ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Bioinspired Vision-based Microflyers

introduction

We aim at developing **vision-based controllers for microflyers** capable of flying **autonomously** in **indoor environments**. Although significant advances have been made in this domain over the past decade, only subproblems have been successfully addressed (for example wall avoidance) and no flying robot is yet fully capable of achieving this goal.

Since **flying insects** show remarkable indoor flight capabilities, they serve as a **major source of inspiration** at the level of both sensor suite and control. Traditional approaches that rely on inertial measurement units, GPS or active distance sensors are indeed **impossible indoors** due to the weight and consumption of these sensors.

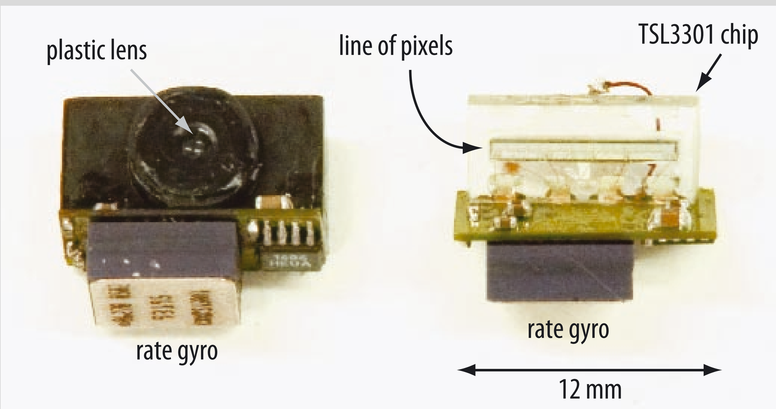
Ultimately, our research goal is a **deeper understanding of the minimal set of mechanisms** required by robots and insects to fly in textured environments.

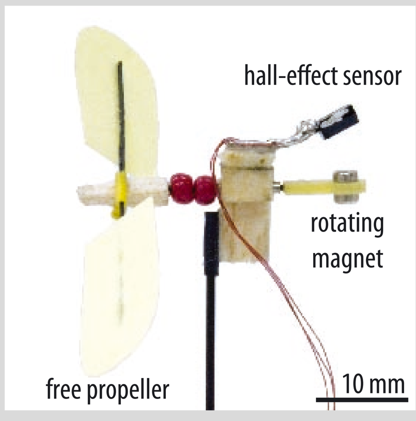
sensor suite

The embedded sensor suite used is closely inspired from that of the fly.

