**Robotic Testing Platform for Variable Centralization Controllers**

**Proposal by William Xing Xia**

**In Collaboration with Natalie Murray**

**Overview**

To what degree does the brain actually control the body? The answer may seem simple, but it turns out that the body is capable of acting independent of the brain; reflexes, for example, are activated before the brain can register the event occurring. Reflexes are a category of decentralized control, which is type of operating schema that allows individual components to act according to local variables. Centralized control, on the other hand, is a type of operating schema that operates individual components through a central command unit. An operating spectrum between the two control architectures is often-times difficult to pinpoint because local perturbations can be mistaken for actual signals sent from a centralized unit; thus the need for a flexible testing platform arises. The platform will not only provide full control over all signals sent to components, but it will also provide greater flexibility in range of movement. I will be working with Natalie Murray on running experiments with the robotic device. She will perform experiments while I manage the robot by writing the necessary code and adjusting it when necessary.

**Background and Related Work**

Harmonic coupling exists in systems which exhibit some sort of phase dependence. These systems can work either as a central controller or a decentralized controller because the individual components can be coupled based on commands from a central unit or in response to local variables. For example, a six-legged insect exhibits the classic tripod gait, which involves three legs oscillating along with three other legs to produce movement. If, however, one leg becomes perturbed due to environmental disturbances, does all the insect’s legs compensate for the disturbance or does the leg itself compensate on its own? The testing platform will be able to answer these types of questions by varying its degree of correlation between local and global variables.

The X-RHex, which is a hexapod robot, will be the inspiration for this project. There have been multiple different iterations, but the general chassis and framework are similar; therefore, the platform provides us with a valuable tool to construct the robotic device, instead of starting from almost nothing. The modular nature of the device also is advantageous because components can be switched in and out in accordance with design considerations.

**Progress to Date**

This past semester, I have already worked with a crucial component of the robot, the Inertial Measurement Unit, or IMU. Using the Raspberry Pi, I interfaced with the MPU-6050, which measures acceleration and angular velocity, to obtain data directly from the movements generated by a *Blaberus*. I studied the physics of how the insect moves, and developed an understanding of how the kinematics of the insect affect the global variables that the robotic testing platform will eventually manipulate.

To satisfy the stringent weight requirements of the sensor, I also designed a Printed Circuit Board, or PCB, to mount directly on the *Blaberus*. The PCB is designed to weigh as little as possible and is much smaller in comparison to the insect so as to minimize interference of movement. I gained experience in fabricating and designing circuitry, a skill which will prove useful in constructing the robot, which will undoubtedly have many components arranged in a tight configuration.

**Purpose**

The robot will allow more detailed test to be conducted, such as examining how perturbations can affect the overall response of the robotic system, since parts of the robot’s functionality may be changed at will. This flexibility allows the robot to have coupled and independent motor functionality at the same time, giving rise to a mix of centralized and decentralized behavior. Local variables such as motor speed can be tuned to respond to strictly local or global input.

The ultimate goal of this device is to help answer biological questions using biologically inspired machines. To that objective, one of the main questions that we will attempt to answer is how the physiology of the robot affects how it responds to information. For example, *Blaberus’* anatomy has been shown to play a major role in how it navigates its environment (Li, et. al, 2015). Altering the anatomy of a testing platform by placing different shapes on the shell would allow the same control architecture to respond to different configuration schemas.

Being able to vary the control schemas governing the operation of the robot will be one of the main benefits of this project. Multiple different control hypotheses may be tested and examined, and biologically accurate control architectures may be determined from comparing data from the robot to a living *Blaberus*. This device should allow biologists, physicists, and engineers alike to gain insightful knowledge on how centralization can be altered to create interesting new configurations.

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