

Collision avoidance using a model of the locust LGMD neuron

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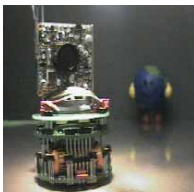


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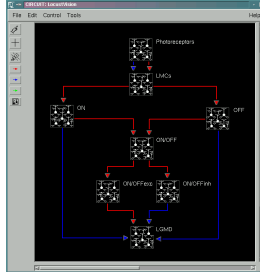
Introduction 1

- 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 us 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 4

- Using IQR421 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 simulation 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.

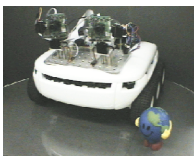


Tracking LGMD responses 7

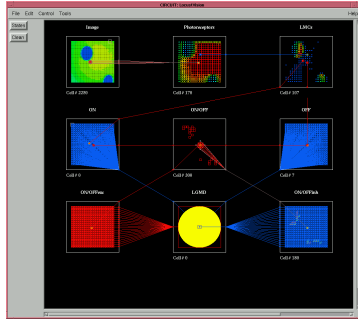
- We evaluated the properties of the LGMD model by investigating its behavioural implications for the robot.
- The robot explored a secluded space (dot-world) where the walls were covered with high-contrast circles.
- Simultaneously we sampled the responses of the LGMD neuron and the positions visited by the robot.
- This allows us to determine which avoidance actions of the robot were triggered by the LGMD cell.
- This behaviour was evaluated in a trial which lasted for 10000 time steps, corresponding to approximately 11 minutes of actual time.
- An estimated 80% of avoidance responses were due to activity in the LGMD.

Project goals 2

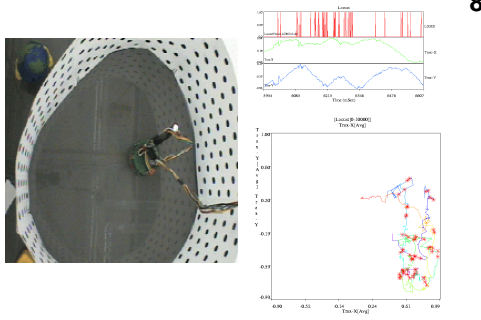
- Our study of insect vision has three main aims:
 - to develop models of independent pathways of processing which respond to different visual features.
 - to investigate how the information from several pathways can be integrated to produce behaviour.
 - to produce artificial devices capable of navigating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



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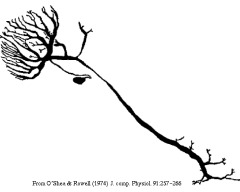


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The locust LGMD neuron 3

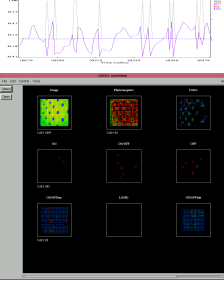
- The lobula giant movement detector (LGMD) is a large neuron in the optic lobe of the locust.
- Over the past forty years extensive research has been conducted to investigate the LGMD's responses and function.
- Approaching objects produce the strongest responses from the LGMD suggesting a role in detecting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



From O'Shea & Rind (1971) J. comp. Physiol. 91:237-268

Responses of the model 6

- 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.



Conclusions 9

- Our preliminary results show that a model which is accurately reflecting basic properties of the LGMD neuron and its afferent circuitry produces robust visually-guided avoidance behaviour 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.

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