Dinosaur Robotics at the Leg Lab M2

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The Problem: To construct a robust walking autonomous prototype of a robotic Troodon (a small bipedal dinosaur), and to explore robotic and biomechanical locomotion.

Motivation: To develop a prototype of a functioning bipedal walking robot that may be viable for museum exhibit use, despite the current lack of this type of technology in the commercial sector. Also, such a robot might offer some insights into the biomechanics of legged locomotion, and be a useful device for testing theories that make predictions about walking dynamics in animals.

Previous Work: There have now been a number of bipedal robots[3, 2, 6], however there have been relatively few bipedal free-standing walkers, and even fewer truly autonomous ones, namely the Honda P3. Also these robots have tended to be “stiff” jointed robots, more like the industrial robots that are used in automotive factories, as opposed to the “soft” joints found in animals.

The Leg Laboratory where this research is ongoing has produced a number of hopping and running robots[6], and more recently a planar walker called Spring Flamingo[4]. These robots tend to be more biologically inspired than their factory counterparts, in that they are meant to exploit the natural dynamics of legged locomotion. In particular, recent work overseen by Leg Lab director Prof. Gill Pratt has led to the development of “series-elastic actuators” that incorporate a physical spring into the robot’s actuators. These actuators are better able to cope with the sudden impacts of legs striking the ground during walking, and are capable generating a wide range of forces.

Work on the robotic dinosaur project, called “Troody”, has been ongoing for about four and half years. The robot is currently able stand up from a sitting position, transition to a stable one legged balance pose on either leg, and can walk forward slowly. Until this year, the robot project has been primarily in a hardware prototype/de-bug phase, however the hardware is now considered stable and research is now focused on control of the robot.

Approach: I am currently attempting to develop a walking control strategy that uses dynamic center of mass control, in a coordinate system that rotates about the Z-axis (the vertical axis) as one foot moves in front or behind the other, and that corresponds to the familiar X and Y-axis when the feet of the robot are next to each other. We have termed this “PQ-control”. The Q-axis runs from one foot across to the other, and the P-axis is perpendicular to Q. The main idea behind this control strategy is attempt to simplify the coupling that normally occurs between X and Y-axis dynamics during stepping. Instead of trying to control the robots dynamics in X and Y separately, the PQ-controller controls the dynamics along an axis that corresponds to the direction in which the robot will tend to fall, namely the line running from the back foot to the front foot during a step. Another possible advantage of this controller is it’s robustness to a wide range of foot placement positions, since the coordinate system that the robot is using to maintain stability will rotate and thus “adapt” with a change in foot spacing in X and Y.

Difficulty: The design of an autonomous bipedal robot is fraught with difficulties, most centered around the fact that a bipedal robot, as opposed to a robot with more legs, is more unstable, even when moving very slowly. This means that both the hardware and control system must be able to react quickly and smoothly to maintain stability. Also, our current state of knowledge about how control walking robots is limited to a few examples most of which tend to rely on “playback” of human walking data, or other pre-determined trajectory control. My work is an attempt to have the robot be more flexible than a playback style walker, and thus be better able to cope with environmental disturbances.

Future Work: Once faster walking has been achieved, I intend to work with the museum industry to bring a number of extinct creatures back to life in the form of robots, both bipedal and quadrupedal, and to further develop the control system to increase robustness and range of activities that the robot can do.

References:


