Low-cost, Modular Force Control Solution

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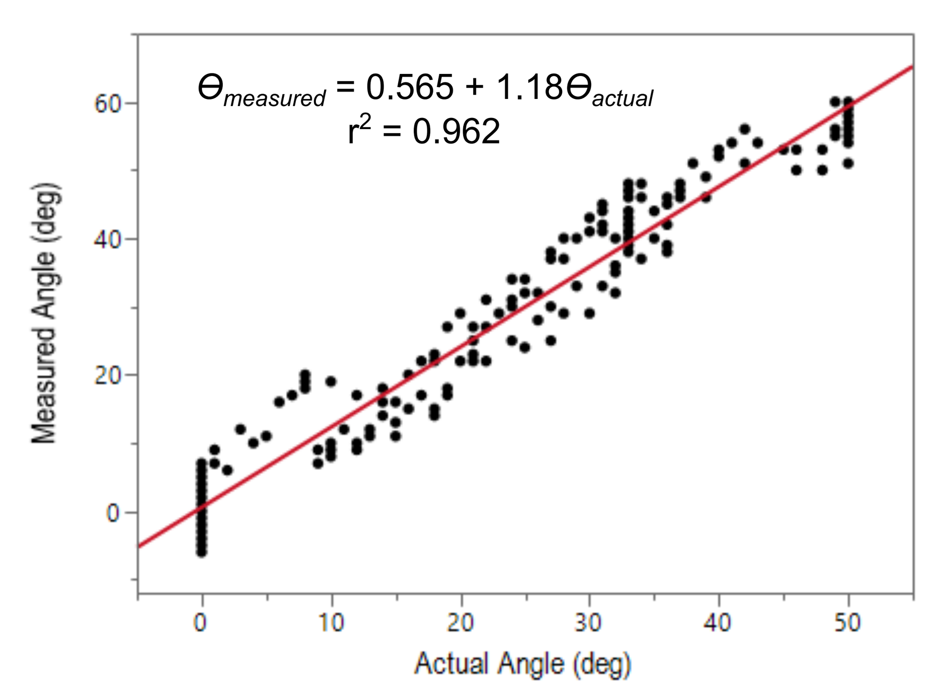
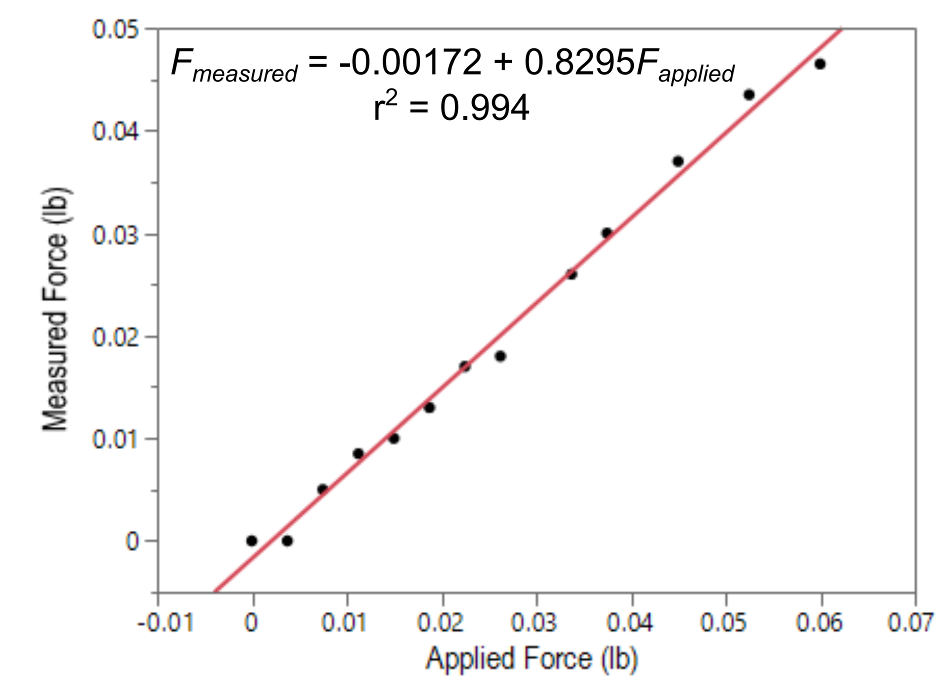
Introduction

