CalPolyPomona

College of Engineering

Design and Fabrication of Series Elastic Actuator for Humanoid Robot Applications

By,

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ME 5741: BIOMECHANICAL ROBOTS

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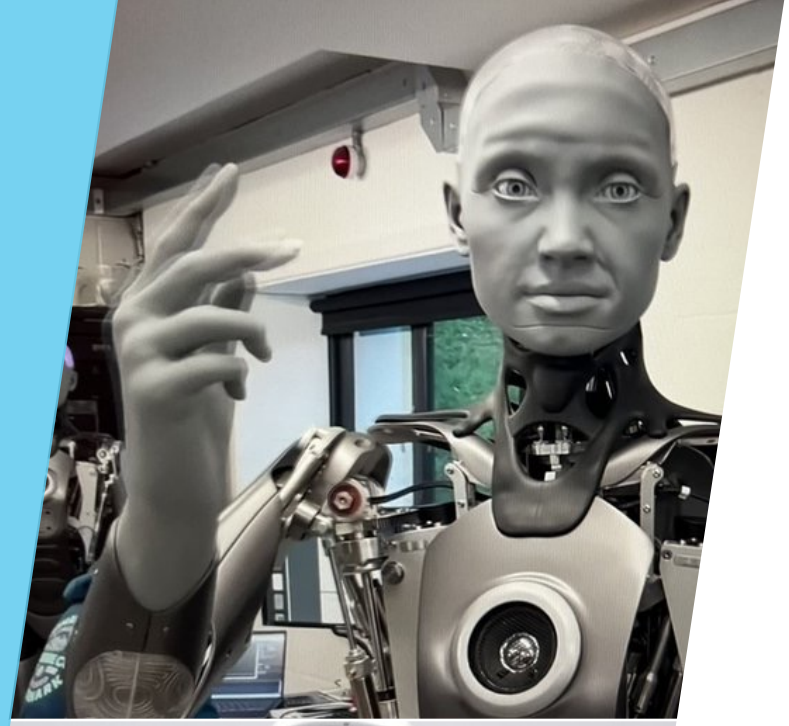
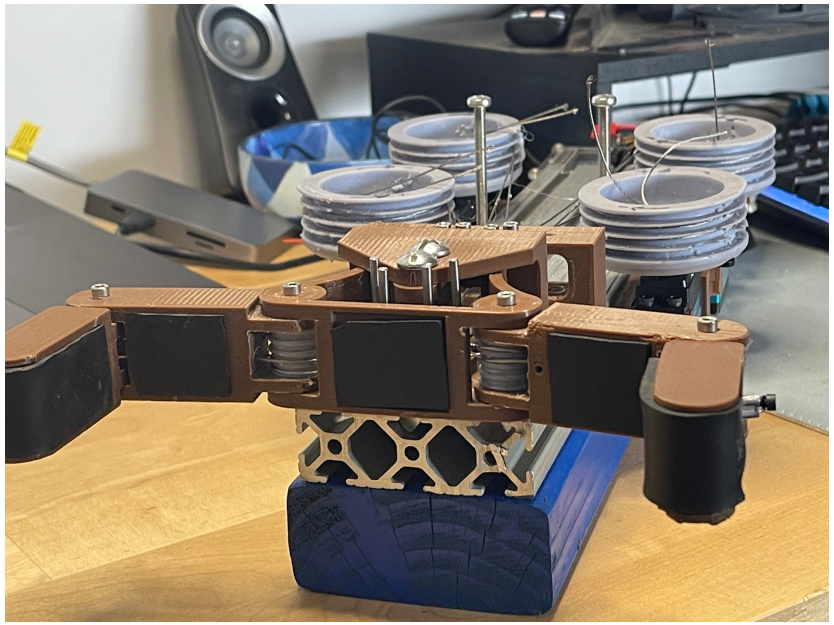
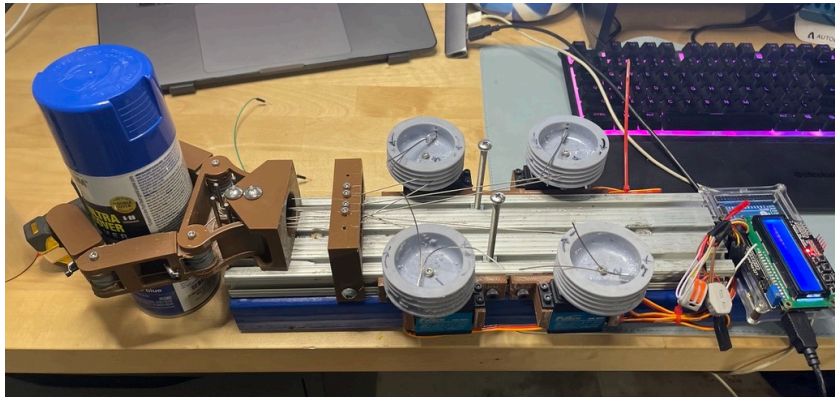


