ARMY RESEARCH LABORATORY

The VTD Bugbot – Version 1 Summary

by Justin Shumaker

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Presented is an overview of the work accomplished toward the development of a fully autonomous mesoscale hexapod robotic system. A circuit board and mobility system were developed in-house during the summer of 2008 to serve as the first generation of this platform. Much of the attention for this project has been focused on designing the system to be lightweight, small, and computationally capable of autonomous behavior using state-of-the-art embedded electronics components.

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1. Overview

The Vehicle Technology Directorate (VTD) Bugbot is an in-house mesoscale autonomous hexapod robot that was originally based on the HEXBUG,* a robotic toy manufactured by Innovation First, Inc. This six-legged robotic bug crawls and avoids obstacles with touch sensors and can be controlled by its acoustic sensor using sudden loud noise. The objective of this project was to enhance the capabilities of the HEXBUG platform by making radical changes to the mechanical and electrical components, thus transforming the HEXBUG into the VTD Bugbot.

The stock HEXBUG platform comes with a single motor and gear train that provides forward movement and reverse movement in a counterclockwise path. The drivetrain was augmented with an additional motor and gear train by Raymond Von Wahlde (U.S. Army Research Laboratory, VTD) to provide independent control of each group of legs on either side of the Bugbot. The second motor and gears were obtained from a second HEXBUG. This enhancement allowed the Bugbot to turn both left and right, as well as move forward and backward. It was later realized that by decoupling the leg phases, which are normally 180° out of phase, the tripod locomotion phase constraint no longer existed. This resulted in erratic behavior from the mobility system. The HEXBUG chassis required a drivetrain holder that was designed with a computer numerically controlled milling machine.

The Bugbot utilized an entirely new circuit board to provide autonomy by a programmable 32-bit ARM7 microcontroller and a miniature complementary metal oxide semiconductor camera. The Bugbot also had a communications system consisting of a 1-mW Maxstream Zigbee module. The microcontroller provided the computational power necessary to process 128- × 96-pixel grayscale images for object recognition and optical flow algorithms. The communications module provided the Bugbot platform with the capability to communicate with a ground station or with other Bugbots. A ground station consisting of a GTK graphical user interface was developed to control the Bugbots and receive video. The camera, microphone, and communications modules provided the foundation for developing swarming behaviors on these platforms.

The Bugbots were constructed with the aid of several students during the summer of 2008. Test programs were developed and executed on each platform to test mobility, image capture, and communications. During a Micro Autonomous Science Technology meeting in August 2008, it was realized that if the electronics control system were miniatured by a factor of 2, it would become applicable to a host of even smaller robotic systems, both ground and air. Work is currently being done to miniaturize this system with a target mass of under 5 g. Collaboration

*HEXBUG is a trademark of Innovation First, Inc., Greenville, TX.

with Vijay Kumar (University of Pennsylvania) and Ron Fearing (University of California Berkeley) will provide the VTD Bugbot with a smaller mobility package and mature navigation algorithms necessary for a robust autonomous microrobotic system. Future versions will focus on reducing mass, improving mobility, and improving computational capability without increasing energy consumption.

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