DESIGN, OPTIMIZATION AND CONTROL OF A SOFT PNEUMATIC ACTUATOR

Jahnav Rokalaboina, Robotics and Autonomous Systems, MS
Mentor: Wenlong Zhang, Associate Professor
Ira A. Fulton Schools of Engineering

Introduction

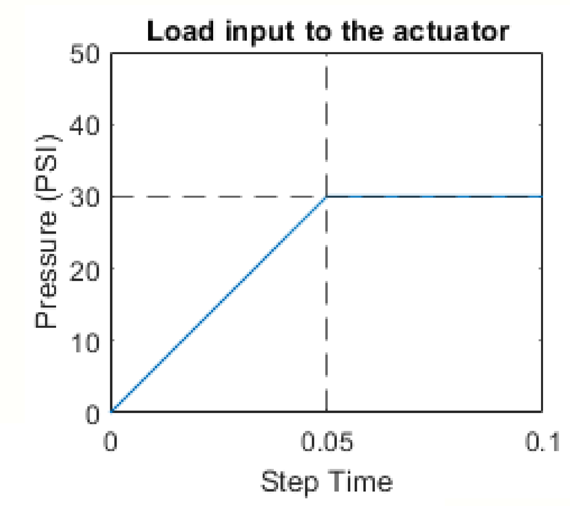
- Soft Pneumatic Actuators (SPA) present a promising solution to generate torque in wearable assistive devices.
- The nonlinear nature of materials used in fabrication and modeling of SPAs magnify the difficulty in estimating the state of the actuator including position, orientation and torque output [1].
- In this project, techniques to optimize design without completely relying on manufacturing multiple actuators but by finite element analysis are to be explored in addition to control and experimental validation.

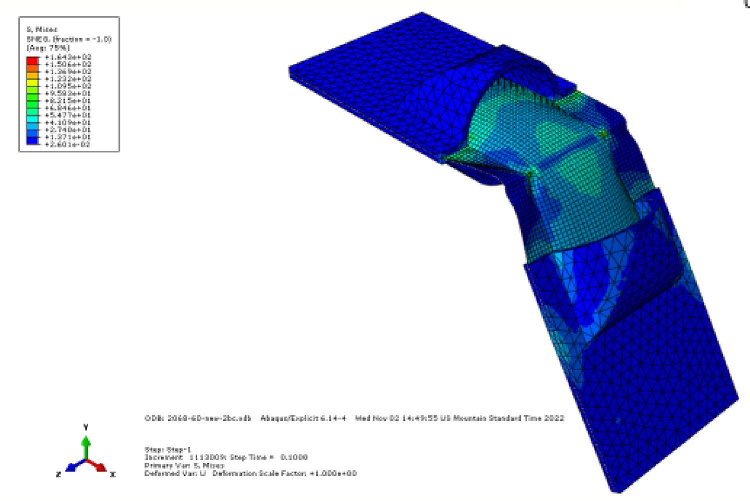
Methodology

- Soft Pneumatic Actuator (SPA) is designed, and finite element analysis is performed using Abaqus CAE with relevant boundary conditions.
- Torque result can be calculated by measuring the resultant force from actuator with pressure load of 30 psi.
- The orientation of actuator is at 60 degrees because it is the maximum angle of a human knee during gait cycle [2] and it gives us the estimation of working range of the SPA.

