Architectural Studies for Visual Processing

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Abstract

This thesis explores the issue of copying natural vision processes with a view to providing sensing information in real-time to the lowest control levels of an autonomous vehicle. The approach is first presented within the general context of cognition, and it is argued that the interpretation of sensory data should result in a level of perception which is tailored to the requirements of the control system.

The argument is supported by electrophysiological evidence suggesting that some species rely primarily on motion information in order to navigate and to avoid obstacles. In particular, the motion detection and motor control mechanisms of insects appear to be closely linked, thus implying that their responses to stimuli may be induced from a low level of perception. Hence, by utilising some of the underlying features of the insect visual system, the computational costs associated with some conventional visual processing methods may be bypassed in an innovative way.

In an attempt to assess the validity of the argument, it is proposed to build a concept demonstrator on a single VLSI chip, by exploiting analog and digital design techniques. The chip implements a model which consists of interpreting local changes in contrast in order to infer directional motion information. Moreover, the information is conveyed in a readily usable format, and new algorithms to estimate the relative velocities of moving objects are presented. Results obtained by testing the chip in real-time indicate that the directions of moving stimuli are correctly perceived and are consistent with their velocities. However, some aspects of the implementation should be improved upon to make the chip suitable to a wider range of applications.

The results indicate that directional and velocity data may be further interpreted in order to estimate the range of objects in the visual field, and to provide a collision avoidance mechanism. Finally, the interactions between sensing and control are discussed, with a view to enhancing sensory information through adaptive behaviour.