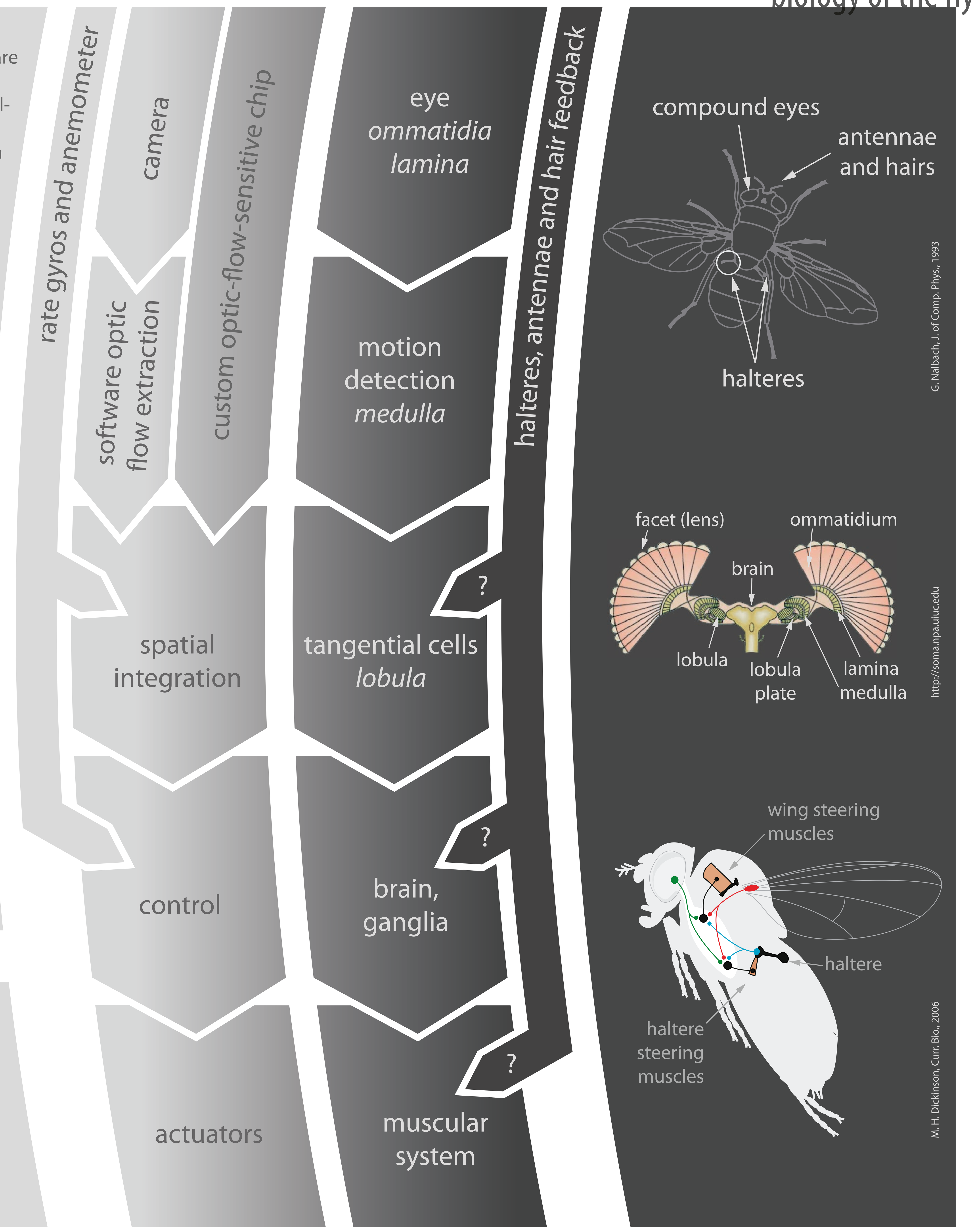
- The main modality is vision, and in particular **optic flow**. Two approaches are explored to extract it.
  - Regular low-resolution cameras combined with optic flow extraction algorithms.
  - Custom-designed optic-flow-sensitive vision chips (collaboration with INI, Zurich).
- **Rate gyros** are used to measure rotation speeds.
- Airspeed is measured using a **miniature anemometer**.

J.-C. Zufferey *et al.*, IROS'06





biology of the fly



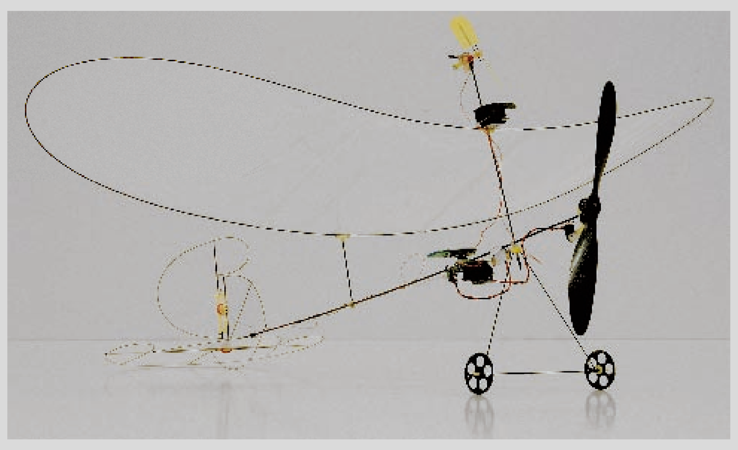
control

Again, the control architecture is inspired from flying insects.

1. **Spatial integration:** combination of all local optic flow measurements into fewer, less noisy and behaviourly relevent signals. We consider:
   - use of optic flow algorithms that operate on wide field of view
   - linear averaging of optic flow extracted by simple detectors
   - non-linear integration of optic flow based on recent biological models
2. **Integration of other sensory modalities.**
   - rate gyros are used to compensate rotation-induced optic flow
   - flight speed is controlled using the anemometer
3. **Behaviour control:** generation of actuator commands, using either:
   - hand-desgined controllers
   - neural networks

Our main tools are **3D physics-based simulation** and **genetic algorithms**.