Humanoid Robotics

- Specifically design to operate in unstructured environments.
- Bridge the gap between industrial robots and humans.
- Compared to industrial robots humanoid robots have improved:
  - Dexterity
  - Locomotion
  - Sensory feedback
  - intelligence

Robotic Gripper Overview

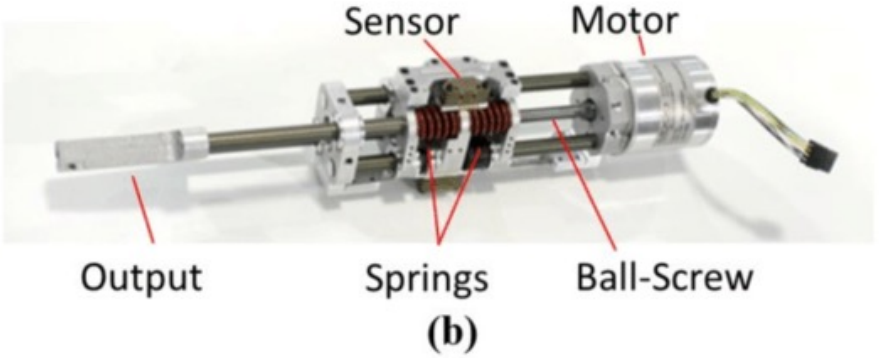


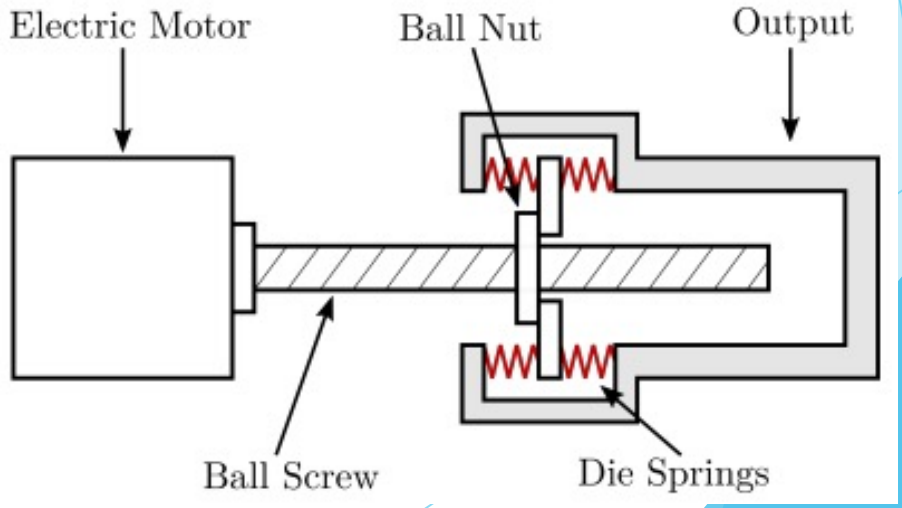


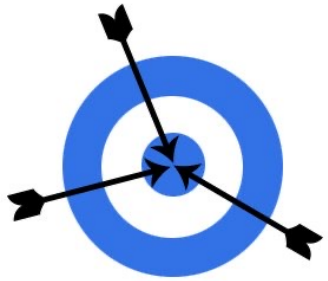
- Project 2 : 2 Finger Gripper
  - Cable Driven
  - 4 DOF
  - 4 servo
- Needs Improvement:
  - Dynamic force Feedback
  - Built In Compliancy
  - Larger load
  - Improved Electronics control/power

