Report

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Collision avoidance using a model of the locust LGMD neuron

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Introduction
The visual systems of insects perform complex processing using remarkably compact neural circuitry.

1. Many large motion-sensitive neurons have been identified in different species of insect, but their input circuitry is often poorly understood.
2. Modeling these neurons helps us to investigate hypotheses on this circuitry and its function.
3. By implementing these models on robots, we can investigate their responses in the real world.

Project goals
Our study of insect vision has three main aims:
1. To develop models of independent pathways of processing that respond to different visual features.
2. To investigate how information from several pathways can be integrated to produce behavior.
3. To produce artificial decision systems capable of planning through the visual world.

The locust LGMD neuron
1. The lobula giant movement detector (LGMD) is a large neuron in the locust's brain.
2. Over the past forty years, research has been conducted to investigate the LGMD's responses to motion.
3. Approaching objects produce the strongest responses from the LGMD, suggesting a role in detecting potential collisions.
4. The neural circuit which produces these responses has not yet been identified fully.

Model circuit
Using LGMD, we have designed a model of the LGMD.

1. This circuit was connected to a wide-angle monochrome camera mounted onto the mobile robot Khepera.
2. The neural circuit consists of 700 neurons and 24,000 synapses and runs in real-time.
3. The simulation was run on two Pentium II Linux PCs and comprised three interconnected processes.

Responses of the model
1. The monochrome image derived from the camera sets the membrane potentials of the 400 model photoreceptors.
2. Using a combination of linear-threshold and integrate-and-fire cells, the moving edges within the scene are extracted.
3. Approaching objects are detected by a combination of rapid direct excitation and delayed lateral inhibition.
4. The spikes of the LGMD neuron generate avoidance reflexes in the robot.

Tracking LGMD responses
We evaluated the properties of the LGMD model by investigating its behavioral implications for the robot.

1. We used a wide-angle monochrome camera mounted onto the mobile robot Khepera.
2. Simultaneously, we sampled the responses of the LGMD neuron and the positions visited by the robot.
3. This allowed us to determine which avoidance actions of the robot were triggered by the LGMD.

Conclusions
Our preliminary results show that a model which accurately reflects basic properties of the LGMD neuron and its different circuitry produces robust visually-guided avoidance behavior on a mobile robot.

1. In subsequent work, we will investigate more closely the detailed response properties of this model and its ability to respond to more natural environments.
2. We will also extend our study of insect vision to explore other motion-detecting pathways using our neuromorphic robotics approach.

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