A Cockroach Inspired Robot With Artificial Muscles

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1. Introduction

Biology provides a wealth of inspiration for robot design. There are millions of species of animals that have evolved efficient solutions to locomotion and locomotion control. Insects in particular are well known not only for their speed and agility but also for their ability to traverse some of the most difficult terrains imaginable; insects can be found navigating rocky ground, walking upside down, climbing vertical surfaces, or even walking on water. Furthermore, insects almost instantly respond to injury or removal of legs by altering stance and stepping pattern to maintain efficient locomotion with a reduced number of legs [1]. Given the ultimate goal of autonomy, this ability to reconfigure locomotion strategies will be crucial to the robustness of autonomous robots [2].

2. Actuator Selection

The selection of actuators plays a pivotal role in any mobile robot design, as the shape, size, weight and strength of an actuator must all be taken into account, and the power source of the actuators often provides the greatest constraint on a robot's potential abilities. Biological organisms have a great advantage over mechanical systems in that muscle, nature's actuator of choice, has a favorable force-to-weight ratio and requires low levels of activation energy. Their tunable passive stiffness properties are also well suited for energy efficient legged locomotion. The most frequently used actuators, electric motors and pneumatic/hydraulic cylinders, are far from equivalent to their biological counterparts. In contrast, braided pneumatic actuators (BPAs) provide a number of advantages over conventional actuation devices, and share some important characteristics with biological muscle [3].

3. CWRU Robot V

Case Western Reserve University's most recent robot, Robot V (Figure 1) like its predecessors Robot IV and Robot III is based on the death head cockroach *Blaberus discoidalis*. Robot V has 24 independent degrees of freedom, each actuated by a pair of opposing BPA's. Using a feed forward controller, the robot can produce reasonable forward locomotion. Although this is by no means the robust, agile walking that is the ultimate goal of this project, it is a clear demonstration of not only the robot's capabilities, but also the advantages offered by the BPA's. The ability to move using only an open loop controller is in large part a result of the passive properties of the actuators, which provide compensation for any instabilities in the controller itself and immediate response to perturbations without the need for controller intervention. This same process occurs in biological muscle, which responds nearly instantaneously to perturbation, but only slowly to neurological input [4]. With the addition of a biologically inspired closed loop controller in the future, Ajax is expected to display robust, insect-like locomotion.

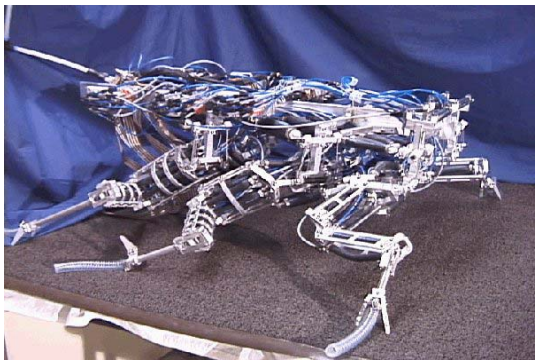

Figure 1: Robot V standing.

4. References

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