

# Insect-based gaze control system and heading stabilization

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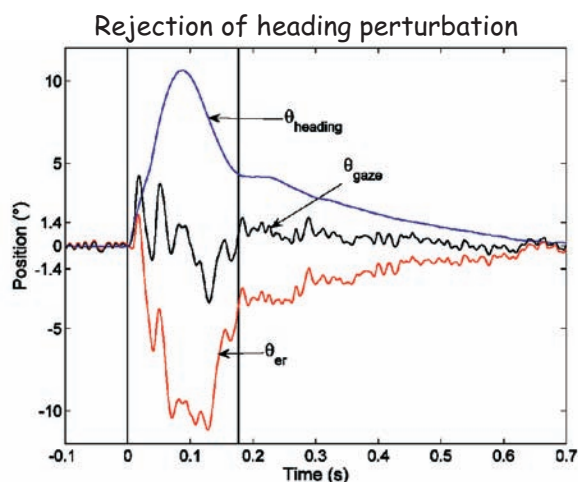
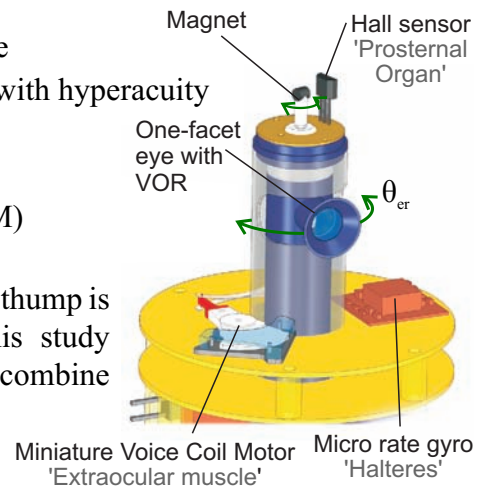
Autonomous guidance of Micro Aerial Vehicles (MAVs) in unknown environments is a challenging task because these artificial creatures have small aeromechanical time constants, which make them prone to be disturbed by gusts of wind. Flying insects are subject to similar kinds of disturbances, yet they navigate swiftly and deftly. Insects' flight capabilities vastly outperforms those of current MAVs because they rely on high-performance visuo-motor control systems (Hengstenberg 1993, Schilstra and van Hateren 1999). Taking inspiration from these sensorimotor reflexes provide us with high performance visuomotor control systems while shedding new light on their natural counterpart.

We built a 100-gram tethered aerial demonstrator, called OSCAR II, which manages to keep fixating a contrasting edge, in spite of nasty thumps that we deliberately applied to its body with a custom-made “slapping machine” (Kerhuel, Viollet, and Franceschini, 2007). The robot's vigorous yaw reactions are based on:

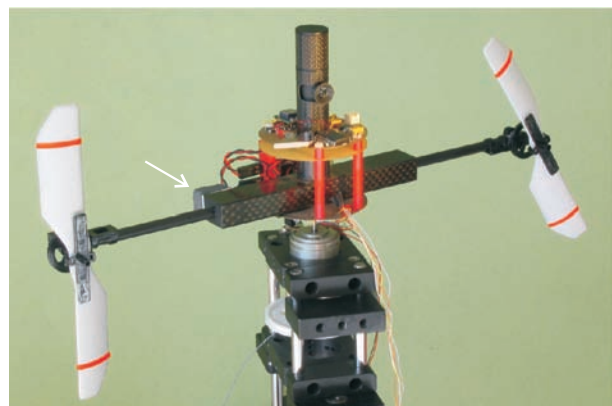
- a mechanical decoupling of the eye from the body
- an active coupling of the robot's heading with its gaze
- an elementary vibrating “eye” able to locate a target with hyperacuity
- a Visual Fixation Reflex (VFR)
- a Vestibulo Ocular Reflex (VOR)
- an accurate and fast actuator (Voice Coil Motor, VCM)

The curves show that OSCAR II's immediate reaction to the thump is to keep its gaze locked onto the contrasting edge. This study illustrates how two sensory modalities (visual + inertial) can combine in favour of robust gaze and heading stabilization.

OSCAR II's Visual system



The eye rotation  $\theta_{er}$  can be seen to immediately counteract the change in heading  $\theta_{heading}$  caused by the thump received at time  $t=0s$



OSCAR II Robot mounted onto the shaft of a resolver. The arrow indicates the point of impact of the strong thump applied to the robot's body

# A novel virtual reality environment offering panoramic visual stimuli with high spatio-temporal resolution

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Ideally one would like to study neural systems without experimental limitations, i.e. monitor neural activity of unconstrained animals behaving in their natural environment. While this is not currently feasible one can mimic natural settings in the lab with a virtual reality environment where animal is sufficiently but minimally restrained and the environment can be accurately controlled by the experimenter.

We have developed a novel virtual reality environment based on spherical projection of computer generated images using DLP data projector as a signal source. Features of this system are compared with those of an ideal one in the table below. Although it does not meet all the criteria it offers significant benefits over traditional (e.g. CRT monitors) and more recent designs (e.g. refs. 1-3). We will present details of the developed system and quantify its dynamic performance as well as the image quality on the projection surface. Advantages and limitations of our approach will be discussed in context of other designs and our ongoing work for improving the system.

Ideal system	Prototype
Equidistant and panoramic coverage of the full visual field	Spherical projection surface with -70 to 80 degrees of longitudinal and -135 to 135 of latitudinal coverage
High spatio-temporal resolution well exceeding that of the visual system	Spatial resolution of 0.6 degrees as seen from the center and frame rate of 360 Hz
High luminance and contrast	Projector output luminance of 1600 ANSI lumens and 2000:1 contrast (full on/off)
Full gamut of chromaticities	8 bit gray scale images
Precise and versatile stimulus generation and control	Custom 3D engine combined with fully customisable virtual reality world
Easy to implement in experiments	Directly applicable to electrophysiological and behavioral setups
Interactive to enable closed-loop behavioral experiments	Implemented in the software

## References

1. J. P. Lindemann et al., Vision Res 43, 779 (2003).
2. M. B. Reiser, M. H. Dickinson, J Neurosci Methods 167, 127 (2008).
3. G. K. Taylor et al., J Exp Biol 211, 258 (2008).