Toward Reduced-order Modeling Approaches for Rapidly Reactive/Adaptive Locomotion

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I. Background

Reduced order models are an effective way to lower the computational burden of control and planning, enabling real time control. This work explores the methods of employing reduced order models for rapidly reactive "disturbance rejection" and adaptive changes to the environment or model control. We demonstrate these methods on "Cassie" and present preliminary results on a drone simulation. As an example of this method we aim to have "Cassie" dodge moving obstacles ie. balls.

II. Methods

A. Rapid reaction with "Cassie"

Using a "Cassie" series robot developed by Agility Robotics, we developed a force based controller which is able to reject large disturbances while balancing without the use of a dynamic model. The model assumes the legs are massless and only used as means to produce forces at the pelvis. This design results in a controller that is not concerned with maintaining a specific foot placement, allowing it react to sudden changes in the terrain.

B. Rapid Planning with "Quadrotor"

We use MPC for rapid planning by formulating a convex trajectory optimization. Using the dynamic model and physical parameters developed in [1] we linearize the system about the equilibrium point of level hovering. By including a constraint which keeps the drone center away from a moving ball's trajectory, an avoidance maneuver is developed as seen in Fig. (1).

III. Results Discussion

We developed a standing controller for the bipedal robot using a simplified model which resists perturbations and remains stable on changing terrain [2]. Four separate tests were performed to assess the controller including sliding the foot in and out, raising a foot up and down, and standing on a soft surface. The controller was able to reject these disturbances including the most noteworthy box drop test Fig. (1) where the foot dropped a distance of 0.2 meters.

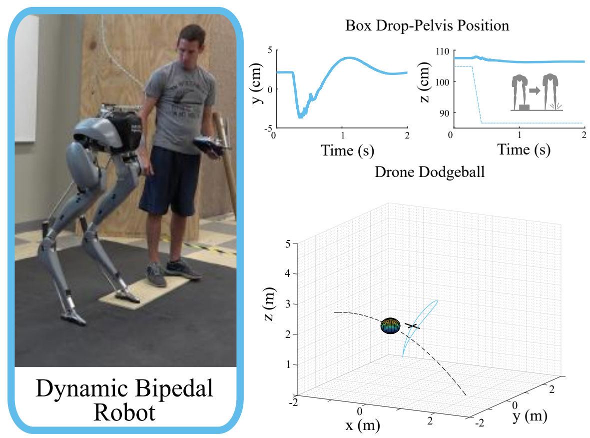

Fig. 1.

Additionally we develop a flight controller for the quadrotor which can fly to way-points and track desired trajectories. Most notably the drone was able to avoid obstacles, including a ball 3 meters away traveling at 7 meters/second.

IV. Conclusion

We were able to develop reduced order models for two separate systems and accurately control them while reducing the computation burden. Future work will combine these methods to allow Cassie to dodge balls and other dynamic obstacles.

V. Acknowledgements

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References

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