Force control provides numerous benefits to robotic mechanisms such as increased sensitivity to interactions with the surrounding environment as well as the ability to perform more natural movements [1]. This research aims to implement an effective force controller in a low-cost robot. At its simplest, a force controller causes a mechanism to apply a certain force instead of moving to a specified position or velocity as other control schemes would have it do. When implemented in a compliant mechanism, the force approach is similar to how animals move and allows robots to achieve fluid, high-speed movements [2].

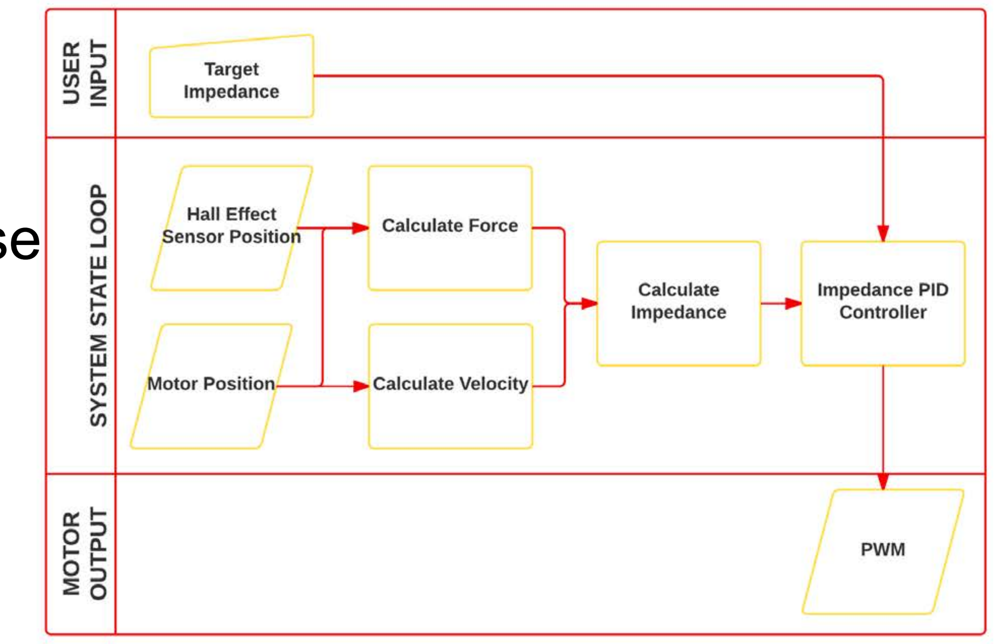
Results



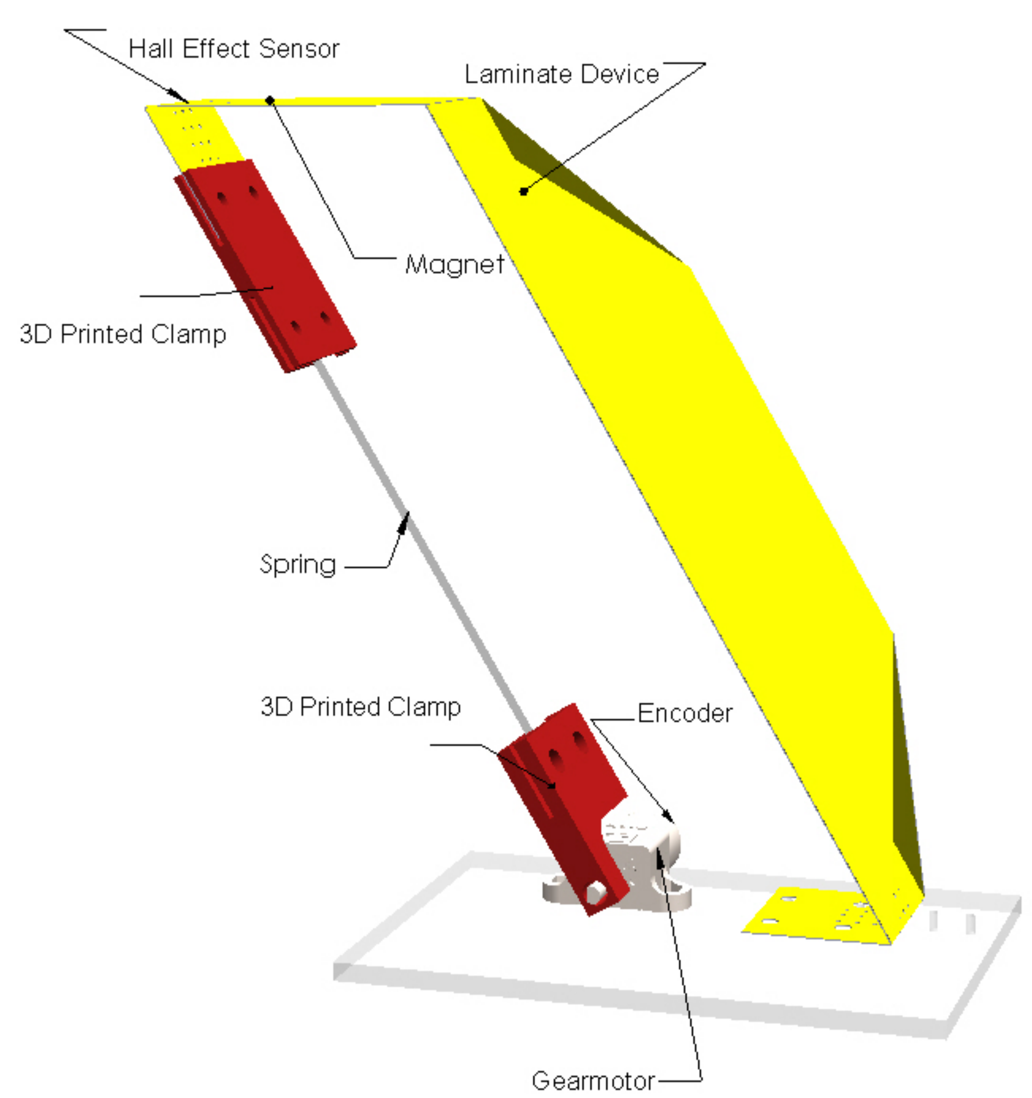


Future Work

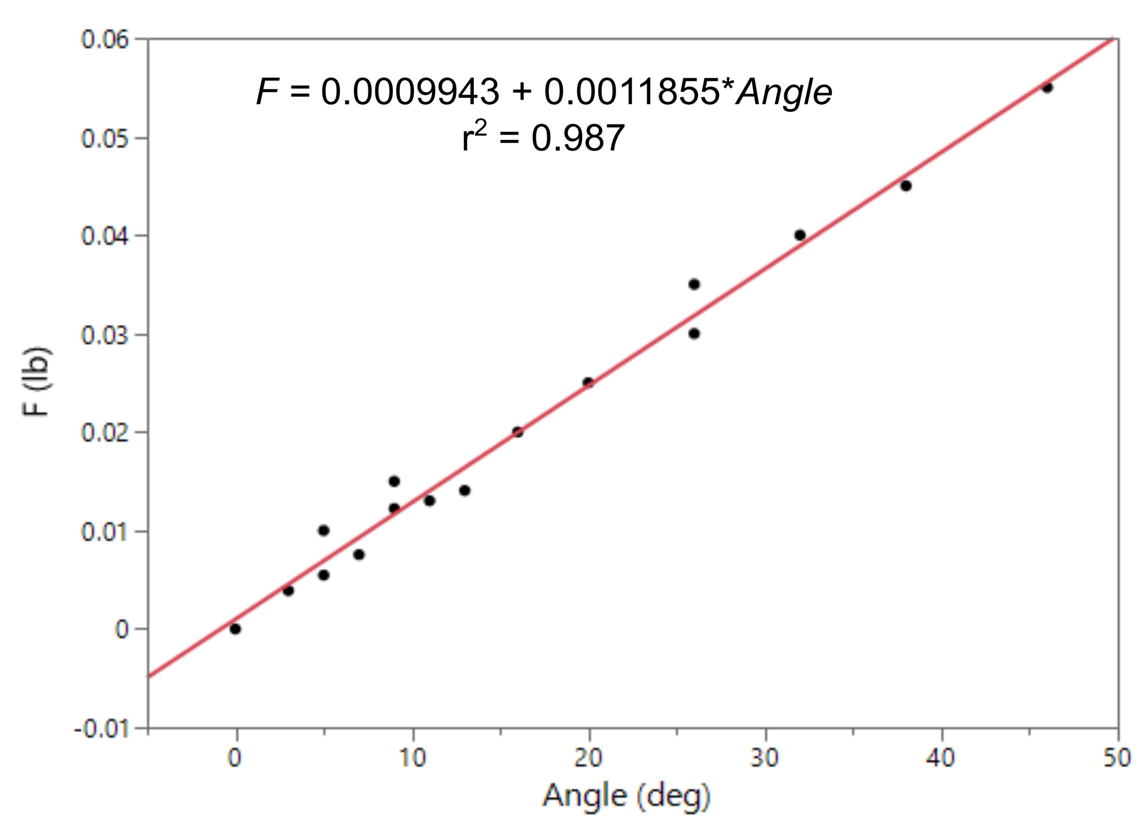
The force control device will be programmed to not only measure force, but also to apply a desired force, hold a specified position up until a maximum force threshold, and move with a specified impedance using a controller following the process proposed below. The controller's response to inputs and disturbances simulating walking, will then be demonstrated.