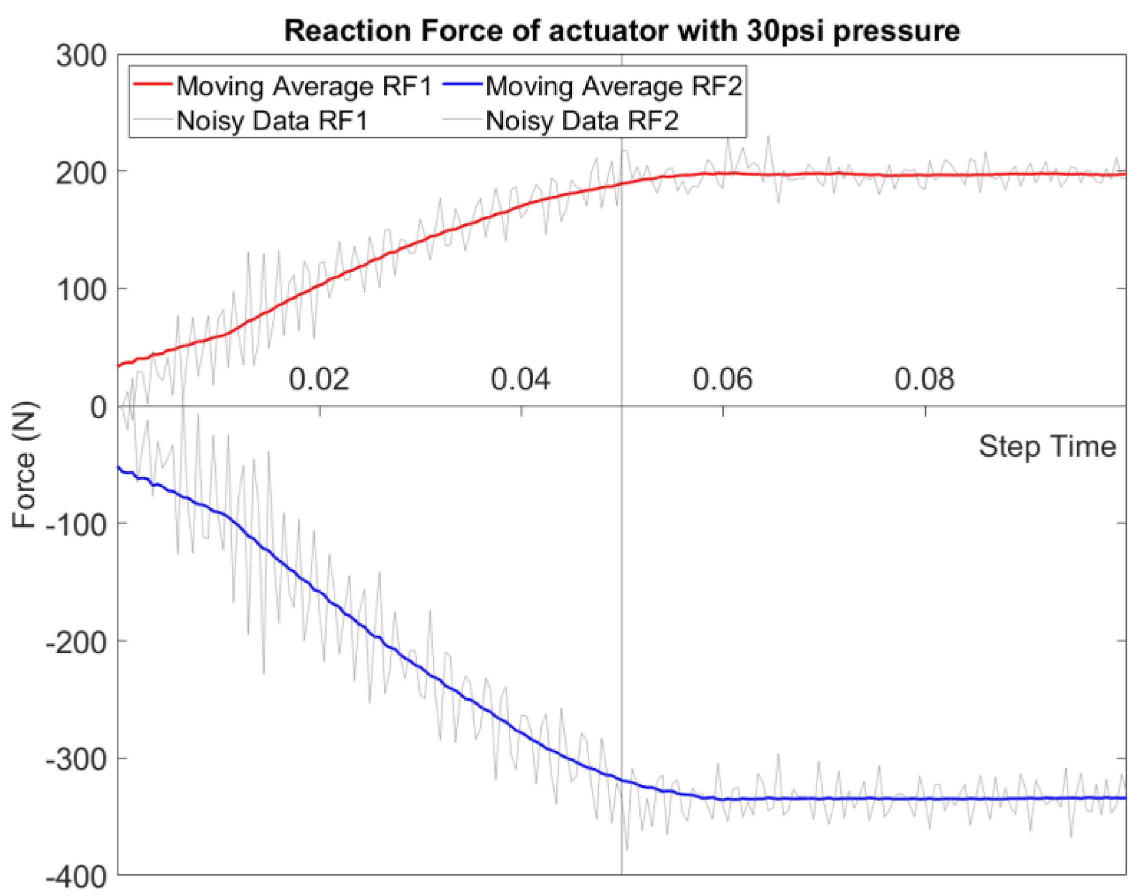
Finite Element Analysis

- The input load, pressure is given as shown in figure.
- The steady state response can be found after Step time= 0.05.



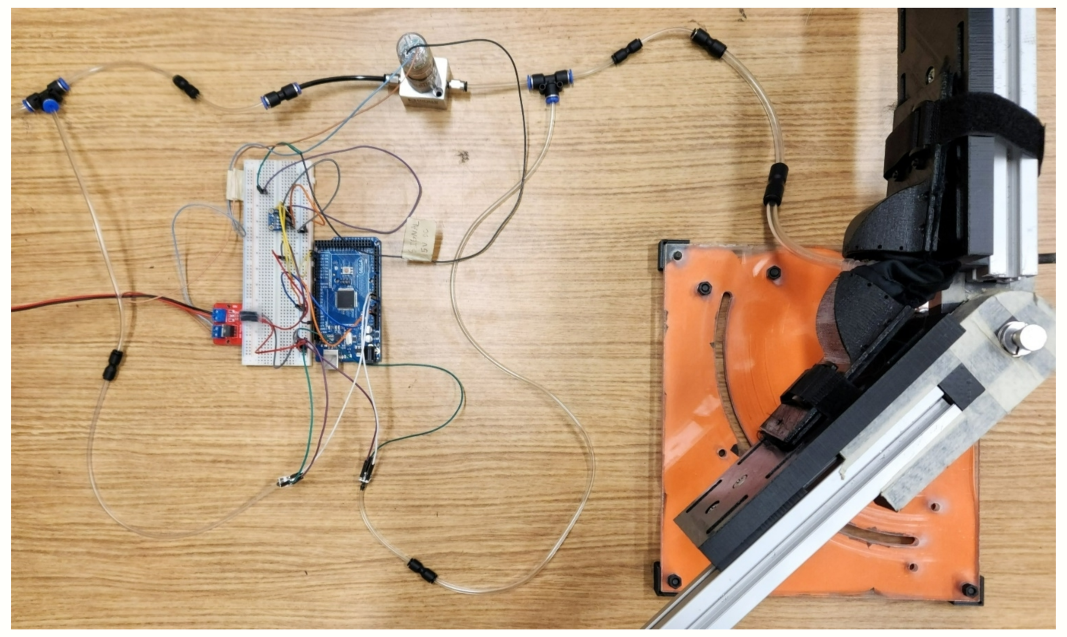


- The torque result for Pressure, P=30 psi for given input using Finite Element Method is:
- The analytical solver of Abaqus solves the model with vibrations and takes a lot of time to reach steady state, so the result is noisy.
- The RF1 and RF2 are X and Y components of resultant forces, torque is estimated from this.

