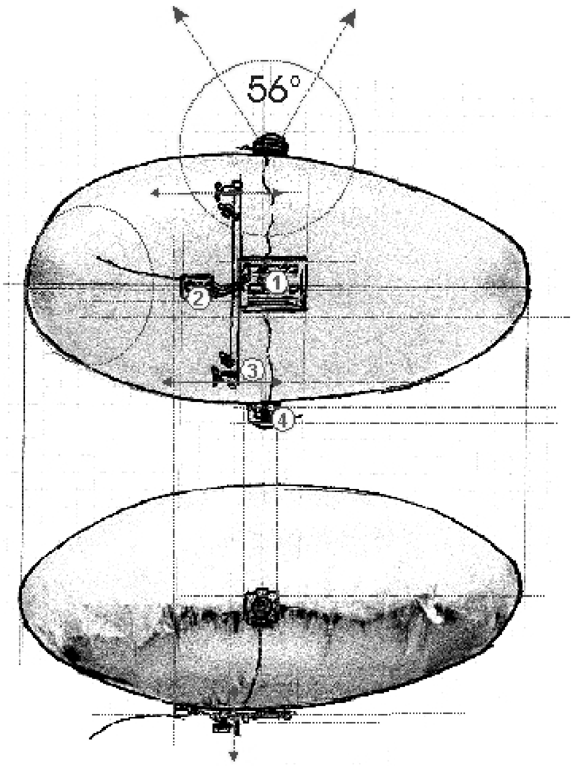
Introduction



❶ Steering unit ❷ Transmitter and receiver ❸ Engines ❹ 5Volt, 56° cameras

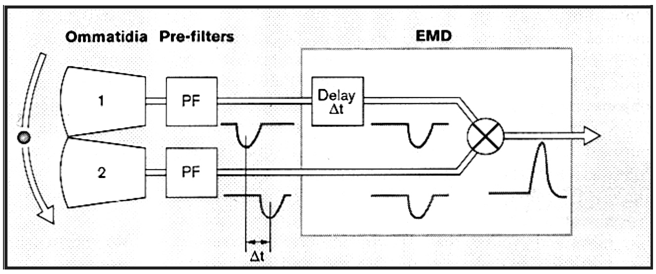
This project is about a partial simulation of the fly's visual navigation. Goal is to implement an algorithm that corrects course deviations using only the information gained through two cameras. We chose a blimp as carrier system, since it moves slowly and has a stable flight. Obviously, the blimp's flight behaviour differs from that of the fly, but there is still enough similarity to gain an insight and a training base for further experimental evaluations.

Description of the flying robot:
Length: 122 cm
Max. Payload: ~120 g
Sensors: two cameras, 56°-view

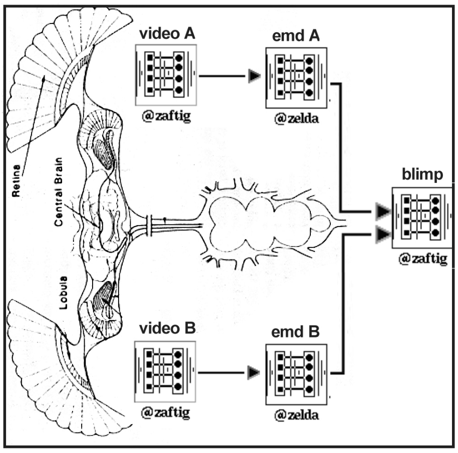
The two cameras A and B, mounted on each side, capture pictures of 10 x 10 Pixels. With both their 56°-views they cover roughly a third of the environment, which is far less than a real fly. But again, it is enough to test the principles. The pictures from the cameras are then transmitted via a wireless connection to a computer where the actual simulation runs. The neural network is simulated in the program IQR421, as explained below. After processing the data, IQR generates motor commands that are sent back to the blimp and executed.

The IQR421-based Simulation

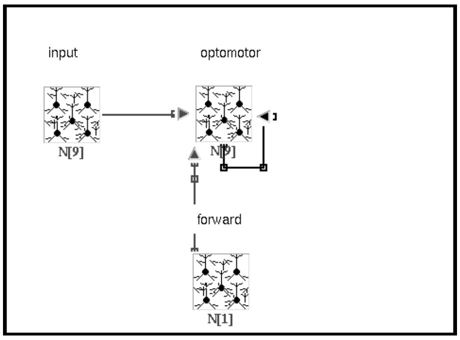
The fly relies on motion detection to correct a deviation from the preset path of flight, in our case a straight line. The Reichardt Correlators combine the optical flow recorded during flight to recognize a right or left rotation.
Principle of a Reichardt Correlator:



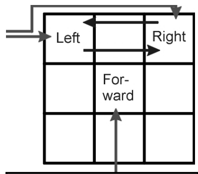
The basic unit of a Reichardt correlator receives inputs from two adjacent ommatidia in the compound eye. The correlator delays the signal from ommatidium 1 and multiples it by the signal from ommatidium 2 to produce a positive output in response to image movement from 1 to 2. This is illustrated with the signals produced by the image of a small dark target, moving from 1 to 2 in time Δt. For simplicity, Δt happens to equal the delay introduced by the correlator. Thus, the delay brings two signals into register and, when multiplied together, a large positive output is produced. The pre –filters (PFs) set the signal to a baseline of zero. Note that the correlator responds only to local motion from 1 to 2.



