Template-Based Control of the Bipedal Robot ATRIAS

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Abstract

This thesis details the derivation and application of template-based controls on a bipedal robot, as well as a description of the software framework that enabled experimentation. The software framework uses a combination of open-source tools including ROS, OROCOS, EtherCAT, and Xenomai to create a real-time environment for the controllers. The first controller makes the robot (ATRIAS) walk as if it was the Spring Loaded Inverted Pendulum (SLIP) model. This demonstrates that ATRIAS, which was designed to be as close to the SLIP model as possible, can behave similarly to the reduced-order model. While the first controller is implemented with a torso that is mechanically fixed in place, the second controller handles an unlocked torso, which adds another degree of freedom. This controller is implemented based on a Torso SLIP (TSLIP) reduced-order model. The controller imposes a Virtual Pivot Point (VPP) by redirecting ground reaction forces to a geometrically fixed point with respect to the torso above the center of mass. Using VPP control, ATRIAS is able to take up to 22 steps on its own without using other techniques to keep its torso upright or inject energy, and it is shown that the generated ground reaction forces are similar to those produced by the reduced-order model. These controllers demonstrate that SLIP-like reduced-order control methods can be implemented on ATRIAS, and are a promising avenue for further research.

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