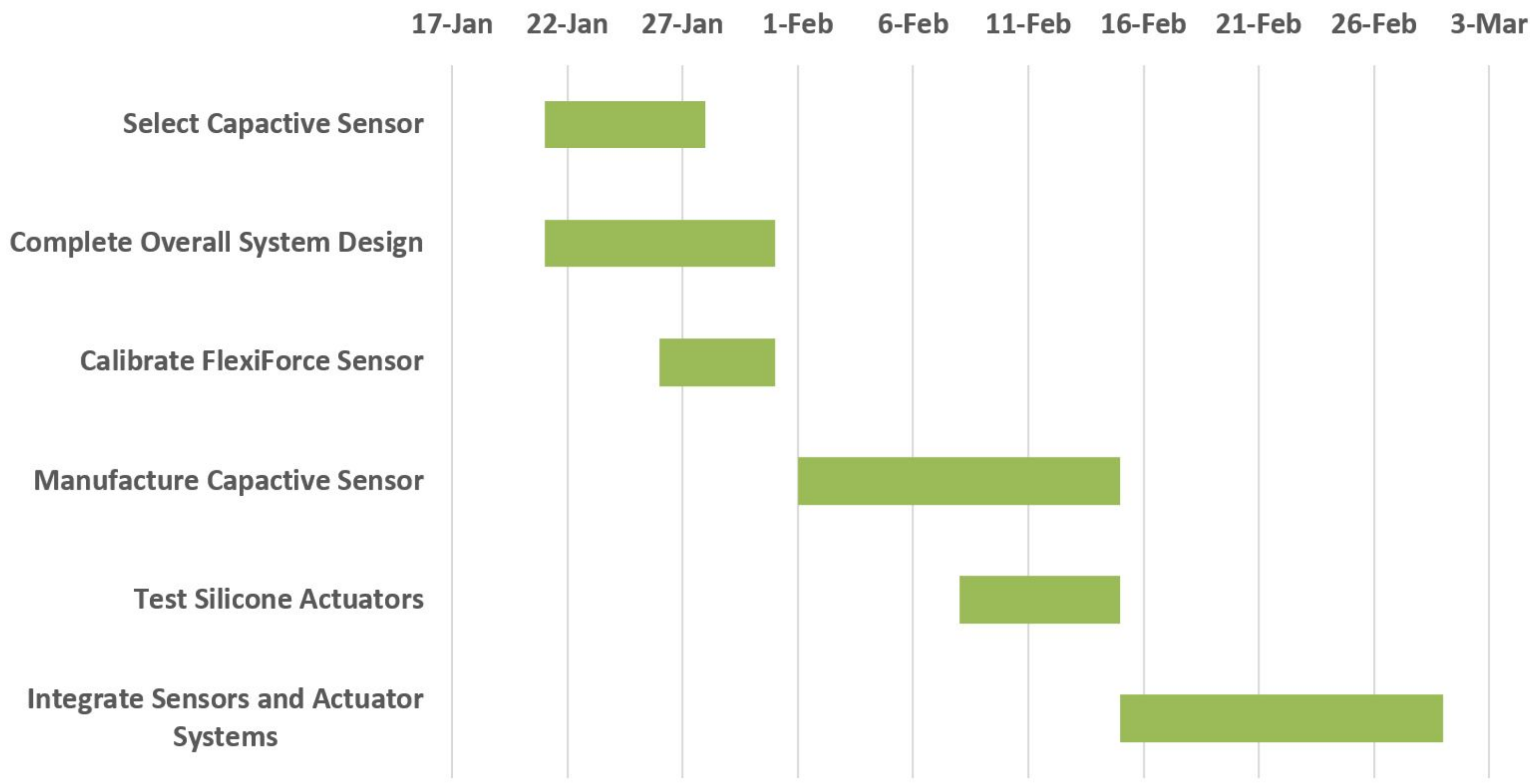
Capacitive Sensor to Detect Pulling Force

- Originally considered a strain gauge, but ultimately selected a capacitive sensor instead
- The strain gauge would only measure pulling “tension” if it was placed on the organ itself
- The capacitive sensor measures small magnitudes of force



- As the organ is pulled, d decreases and the capacitance changes.
- Measure the pulling force with the change in capacitance

Gantt Chart


17-Jan
22-Jan
27-Jan
1-Feb
6-Feb
11-Feb
16-Feb
21-Feb
26-Feb
3-Mar
Select Capactive Sensor
Complete Overall System Design
Calibrate FlexiForce Sensor
Manufacture Capactive Sensor
Test Silicone Actuators
Integrate Sensors and Actuator Systems

Questions?