University of Stuttgart

Institute for Adaptive Mechanical Systems

Master's thesis
Bachelor's thesis

Simulation and Control of a Constrained-Based Walking Mechanism

Topic Areas:	Nonlinear Dynamics, Control, Simulation
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Prerequisites/Prior Knowledge:	DMS or similar, experience with Matlab

Hybrid Zero Dynamics (HZD) is an established control concept for legged robotic systems that is based on introducing *virtual* holonomic constraints to couple the motion of different limbs [1]. In this project, we seek to understand, how this concept can be extended to systems that include physical constraints. In particular, we will to study a walking mechanism, in which the motion of the left and right leg are coupled through a mechanical linkage at the hip, similar to the legs in the demonstrator shown in Figure 2. This coupled degree of freedom will be actuated by a motor, and developing a stabilizing controller to drive this motor is an integral part of the project.

The long-term target application for this walking mechanism will be an underactuated exoskeleton (or *orthosis*) to aid the mobility of an impaired user.
Your specific tasks will include:

- Developing a suitable 2D simulation model of the walking mechanism
- Identifying and stabilizing periodic motions ("gaits") of this mechanism
- Extending model, simulation, and controller to 3D.

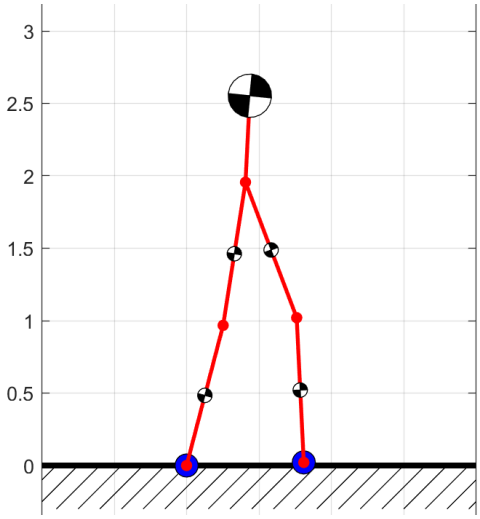

Figure 1: Visualization of a 2D simulation of a HZD-controlled walking robot

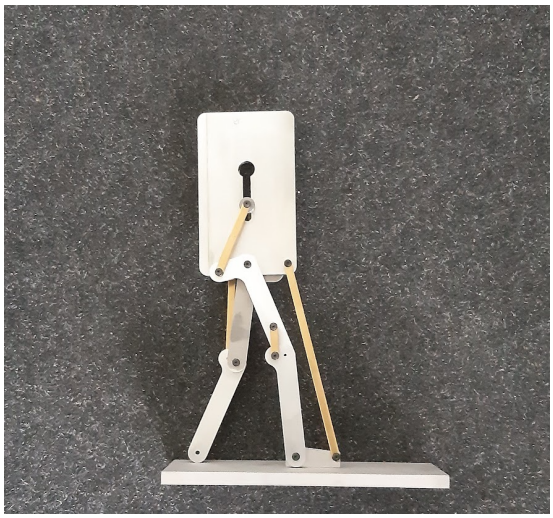

Figure 2: A mechanical demonstration of the concept of HZD

[1] J. W. Grizzle, et.al. *HZD-Based Control of a Five-Link Underactuated 3D Bipedal Robot*, IEEE Conference on Decision and Control, 2008