actuators and body

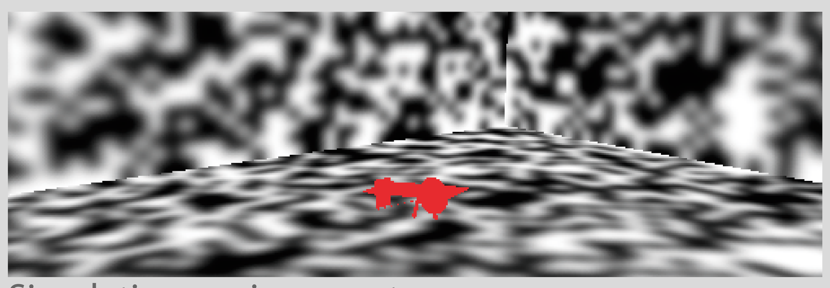


Airframe by *http://www.didel.ch*

Our current prototype of indoor microflyer has the following specifications:

- weight: 10 g
- flight speed: 1.5–2 m/s
- sensor payload: 5 g
- equipped with Bluetooth
- carbon and mylar airframe
- magnet-in-coil actuators

current results

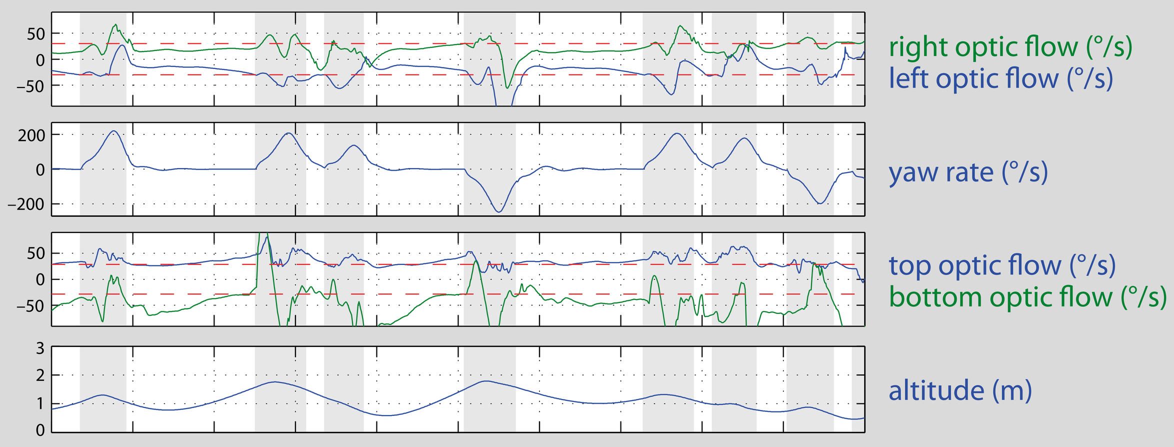


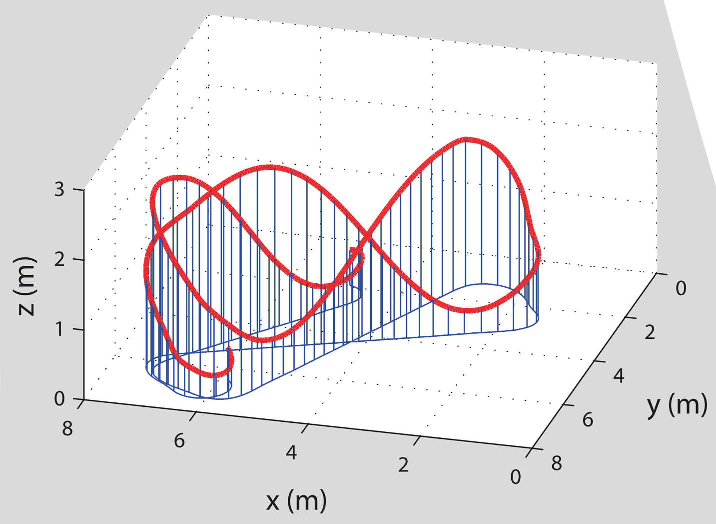
Simulation environment

Results so far include:

- development of a **physics-based 3D simulator**
- hand design and tuning of controllers for 3D flight
- full **3D obstacle avoidance** in simulation using four cameras looking at 45° left, right, top and bottom

A. Beyeler *et al.*, ICRA'07





Data and corresponding trajectory for a typical flight in simulation

outlook

Improvements of the control

- biologically relevent spatial integration
- design of neuromorphic controllers
- use of genetic algorithms in simulation for controller tuning

Improvements of the platform

- transfer of the evolved controllers to the real robot
- use of custom optic-flow-sensitive chip

Our final goal is to develop a platform that will allow us to better understand the mechanisms of flight for both indoor microflyers and flying insects.

A. Beyeler, J.-C. Zufferey, D. Floreano
Laboratory of Intelligent Systems, EPFL

LIS