Design and Control of a Low-Cost Mini Bipedal Robot

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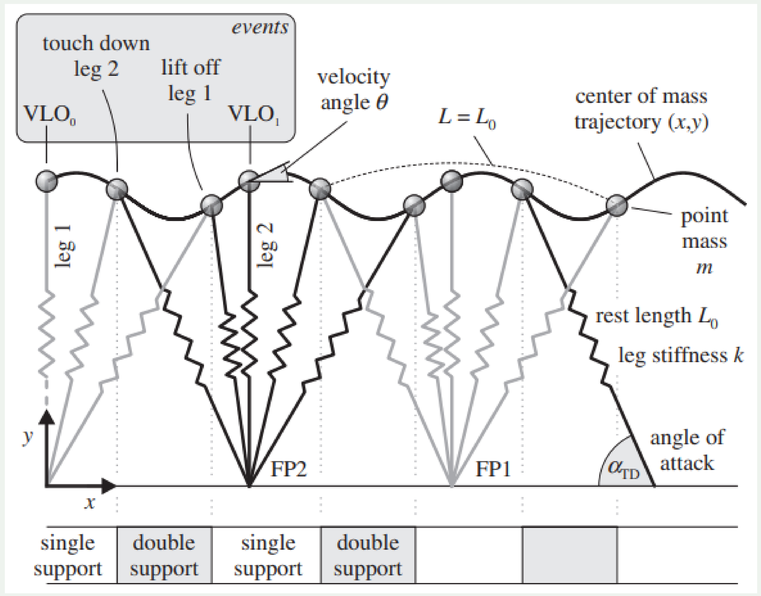
Motivation

A significant barrier in bipedal robot development is reducing cost in hardware. Our robot leverages a compact form factor and affordable materials to minimize price. We aim to make this project open-source, allowing other researchers to freely iterate upon our design and control algorithms.

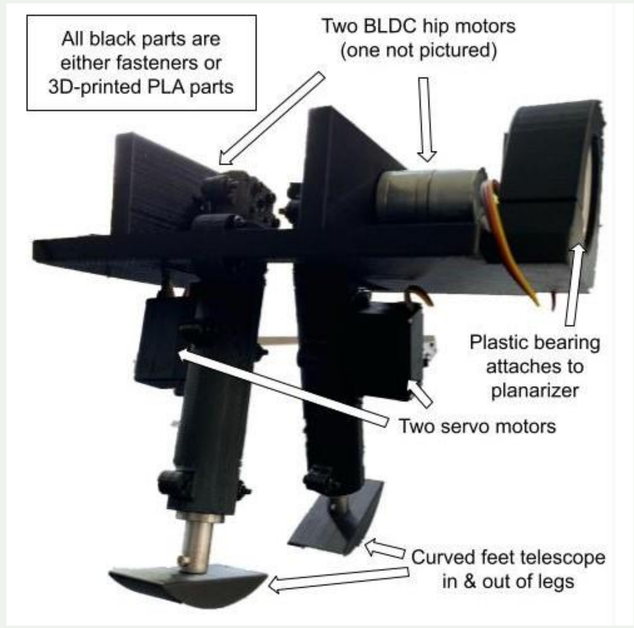
Bipedal SLIP Model

This robot mimics the bipedal SLIP (Spring-Loaded Inverted Pendulum) model seen below. A linear spring is used to model the compression of the foot toward the hip, so our design incorporated a linear spring. The figure below outlines important parameters throughout the single and double support phases.

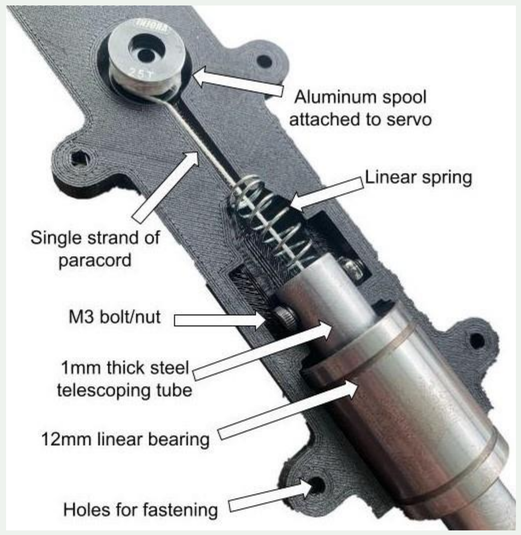


Bipedal SLIP Model in Single and Double Support Phases [1]

Design and Hardware



An isometric view of the first version of the robot. Modular 3-D printed parts are colored black.



A cross-sectional view of the spring mechanism

Control Approaches

Early control algorithms will use PID control on the hip motors to produce a limit cycle walker. Feedback will be applied using motor encoders. Future feedback systems may include a camera-based optical tracking system, radar, or ultrasonic sensors. The robot will walk on a treadmill capable of changing its elevation and adjust gait cycles accordingly.

Future Work

1.) Constrain the motion of the robot to the saggital plane.

2.) Tune PID control algorithms to achieve a stable periodic gait without locally stabilizing the robot's walking trajectory.

3.) Adjust mechanical and controller design to achieve 3-D locomotion.

4.) Update mechanical design to incorporate back-drivable hip motors to incorporate jumping, running, or other motions that require a higher force output.

5.) Publish running open-source documentation including all updates for other researchers to access and iterate upon.

Sources

[1] J Rummel *et al* 2010 *Bioinspir. Biomim.* **5** 046004