Sense Organs

Interfaces between Environment and Behaviour

Sinnesorgane
Zwischen Umwelt und Verhalten

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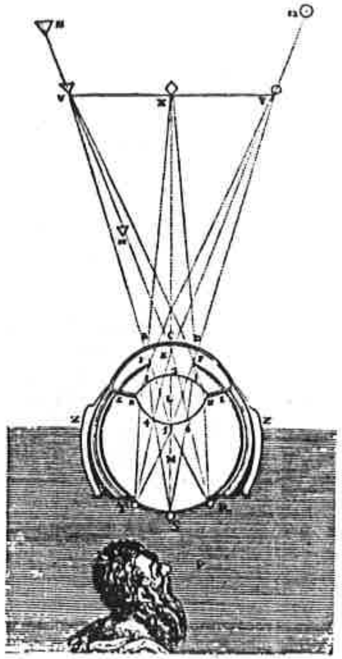

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A LEAKY INTEGRATOR FOR THE PROCESSING OF VISUAL MOTION IN THE FLY'S LANDING SYSTEM

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Velocity-distance control and the detection of obstacles are common visual information processing problems in biological and technical systems (e.g. plunge-dives of sea birds, emergency-braking in human car drivers, computer vision). In order to initiate the appropriate response in time the information about an impending collision has to be extracted from the retinal velocity field. This problem has been investigated using the landing response of houseflies as an experimental paradigm.

When approaching a potential landing site flies reduce their speed and extend their legs to prevent crash-landing. In the present study, the approach towards the landing site was mimicked in tethered flying animals by vertical gratings moving from the front to the back on a screen on either side of the animal. The response was detected by a light barrier which became interrupted whenever the fly lifted its forelegs. The latency of the response was found to decrease with increasing pattern velocity. Since the fly's movement detectors deliver, in a first approximation, a velocity-proportional signal, their output can not be used directly as a trigger signal for landing. Instead, one has to postulate temporal integration of the movement detector output signal before it triggers landing (Borst and Bahde 1986, Biol Cybern 55: 59-69). To avoid long-term accumulation of insignificant movement signals, however, the integrator should be leaky to some extent. This hypothesis was tested by the following experiment.

First, the latency in response to a grating drifting with a contineous velocity was determined. Subsequently, the contineous movement stimulus S_2 was preceded by a brief movement stimulus S_1 using variable time-intervals between S_1 and S_2. Stimulus S_1 was too short to elicit the response by itself. However, due to temporal integration of movement information, S_1 should contribute to the integrated signal thus shortening the time to threshold or the latency in response to S_2. This latency was measured for inter-stimulus intervals ranging from 20 ms to 1 second. Expectedly, the influence of S_1 on S_2 was found to decrease with increasing inter-stimulus interval. This directly demonstrates the leakiness of the temporal integrator. Significant interaction between S_1 and S_2 could still be measured for inter-stimulus intervals of up to 1 second suggesting that the time-constant of the leaky integrator must be in the range of several hundred milliseconds.

The model derived from behavioral experiments on the landing response of the fly might be a general principle of visual motion information processing: similar mechanisms have been postulated e.g. to account for the release of saccadic eye-movements of monkeys (Miles and Kuwano, J Neurophysiol 56: 1321-1354).