Collision avoidance using a model of the locust LGMD neuron

Author(s):
Blanchard, Mark; Verschure, Paul F.M.J.

Publication Date:
2001

Permanent Link:
https://doi.org/10.3929/ethz-a-004266422

Rights / License:
In Copyright - Non-Commercial Use Permitted
Collision avoidance using a model of the locust LGMD neuron

Mark Blanchard, Paul F.M.J. Verschure
Laboratory of Neuromorphic Robotics and Synthetic Epistemology (LNRSE)
Institute of Neuroinformatics, University/ETH Zürich, Winterthurerstrasse 190, CH-8057 Zürich
www.ini.unizh.ch

Introduction
The visual systems of insects perform complex processing using remarkably compact neural circuitry. Many large motion-sensitive neurons have been identified in different species of insect but their input circuitry is often poorly understood. Modelling studies can help to investigate hypotheses on this circuitry and its function. By implementing these models on robots we can investigate their responses in the real world.

Model circuit
Using LGMD we have designed a model of the input circuitry to the LGMD. This circuit was connected to a wide-angle monochrome camera mounted onto the mobile robot Khepera. The overall circuit consisted of 7000 neurons and 24,000 synapses and ran in real-time. The simulation ran on two Pentium II Linux PCs and comprised three interconnected processes.

Project goals
Our study of insect vision has three main aims:
1. to develop models of independent pathways of processing which respond to different visual features;
2. to investigate how the information from several pathways can be integrated to produce behaviors;
3. to produce artificial decisions capable of navigating through the real world using insects.
We are using the LGMD system of the locust as one of our starting points.

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

Responses of the model
The monochrome image derived from the camera sets the membrane potential of the 400 model photoreceptors. Using a combination of linear-threshold and integrate-and-fire cells, the moving edges within the scene are extracted. Approaching objects are detected by a combination of rapid direct excitation and delayed lateral inhibition. The spike rate of the LGMD cell triggers an avoidance reflex in the robot.

Tracking LGMD responses
We evaluated the properties of the LGMD model by investigating its behavioral implications for the robot. The robot explored a marked space (dot-world) whilst the walls were covered with high-contrast circles. Simultaneously we sampled the responses of the LGMD neuron and the positions visited by the robot. This allows 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 efficient circuitry produces robust visually-guided avoidance behaviors on a mobile robot. In subsequent work we will investigate more closely the detailed response properties of this model and its ability to respond in more natural environments. We will also extend our study of insect vision to explore other motion-detecting pathways using our neuromorphic robotics approach.

The authors acknowledge the contributions of Dr. F. Claire Rind, Newcastle University, UK, for providing the biological background of the present model, and J. Förg Conradt, TU Berlin, Germany for building zoala, shown in panel 2.