A reflex based controller for walking robots

Matthew P. Kelly, Andy Ruina
Cornell University
mpk72@cornell.edu

February 10, 2013

1 Motivation

For walking robots to be useful in real world applications they will need to become more efficient and robust. Here we present a control architecture that seeks to address both of these concerns.

2 State of the art

Most modern walking robots are either energy efficient or robust, but not both. Robots that are robust tend to have lots of control authority and have tight feedback loops of one kind or another, although it is not clear that either is necessary. More efficient robots tend to have small actuators and loose feedback loops.

3 Own Approach

The Cornell Ranger [1] is an example of a robot with an efficient controller. Here we describe a controller, that produces a significant increase in robustness with little energetic cost.

On each step, the controller for Ranger tries to track an optimal trajectory. It does this by breaking the step into sections, each separated by an event such as heel-strike. Within each section of the trajectory, the motor follows a quasi-open-loop trajectory that is parametrized by the dynamic state of the robot. Much of the stability of this controller comes from the event-driven transitions between controllers (sections of the trajectory). One further stabilizing feature is added to allow the robot to maintain its desired speed: the parameters that control the step length are adjusted on every step based on the error in the robot's speed.

As of now, this speed controller just adjusts one parameter based on one sensor. We propose an extension of this control concept that uses the entire dynamic state of the robot to adjust the trajectory parameters. This would help stabilize the entire state of the robot, rather than just the speed. At the start of each section of the trajectory, the robot checks it's deviation from the desired dynamical state. Based on this deviation, it adjusts all of the trajectory parameters for the next section of the trajectory. We hypothesize that this will increase the robustness of the controller without compromising much of the energy efficiency.

4 Research Plan

- Test the controller in a simulation of the Cornell Ranger.
- Evaluate the efficiency and robustness of the original and extended controller in simulation.
- Implement the extended controller on the Cornell Ranger.
- Demonstrate the robustness of the new controller on the Cornell Ranger.

5 Acknowledgement

Funding for this research is provided by the National Science Foundation and the Cornell University M&AE department.

References

[1] J. Cortell, B. Hendriksen, C. Paul, A. Ruina, P. A. Bhounsule, and J. G. D. Carson. A robot that walked 65 km on a single charge : energy-effective and reliable locomotion using trajectory optimization and stabilization from reflexes . *International Journal of Robotics Research*, pages 1–39, 2012.