Series Elastic Actuator

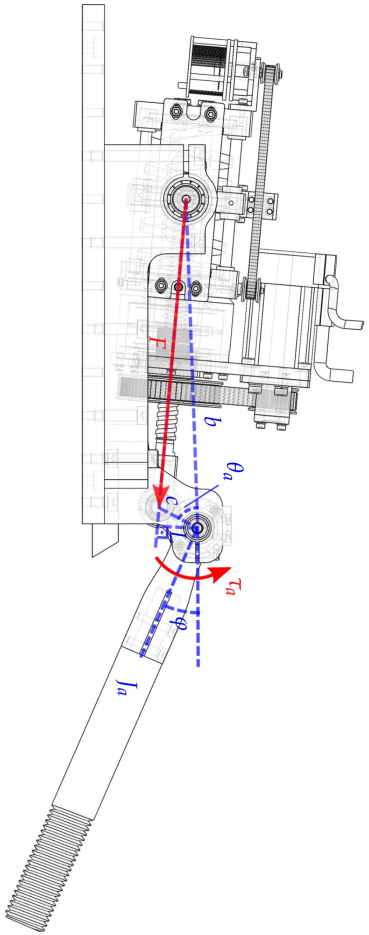
- SEA contains an elastic element in series with the mechanical actuator.
- The elastic element gives the actuator a level of mechanical compliance
  - impact tolerance.
  - high force fidelity (control)







SEA Test Rig Requirements



- Elastic Element:
  - Compliant elastic element
- Force sensor:
  - ability to measure load applied
- Position sensor:
  - ability to measure arm position
- Stability:
  - Ability to have a precise and constant sensor reading with minimal drift or noise
- Size:
  - Relatively compact and design that can be optimized later
- Power:
  - Ability to lift a mass of 15 lb force