Design



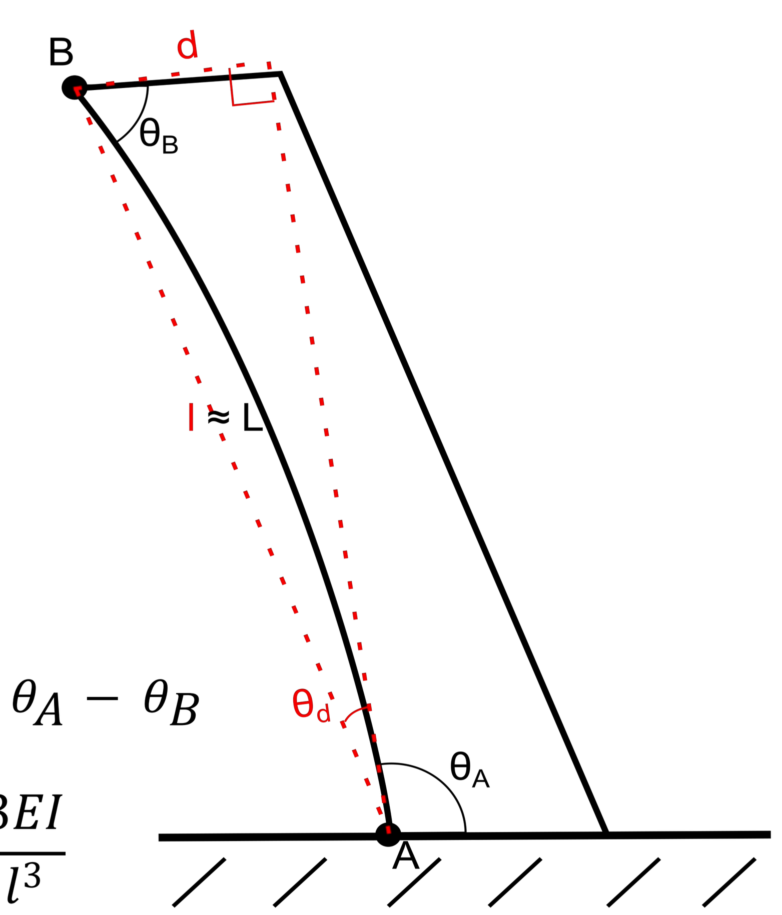
Verifying Spring Constant



$$k_s = .001186\frac{\text{lb}}{\text{deg}} = .0679\frac{\text{lb}}{\text{rad}}$$

