

Note: I am a first year PhD student interested in learning more about the field of dynamic walking. I think one of the best ways to gain a better understanding of the field is to go to this conference. My advisor, Andy Ruina, suggested that I submit an abstract for a poster presentation so that I can apply for a travel grant. I am not claiming that this is path breaking research; rather, it is just my entry point for dynamic walking research.

Format: Poster Presentation

Keywords: Bipedal Balance, Controllability, Optimal Control

Title: Trying to accomplish standing balance of a simple bipedal robot with small feet

It seems that the biggest control authority in bipedal walking is foot placement. However, there is some residual balance authority from moving the body parts relative to each other and from ankle torques. To assess the possible utility, or lack thereof, of such distortions for balance of bipedal robots, we will look at a problem where there is no foot placement at all and where the control authority of ankle torques is limited.

The Cornell Ranger is a simple robot that is capable of efficiently walking large distances, and yet it is unable to balance while standing still without splayed legs. Ranger has four legs that are arranged so the robot walks like a person using crutches, and can be modeled using planar dynamics. The bottoms of Ranger's feet are circular with radius much smaller than the center of mass height, rendering it impossible to balance by merely locking ankles in the appropriate orientation. The objective of this research will be to determine the feasibility of balancing Ranger on one pair of legs (inner or outer) by swinging the other pair of legs and by rolling the feet to adjust the contact point.

This problem is very similar to the well studied problem of balancing an acrobot- a double pendulum with a motor located between the two links. Balancing Ranger is more complicated than the acrobot due to the actuator and sensor limitations on Ranger. Ranger has one advantage in that rocking the foot has the potential to provide additional control authority that is unavailable to an acrobot.

I will start this research by using numerical techniques and a high-fidelity model of the robot, including its actuators and sensors, to determine the maximum size of the region in phase space that is controllable to the configuration for stationary upright balance. Assuming that the controllable region is of a sufficient size, I will then see how well standing balance can be achieved on Ranger. If the controllable region is too small to be feasible for control, I plan to study how the various limitations of the hardware affect the size of the controllable region.

For the discussion I intend to focus on the following three questions:

- How does this model compare to a human balancing on the balls of their feet?
- Is this approach to balancing practical for use on this and other robots?
- If successful, could these techniques be extended to control of walking trajectories?