Design & Manufacturing

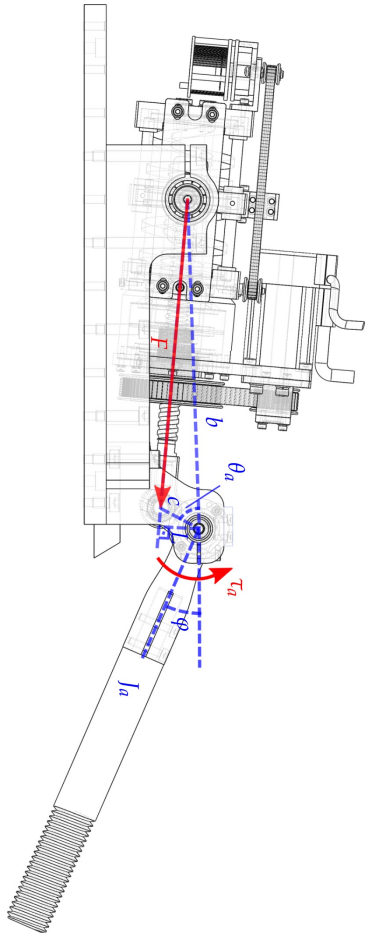
Fusion 360

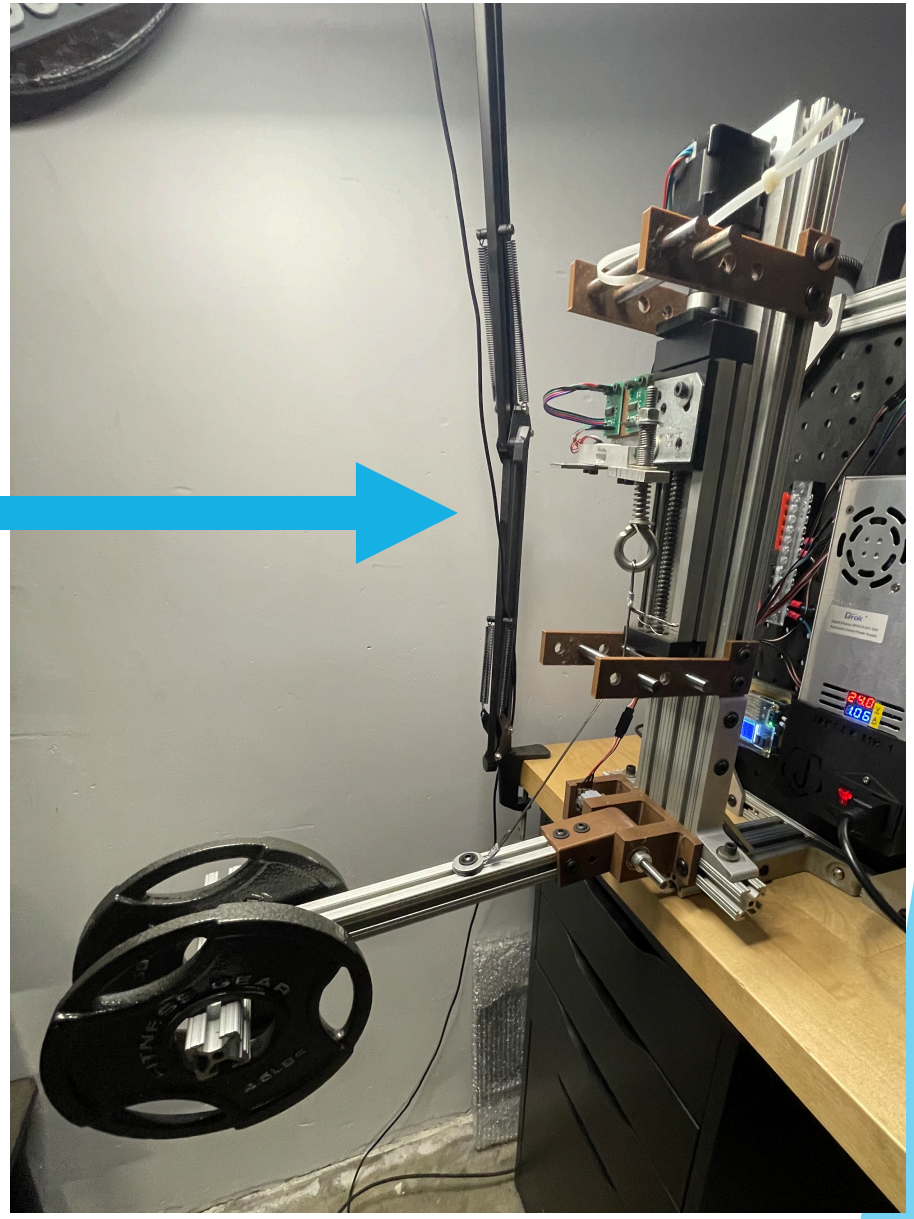
3D Printing

CNC

Assembly

Coding



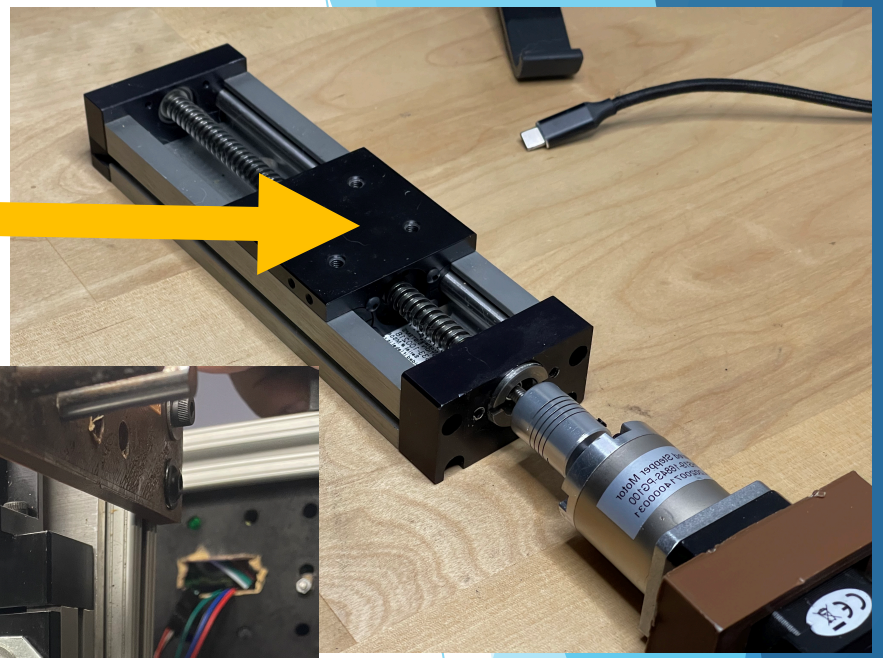


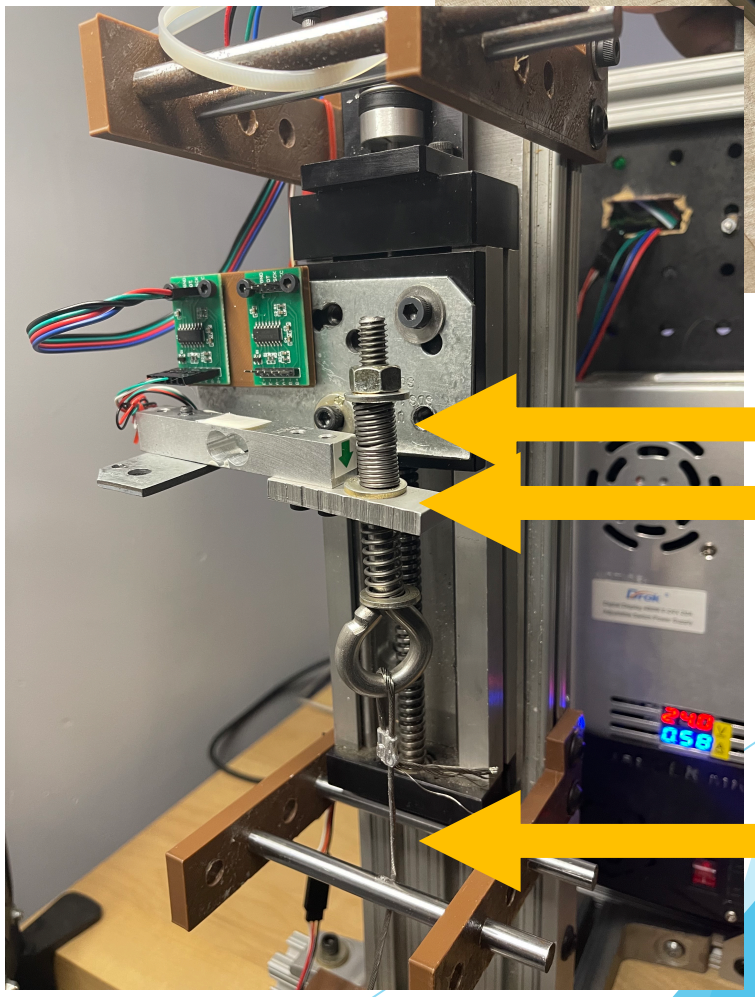
Control Unit

- Upgraded to a 24 V Power supply
- Romeo BLE - A Control Board for Robot – (Arduino Uno) - Microcontroller
- Stepper motor Driver
- 32 Pixel LED ring for visual feedback
- 124 x 64 OLED for quantitively feedback

