Applying Capture Points to the Control of a Dynamic Walking Bipedal Robot

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SUMMARY

We discuss balance, walking, and push recovery control of the Yobotics-IHMC biped. The robot is a twelve degree of freedom lower-body humanoid robot with force controllable Series Elastic Actuators at each degree of freedom. Virtual Model Control is used to control the orientation and height of the robot. Speed is controlled through the center of pressure on the support feet and through foot placement. To determine the most appropriate place to step, we use the concept of Capture Points and Capture Regions. A Capture Point is a point on the ground in which the Center of Pressure can be placed in order to stop a robot. The Capture Region is the set of Capture Points. We use a Linear Inverted Pendulum plus Feet Model for determining the location of the Capture Region. With this model the Capture Point dynamics are linear and first order, allowing for easy determination of where to step.

INTRODUCTION

Dynamic walking or running robots in real world environments will encounter various disturbances, such as pushes and unmodeled uneven terrain. To recover from these disturbances, appropriate Center of Pressure regulation and foot placement is important.

In previous work [3,4] we introduced the concept of Capture Points and Capture Regions to help determine appropriate places to step. Loosely speaking, a Capture Point is a point on the ground that a robot can step to and place its Center of Pressure at in order to stop. A Capture Region is the set of Capture Points. Capture Points are useful for balancing, dynamic walking, disturbance recovery, stability analysis, and path planning.

METHODS

To approximate the location of a Capture Point, we use the Linear Inverted Pendulum Model [1]. With this model the dynamics are linear and second order. If we write the dynamics in terms of the Capture Point location, then they become first order.

The Linear Inverted Pendulum Model assumes a point mass robot walking at a constant height. While this model is a simplification of a real robot, we find that it is adequate for walking and recovering from moderate disturbances.

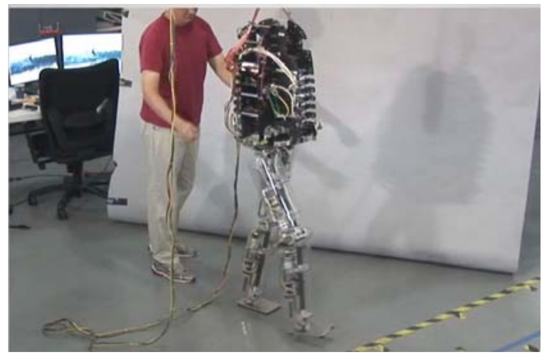

Figure 1: Humanoid Robot recovering from a moderate forward push while standing and balancing on one leg. The robot continuously computes the Capture Region. Once the Capture Region no longer intersects the support foot, the robot determines where to step such that the Capture Region will intersect the support polygon once the step is complete.

RESULTS AND DISCUSSION

To date, the robot can walk at slow speeds and recover from small pushes using the Capture Point based on the Linear Inverted Pendulum Model in order to determine where to step. We are currently extending this technique for larger pushes, uneven terrain, and path planning over complex terrain.

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