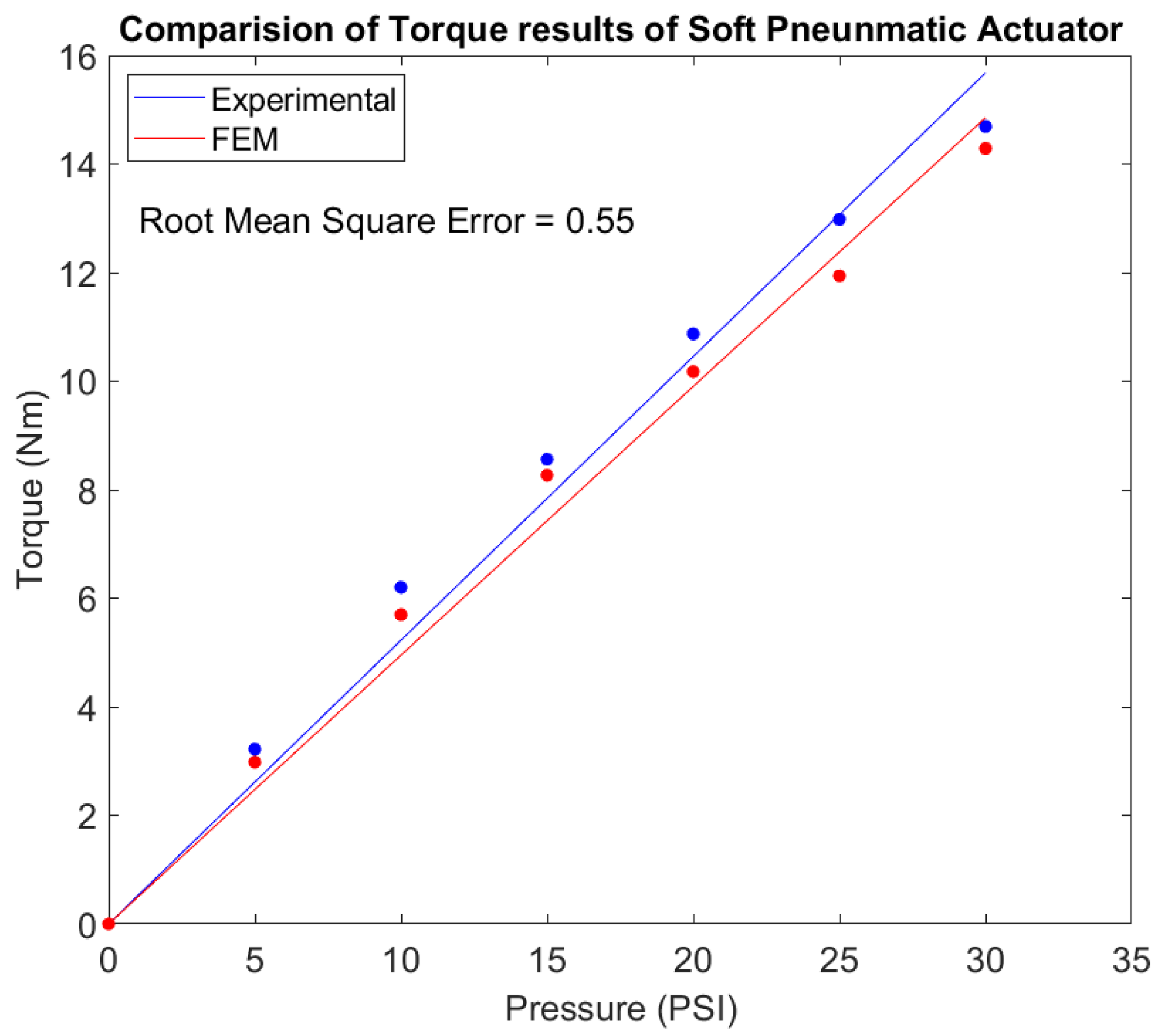


Experimental Results

- The soft pneumatic actuator is controlled using proportional valves which can output desired pressure with analog voltage input and torque is measured using torque sensor.



- The torque results from experiment and FEM are compared for validation for different pressures



Future Work

- The control system of this actuator using proportional valves is to be developed yet.
- The mathematical model of the control system is being developed which can validate experimental desired pressure.

Conclusion

- The finite element analysis helps in optimizing the design for different exosuits which require different torque output.
- The proportional valves can reduce the delay in inflating/deflating the actuator which helps in tracking gait cycle effectively.

References

[1] Lipson, H., 2014. Challenges and opportunities for design, simulation, and fabrication of soft robots. Soft Robotics, 1(1), pp.21-27.

[2] Ahn, J. and Hogan, N., 2012. Walking is not like reaching: evidence from periodic mechanical perturbations. PloS one, 7(3), p.e31767.