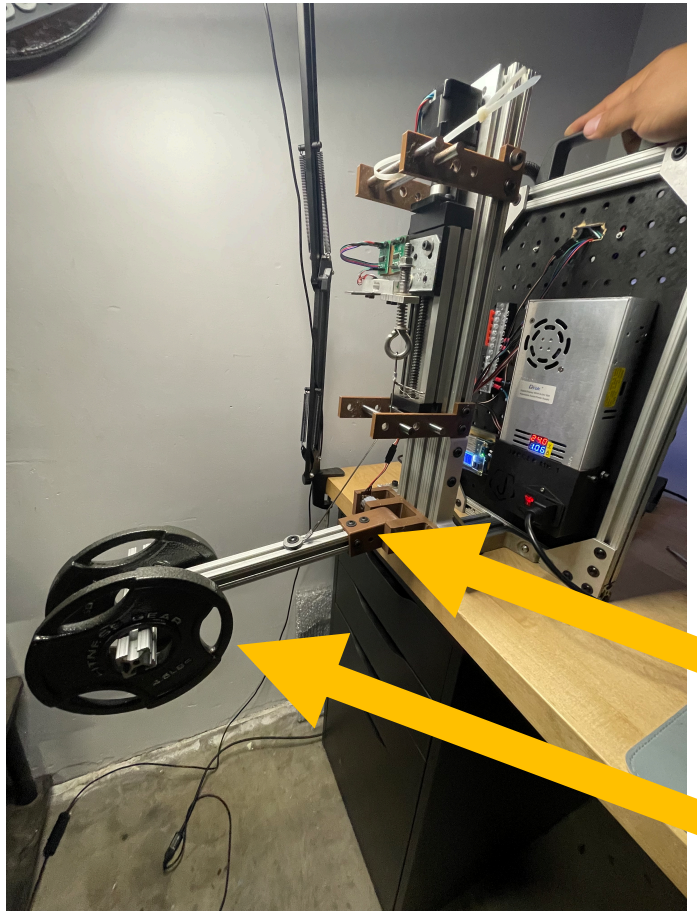
Actuator

- Linear Rail with lead screw and carriage
- Actuator
  - 100:1 Nema 17 Stepper motor
    - 30 LB
    - Very Slow / low dynamic compliancy
  - Nema 17 Stepper motor
    - 30 LB
    - Very Slow / low dynamic compliancy
- 10 KG load cell with analog to digital converter
- Cable “tendon” connected to load cell in series with springs