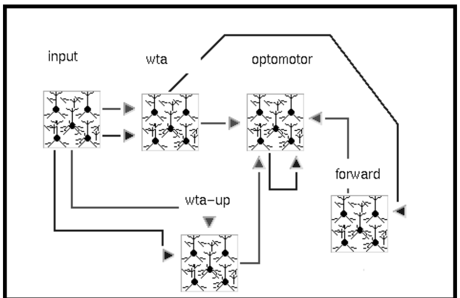
As shown in the figure to the left, video A and video B represent the system's eyes (retinae). The elementary motion detectors (emds) containing the Reichardt Correlators, would then be located in the lobula area. The images gained by the two cameras are processed in an edge enhancement filter, to gain more contrast, and it therefore becomes easier to detect motion. Both emds project into the blimp unit, where the values for navigation correction are computed. These values are the basis to compute the motor commands. The blimp unit unifies the brain structures in the central brain, responsible for generating the wing motion commands. Function and mode of operation of this last piece is not documented very well in the fly. So different models try to deal with the sensitive generation of motor commands.



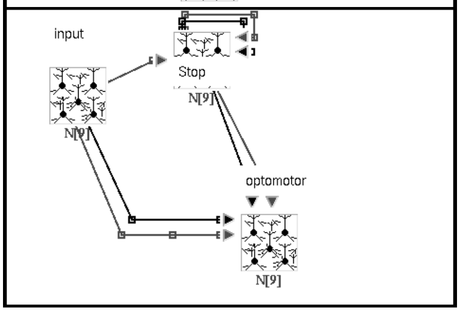
Module 1:
The input from the emds goes straight to the optomotor unit, which acts as a winner–take-all. That means left and right motion inhibit each other, so that only the stronger potential is taken into account. A forward unit provides the basic forward thrust. The cell potentials are translated into motor commands before they are transmitted to the blimp.



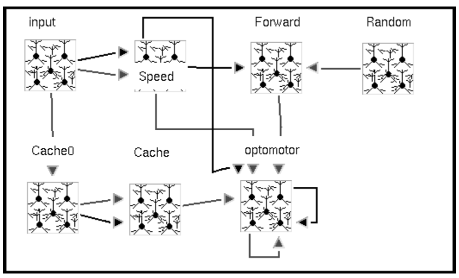
Inside the optomotor



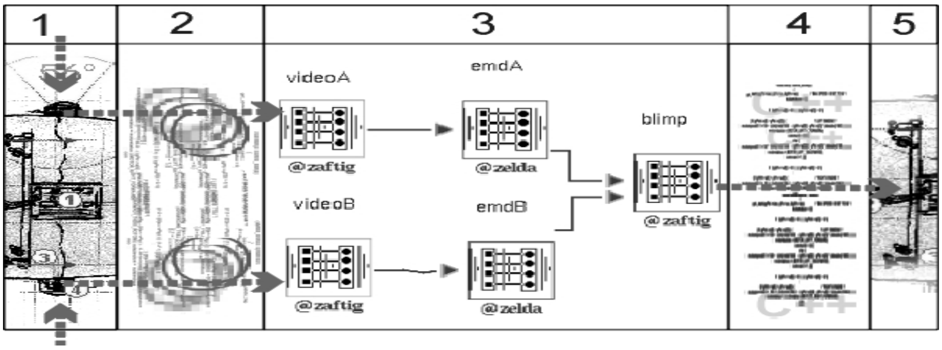
Module 2:
The winner-take-all (wta) is a separate cell component. Additionally, up and down motion detection has been implemented. Forward motion is inhibited by the wta cell, thus avoiding forward thrust when deviating from course.



Module 3:
The winner-take-all structure is returned into the optomotor unit. The stop unit keeps the blimp at optimal speed, avoiding erratic flight behaviour due to too high speed.



Module 4:
This final module is a combination of several parts from the proceeding ones. The cache unit was included to synchronize the time steps, so that all signals reach the optomotor simultaneously. The speed unit calculates forward speed by comparing the motion from the two cameras. It then shifts the weights in the optomotor to gain a more stable flight.



❶ Video cameras A & B ❷.Edge enhancement filter ❸ IQR421 ❹ Motor command assembling ❺ Blimp engines

Goal of this Project

The goal of this project is to evaluate if a navigation system based only on the Reichardt detectors, is accurate enough to steer a flying robot, i.e. stabilizing the blimp during straightforward flight.

Status of the Project

The blimp was reanimated and minimally redesigned. It now can fly in a straight line and correct deviations from its course. Additionally, a module to detect the line of horizon helps to keep the blimp's altitude.

Known Problems and Limitations

The blimp's aerodynamics is really poor at slightly increased forward thrust, limiting forward motion to slow speed. Airflows in the room were measured and roughly eliminated by shutting off the vent and closing the doors. Since a battery pack is too much of a cargo, a thin cable powers the blimp. This connection influences the flight, especially up and down motion. By now, the best way to minimize this influence is to manually carry the cable after the blimp. The weight of the steering and transmission unit forced us to the relatively big size of the blimp.

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