$$d \cong \theta_d L \therefore k_s = .2717\frac{\text{lb}}{\text{in}}$$

Deflection Calculation



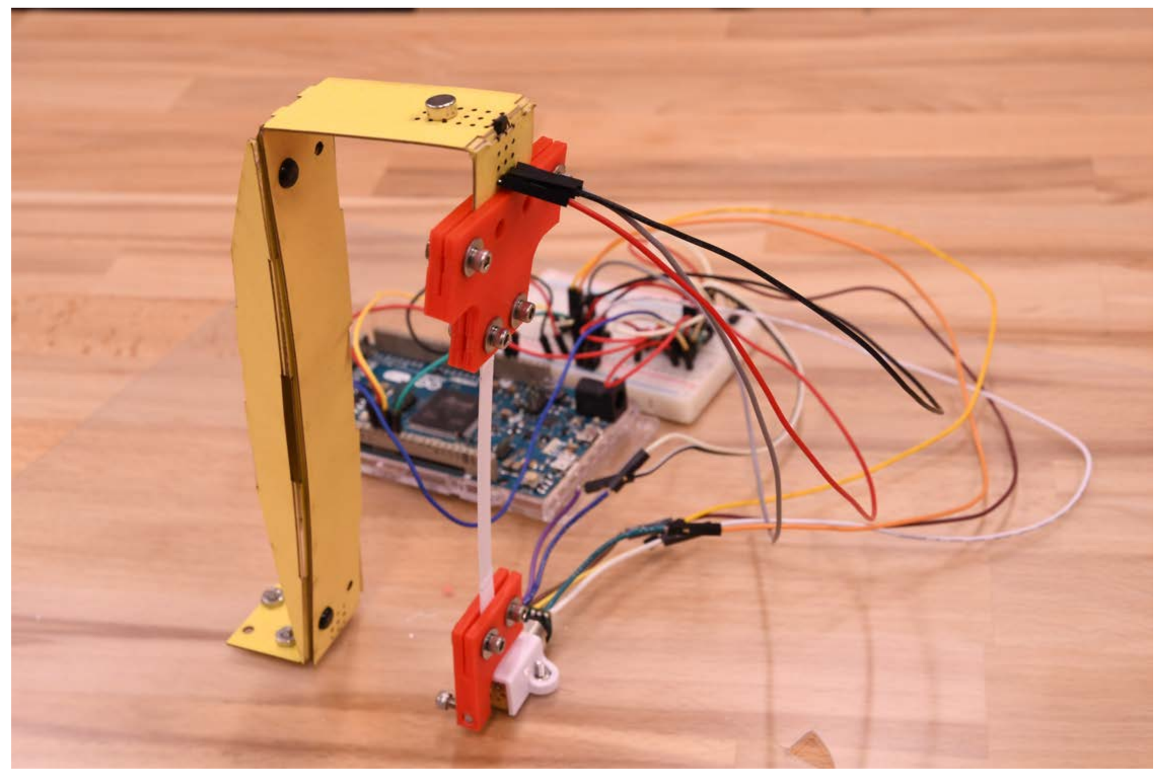
$$\theta_d = 180 - \theta_A - \theta_B$$

$$\frac{F}{d} = \frac{3EI}{l^3}$$

$$\frac{F}{d} = \frac{3(29{,}000{,}000\text{psi})[\frac{1}{12}(0.21\text{in})(0.022\text{in})^3]}{(4\text{in})^3} = .2533\frac{\text{lb}}{\text{in}}$$

$$0.2717\frac{\text{lb}}{\text{in}} \approx 0.2533\frac{\text{lb}}{\text{in}}$$

Fabrication



References

[1] J. Buchli, F. Stulp, E. Theodorou, and S. Schaal, “Learning variable impedance control,” International Journal of Robotics Research, 2011.

[2] A. Ramezani, J. W. Hurst, K. Akbari Hamed, and J. W. Grizzle, “Performance Analysis and Feedback Control of ATRIAS, A Three - Dimensional Bipedal Robot,” J. Dyn. Sys., Meas., Control, vol. 136, no. 2, pp. 021012-021012-12, Dec. 2013.