CALIFORNIA STATE POLYTECHNIC UNIVERSITY, POMONA

DEPARTMENT OF MECHANICAL ENGINEERING

ME 5741

BIOMECHANICAL ROBOTS

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Assignment # 3

Design and Fabrication of Series Elastic Actuator for Humanoid Robot Applications

By

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1 Introduction

1.1 Review of Our Custom Gripper

Previously we took inspiration from the human biology and design a cable driven anthropomorphic robotic end effector. End effectors allows robots to interact with their environments, like how human uses their hands. Our gripper consists of a two double hinged finger, servo actuators, and an LCD user interface as seen in figure 1.

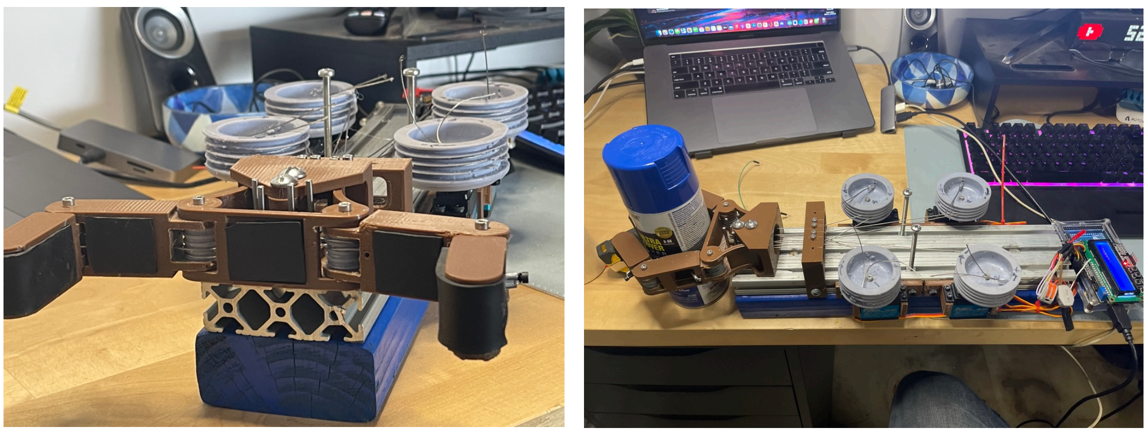


Figure 1 Custom Gripper

Overall, the system works as designed. The gripper successfully interacted with objects in the desired size range of 4 inches and at weights up to 1 lb. However, the system was far from perfect. Many modifications can be made to improve the durability, accuracy, and the strength of the design, but two key design flaws were highlighted.

First was the design of the control wire and how they connect with the actuator. Because of the anchoring method used it was quite difficult to ensure even tension of the cables. Loose cables will lower the control the actuator had with the desired joint. Loose control cables negatively affected the accuracy, repeatability, and the holding force of the finger. A different tensioning system/ anchoring method would be recommended to solve this problem.

The second design flaw was the direct connection between the cable and the actuator. The direct connection gave the servo a negative mechanical advantage, limiting the maximum amount of payload the gripper could carry. The pulley itself was also poorly supported and could not sustain the maximum load without deforming the mounting structures. Lastly, the system was not properly compliant. All the compliancy in this system was due to the poorly tensioned cables. At the correct tension all force is directly transformed into the motor and structure with no proper compliant mechanism. This would not be acceptable for a humanoid robot. Compliancy is needed to avoid damaging the key internal mechanisms and the object the robot is interacting with.

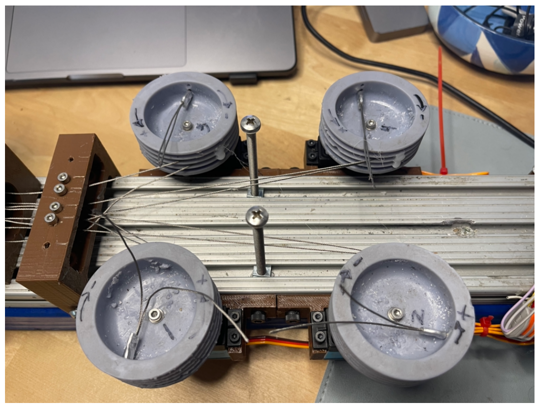
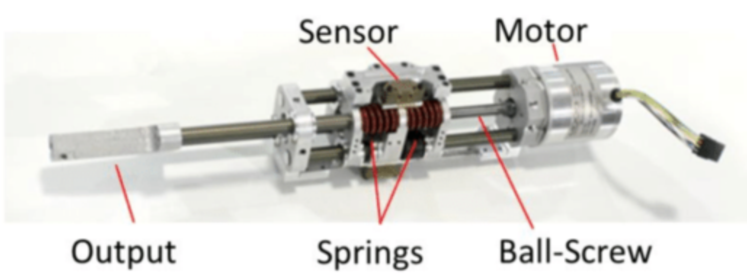


Figure 2 Gripper Actuator and Control Cables

1.2 Series Elastic Actuator

Unlike the rigid actuators previously used a new compliant actuator called a series elastic actuator (SEA) will be developed. SEA contains an elastic element in series with the mechanical actuator. The elastic element gives the actuator a level of mechanical compliance. This allows the actuator to have impact load tolerance, low mechanical output impedance, and increased power output.



