Progress on Controlling MARLO, an ATRIAS-series 3D Underactuated Bipedal Robot

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1 Motivation

MARLO is a highly underactuated 3D bipedal robot with series-compliant actuators, designed to walk on point feet but capable of being fitted with nontrivial feet as well[1]. (See figure 1). During the single support phase, the robot has 13 degrees of freedom (DOF) and 7 degrees of underactuation (DOU), and therefore presents an interesting control challenge. Previous work has established the effectiveness of the Hybrid Zero Dynamics (HZD) approach for controlling planar biped walkers such as MABEL[2], and the current research seeks to extend these results to achieve untethered 3D locomotion for MARLO.

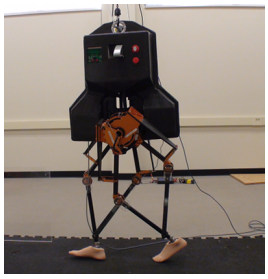
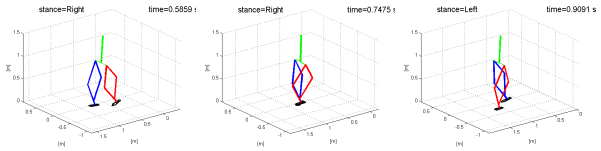


Figure 1: MARLO, a 3D bipedal robot.



(a) (b) (c)

Figure 2: Simulated walking with compliant ground and nontrivial feet.

2 Current work

Initial efforts have focused on finding fixed-point walking gaits through optimization for energy efficiency, testing control methods in simulation, and setting up the experimental testbed for signal acquisition and real-time processing. Multiple control approaches are being tested, including standard HZD controllers as well as one-step event-based control methods that make use of left-right symmetry, LMI's, and robust optimal control to stabilize the periodic walking gaits[3, 4]. These event-based methods may be especially necessary for control of the frontal plane dynamics, which are particularly susceptible to instability. We have developed a simulator which includes a compliant ground model as well as the option to incorporate nontrivial feet, and this provides a method to test candidate controllers in an environment which is reasonably close to the actual experimental environment in the lab. (See figure 2.) We have tested event-based controllers as well as standard (non-event-based) controllers in simulation and achieved stable walking with point feet as well as nontrivial feet. As one important step in going forward, we are also in the process of developing reliable methods for transitioning the robot from a static starting pose into the basin of attraction for a stable walking gait, making use of time-based transient controllers.

3 Future work

The long term goal of the ATRIAS series of robots is to demonstrate an untethered bipedal robot that combines energy efficiency (cost of transport within a factor of 3 of humans) and agility (able to walk over ground presenting 10 to 15 cm of variation step to step and run over smooth ground at a speed of 3 m/s). By the time of the conference, we hope to demonstrate untethered walking over smooth ground.

4 Acknowledgments

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References

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