Hardware Demo: UT-SEA

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1 Background

Series Elastic Actuation (SEA) is a departure from the traditional approach of rigid actuation commonly used in factory room robotics. Unlike rigid actuators, SEAs contain an elastic element in series with the mechanical energy source. The elastic element gives SEAs several performance benefits compared to rigid actuation including high force fidelity (by measuring elastic deformation), low mechanical impedance, tolerance to impact loads, and the opportunity for mechanical energy storage. However, SEAs have much lower resonant frequencies than their rigid counterparts, thus reducing achievable system bandwidth.

The University of Texas Series Elastic Actuator (UT-SEA) is a compact, light-weight, high-power actuator designed to enable energetic and high speed locomotion in electrically actuated legged systems (Figure 1). The design and control challenges associated with this goal include studies in energy transfer from a power source, through a motor, drivetrain, and mechanical actuator dynamics, to the actuated joint efficiently and in a controlled manner. These challenges have been addressed with contributions in high-voltage motor interfacing for increased actuator torque and an efficient, power-dense mechanical design. We will present intelligent model-based controllers designed to maximize both tracking accuracy and bandwidth.

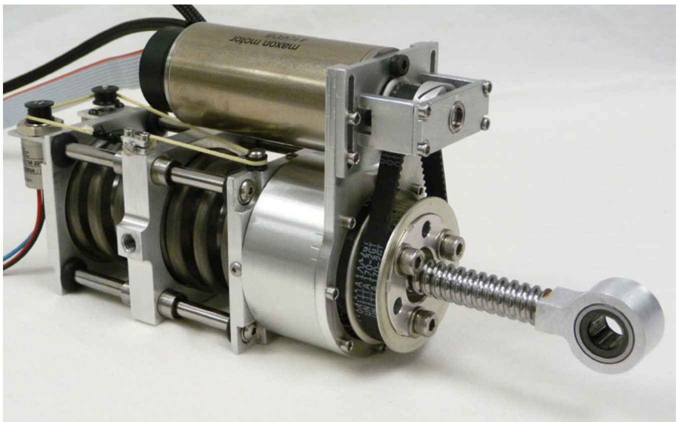

Figure 1: UT-SEA

Table 1: UT-SEA Design Parameters

Weight	1168 g
Stroke	6 cm
Max Speed	32.5 cm/sec
Continuous Force	848 N
Intermittent Force	2800 N
Spring Stiffness	277.78 N/mm
Force Resolution	0.31 N
Operating Voltage	80 V

2 Hardware

Unlike other motor-driven prismatic SEA designs, our design drives the ballnut instead of the ballscrew. Driving the ballnut enables two features which help reduce the size and weight of the UT-SEA. First, ballscrew support is incorporated directly into the actuator housing using an innovative piston-style guide. This feature replaces the long, bulky rails used to support the output carriage in conventional prismatic SEA design. Secondly, the compliant element is placed concentrically around the piston-style ballscrew support which gives series elasticity without adding to the length of the actuator.

The end result is is a pushrod reaction style SEA that is compact enough to be placed at each joint of an articulated leg. Such small size enables a modular leg design similar to those seen in hydraulically actuated robots. A summary of the design parameters for the actuator can be seen in table 1.

3 Controllers

In our poster we will present intellligent, model-based controllers that maximize force and position tracking performance of reaction style SEAs. The UT-SEA uses a soft elastic element which maximizes energy storage at the cost of lowering mechanical system bandwidth. This choice necessitates careful consideration of the dynamic response of the actuator in order to control both force and position setpoints accurately. Our control approach uses dynamic compensation at multiple levels and a nested PID/Disturbance-Observer control loop around the actuator plant model.

4 Setup Requirements

Our demonstration requires a sturdy table to place the actuator on and one power outlet to power the setup and control computer.