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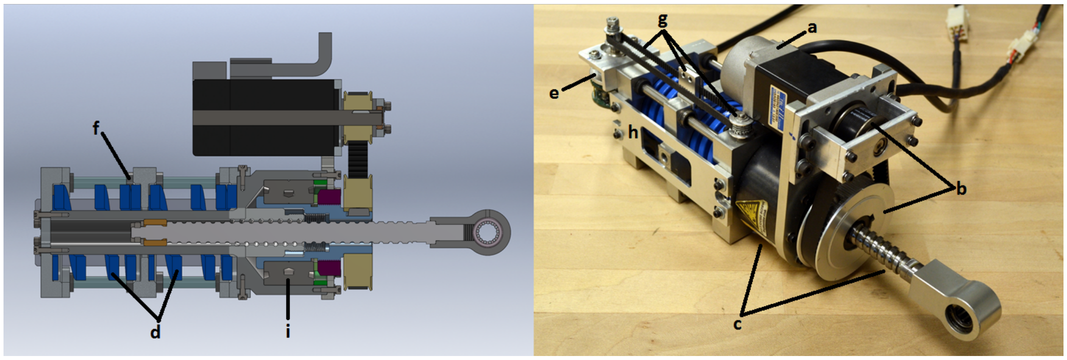

Figure 3 Series Elastic Actuator

As seen in figure 3 a SEA actuator consists of a motor with gearbox to provide the power, a ball screw that would provide better mechanical advantage to transfer the power to the load. A carriage with springs that allows displacement between the output shaft and ball screw. A output shaft that is either directly connected to the desired joint or indirectly connected by a control wire. Lastly series elastic actuator contains supporting electronics that controls the unit and measured the active load of the system allowing dynamic control of the output force.

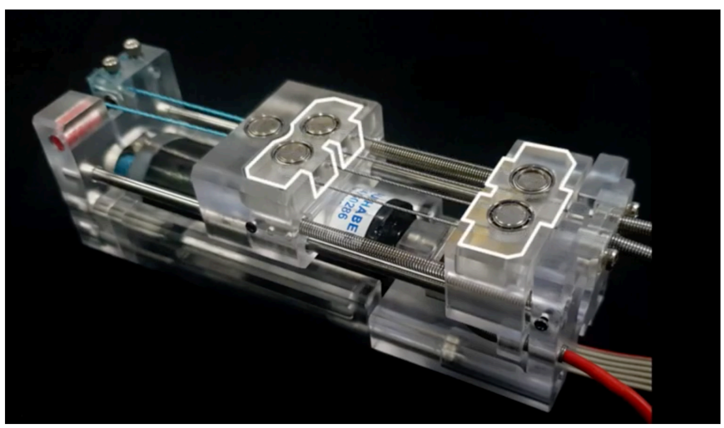

Figure 4 Series Elastic Actuator with Control Wire

1.3 Objectives

The objective of this project is to design and fabricate a custom series elastic actuator that could be used on humanoid robot. Our series elastic actuator will be designed to be used for the bicep of a humanoid robot. To successfully perform the desired task the actuator needs to meet certain requirements. The actuator requirements include the following:

- Ability to lift a mass of 45 lb force.
- Ability to hold said mass for 1 minute.
- Incorporate active force compliance via sensor
- Compact size and low weight

Our custom series elastic actuator will be built into a test stand. On this test stand a series of trials will be conducted to test different subsystems and identify areas of potential improvement. As shown in figure 5 our actuator will be connected to a load arm that will be representing the robot's future forearm. A load will be placed at the end of the forearm and the actuator will need to actuate the arm to the desired angle and maintain the desired holding force. External forces will be applied to the actuator to test the system mechanical compliancy. We will also test difference active feedback compliancy modes that necessary for future robotic development.

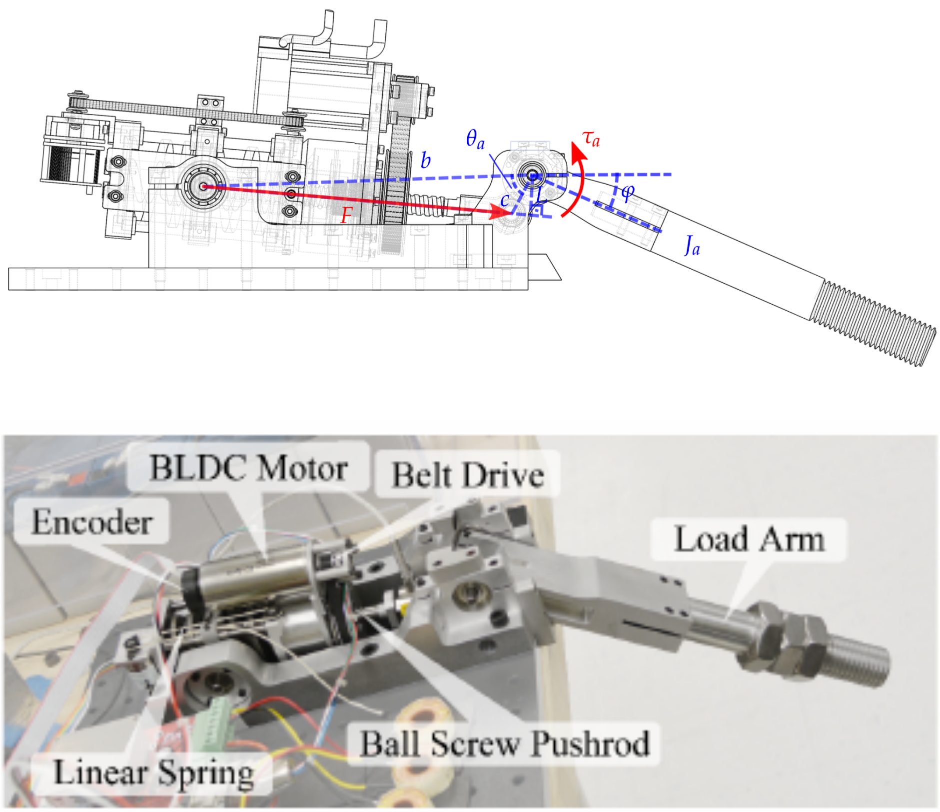

Figure 5 Test Bench