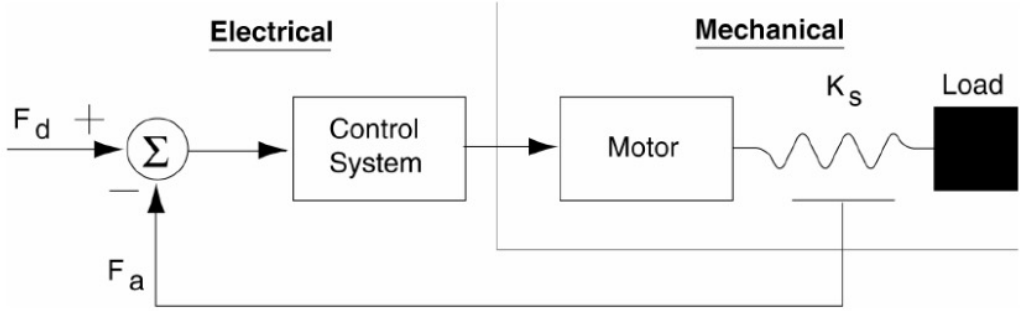


Forearm



Potentiometer

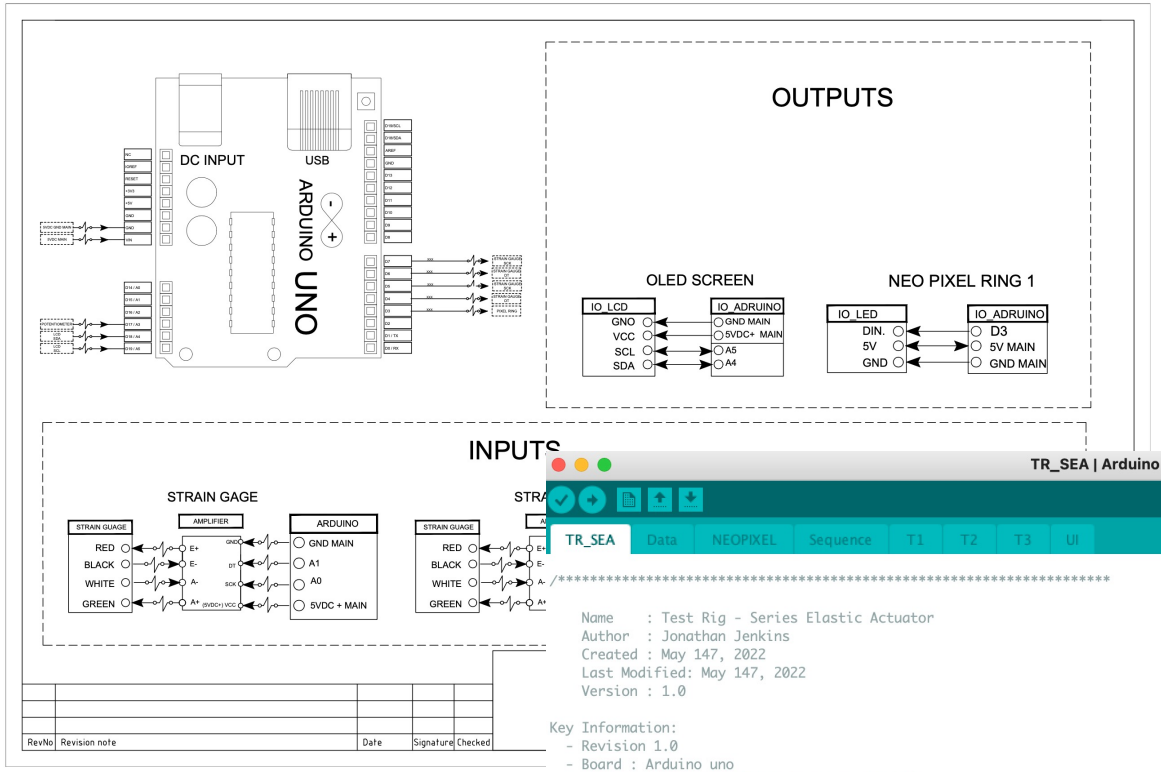
Load / Arm



- Angle and Force data are used to make a close feedback control system
  - Desired Force and measured force
  - Desired angle and measured angle

Programing

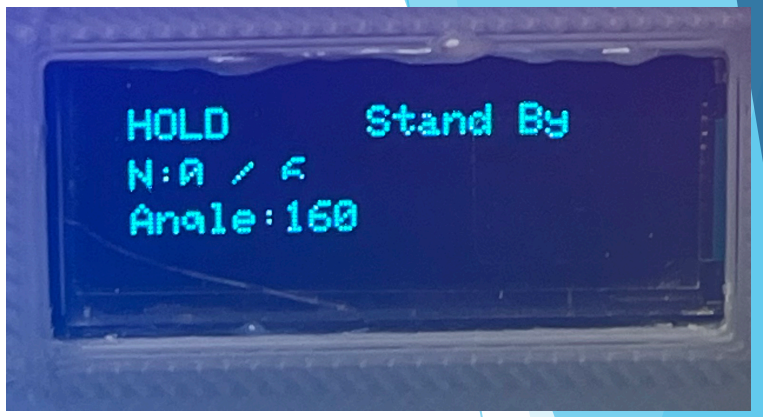
- Program the force calculations
- Program the compliant feedback
- Program the sensory/haptic feedback
- Calibrate the system with known weights

