

Compact Internal Representation - A Mathematical Model of *Drosophila*'s Prediction Capabilities in Flight Control

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Easily one can imagine, how difficult it must be for a flying fly to navigate in an environment rich of moving objects. How to avoid collisions and make a soft landing, when for instance seesawing plants provide ample distraction? Flies have to rely on their sensory systems to survive, but the information they perceive is rich and complex. Remarkably, flies show prediction capabilities, when their environment changes in a regular manner with time.

The aim of this project is to investigate, how flies perform the processing of systematically time-dependent sensory information, and to find brain areas involved in the high-level processing of such information. We try to understand this information processing by starting from the mathematical concept of Compact Internal Representation (CIR).

CIR is based on two preconditions: First, the agent is able to predict the future progression of its environment and second, the agent will understand the influence of its own movements on the predicted environmental progression. With the same visual input, the behaviour of flies at a flight simulator will be compared to the predictions of the CIR model.

For this purpose we are monitoring the flies' responses to moving landmarks during stationary flight in a flight-simulator (wingbeat-processor, Götz 1968), where the differences in stroke amplitudes of the right (R) and left wing (L) are used as a measure for intended changes in flight direction. The wingbeat analyser captures the shadows of the wings during stationary flight casted by infrared diodes. The flies are surrounded by a cylindrical arena consisting of optical fibres, which display a 280° panorama from a flat computer screen.

Wild-type flies can follow precisely a moving landmark, even when this landmark disappears spontaneously behind a screen up to 40° width. But how can one distinguish between a passive continuation of the current flight direction and true prediction behaviour? In experiments, during which a continuously rotating landmark was shown to the flies for 10 full rotations before a screen appeared, the flies did not follow the hidden landmark in this first instance after training. This outcome points to prediction rather than passive continuation. Furthermore, flies which have lost their mushroom bodies due to chemical ablation do show passive continuation of their flight direction. They have problems to change their flight direction in an adaptive manner. Earlier experiments had shown, that the ellipsoid body and the protocerebral bridge are involved in various aspects of flight control (Ilius et al. 1994; Strauss et al. 1992), like anticipation behaviour in landmark fixation, and the time to optomotor reversal in a striped drum, which regularly switched the direction of rotation. The CIR-Model should help to understand the high-level processing of sensory information in the fly brain.

This work is kindly supported by the EU project EMICAB (FP7-ICT, No.270182) "Embodied Motion Intelligence for Cognitive, Autonomous Robots". For more information visit <http://www.emicab.eu>

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