Control Improvements for Low Impedance Bipedal Walking Robots

Submitted to the 2004 International Control Conference

Prof. Gill A. Pratt
Franklin W. Olin College of Engineering
Needham, MA 02492
gill.pratt@olin.edu

Andreas Hofman
MIT Computer Science and Artificial Intelligence Laboratory
Cambridge, MA 02139

Pace Willisson, Clive Bolton
Software and Hardware Consultants
Franklin W. Olin College of Engineering

Abstract

We have made several improvements in the control of Low Impedance Bipedal Walking Robots. These include:

1) Transformation of the virtual model control approach from one that outputs joint torques to an approach that outputs joint impedances consisting of three parallel Norton components: stiffness, damping, and additive force. This higher level output allows for a multi-rate hierarchical control architecture to be used, with the joint impedance parameters more slowly changing that joint torques and the system more tolerant of high level control latency.

2) Implementation of a joint-level impedance controller for series-elastic actuators that limits the use of joint angle sensor information, instead using information from co-located commutation sensors on the back of the brushless motor and a compression sensor on the series elasticity. This approach is both more robust and less subject to instabilities due to delay and backlash.

3) Transformation of the virtual model control approach from an iterative process considering each virtual component independently to one that considers all components simultaneously, allowing for a variety of constraints and optimizations on the output of the transformation to be applied.

4) The development of constraints and optimizations that restrict operation to desired regimes (e.g. no foot rotation at certain times) and optimal operating points when redundancies exists (e.g. ones that minimize internal forces and overall power consumption when both feet are on the ground). These optimizations run in real time inside the high level control loop.