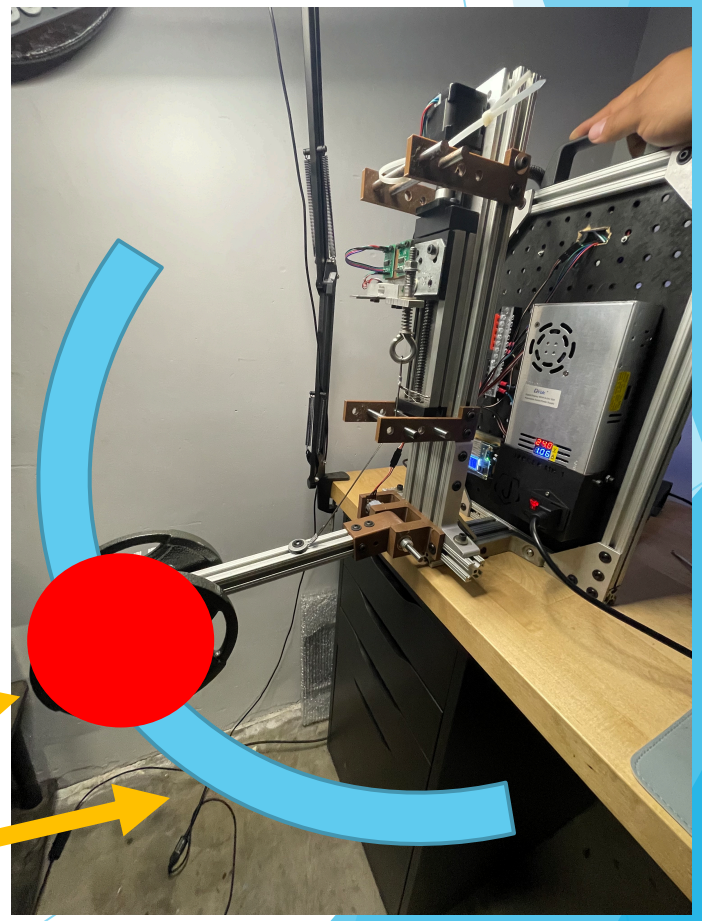


DEMONSTRATION & ANALYSIS

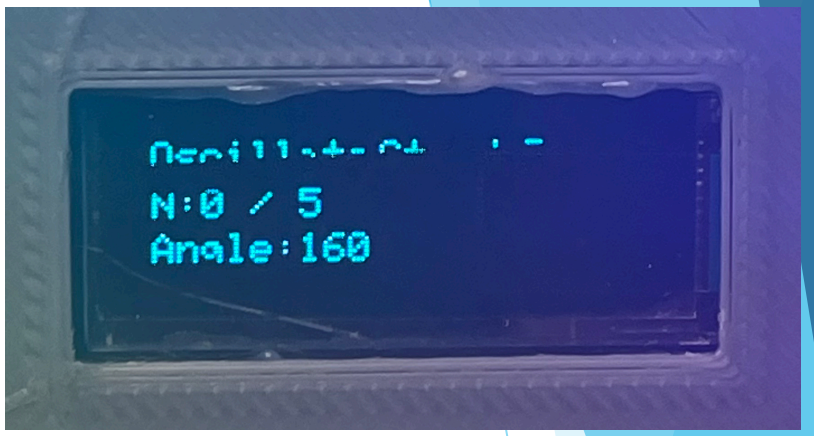
Dynamic Position Hold

- Sets the desired load you want the actuator to tolerate
- Compliant feedback allows operator to manually change the arm position
- Actuator will hold new position

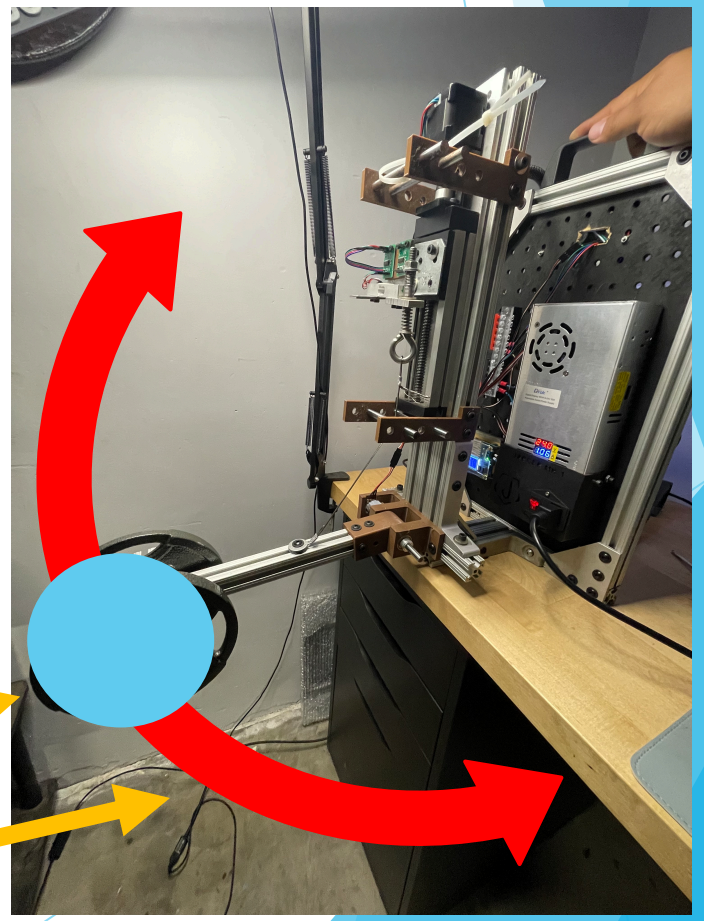




Dynamic Oscillation



- Sets the desired load you want the actuator to tolerate
- Compliant feedback allows arm to be held at any position during its motion to comply with external forces



Conclusion

The Good

- Successfully detects force and Complying with external interaction
- Improved Power system and controller
- Demonstrated decent power

The Bad

- Noticeable delay in the detection of force and the reaction of the actuator
- Actuator is to weak
- Actuator is to slow
- Potentiometer is noisy