LAMPETRA

"Life-like Artefacts for Motor-Postural Experiments and Development of new Control Technologies inspired by Rapid Animal locomotion"

www.lampetra.org

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

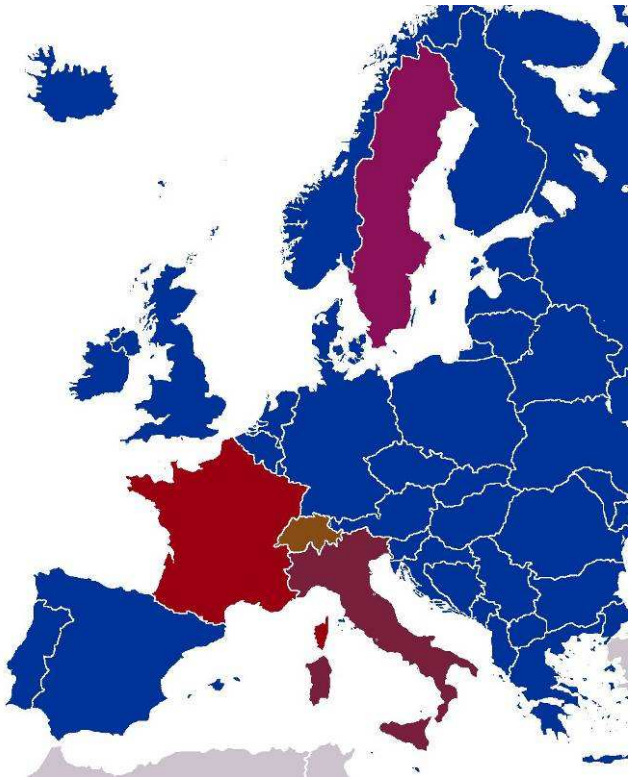
Institut national de la santé et de la recherche médicale

The Lampetra Consortium

Starting date: 01/02/2008

Duration: 36 months

Funding: 1.7 M€



Five partners, Four countries, Three scientific areas

Bioengineering/bio-robotics

- Scuola Superiore Sant'Anna, Italy (prof. Paolo Dario) **Project Coordinator**
- Ecole Polytechnique Fédérale de Lausanne (prof. Auke Ijspeert)

Neuroscience

- Karolinska Institutet, Sweden (prof. Sten Grillner)
- Centre de Recherche INSERM U862, France (prof. Jean Marie Cabelguen)

Biology-focused Computer Science

- Royal Institute of Technology, Sweden (prof. Örjan Ekeberg)

Information Society Technologies

The NEUROBOTICS Lamprey (FET Project 2004-2008)

Neurobotics

Future and Emerging Technologies

EPFL “Salamandra robotica” (NSF Swiss Program: 2005 - 2008)

Our Dream(s)

Bio-roboticists

To design **extreme performance**, future generation autonomous machines, based on novel ICT technology, able to **act** and **behave** like (or even better than ?) animal models

Neuroscientists

To completely understand vertebrate **neural systems** and unveil the **origin** of actions from the selected animal models

Computer Scientists

To build "**in-silico**" tools and platforms able to virtually recreate bodied situations of individual and collective agents, founding **new AI approaches**

Lampetra Team

LAMPETRA Objectives

The overall objective of LAMPETRA is to **(1) develop and (2) use lamprey/salamander bioinspired artefacts** with a twofold goal:

- (a) to conduct **neuroscientific studies** on vertebrate mechanisms involved in the neural control of **goal-directed locomotion**
- (b) to find new solutions for high-performance **artificial locomotion** in terms of **fast-response, adaptability, reliability, energy efficiency, control**.

The final aim is to go beyond steady state locomotion and investigate locomotion that is continuously modulated for implementing a rich variety of behaviours.

LAMPETRA Expected Results

Advances in neuroscience

Better models of **goal directed locomotion**, and in particular of:

- mechanisms addressing striatum/basal ganglia in the **selection** between different patterns of **behaviors** based on visual input, other senses and previous experience;
- **motivational control** as in the case of hunger, aggression, sexual partner selection, day/night cycle.

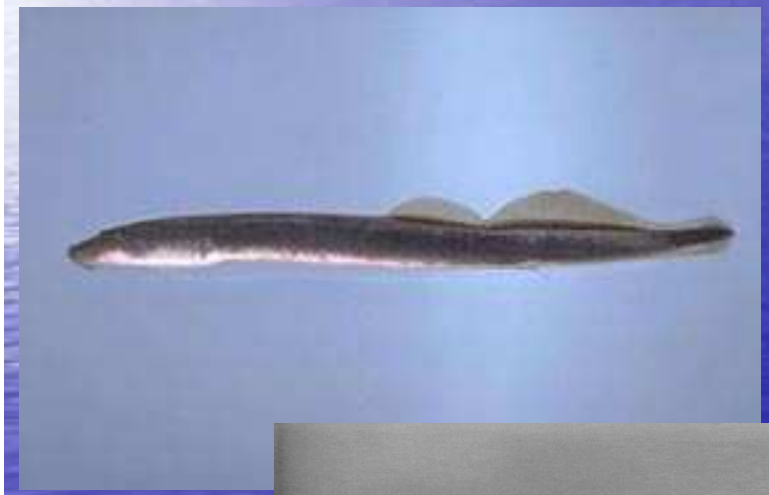
Advances in ICT technology

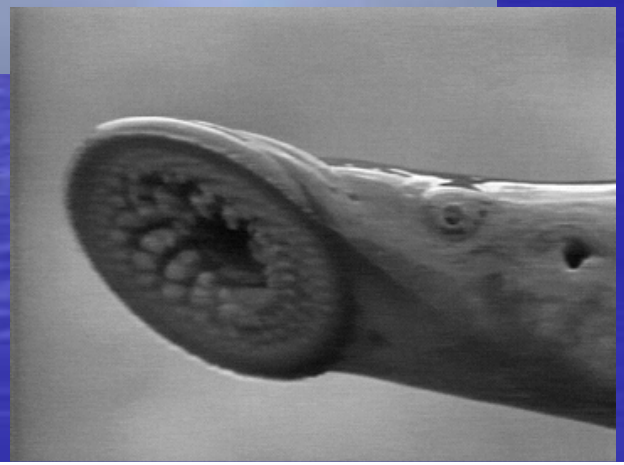
- **Control**: rethinking traditional control by exploiting interacting layers of different behaviours instead of adopting a more traditional approach of modelling and planning, allowing to control complex systems (thousands of receptors, hundreds of actuators, multimodal sensory inputs).
- **Hardware**: New technologies for actuators, sensors and materials enabling soft-bodied robotics.

Lamprey as a Vertebrate Prototype

A phylogenetic important position in evolution

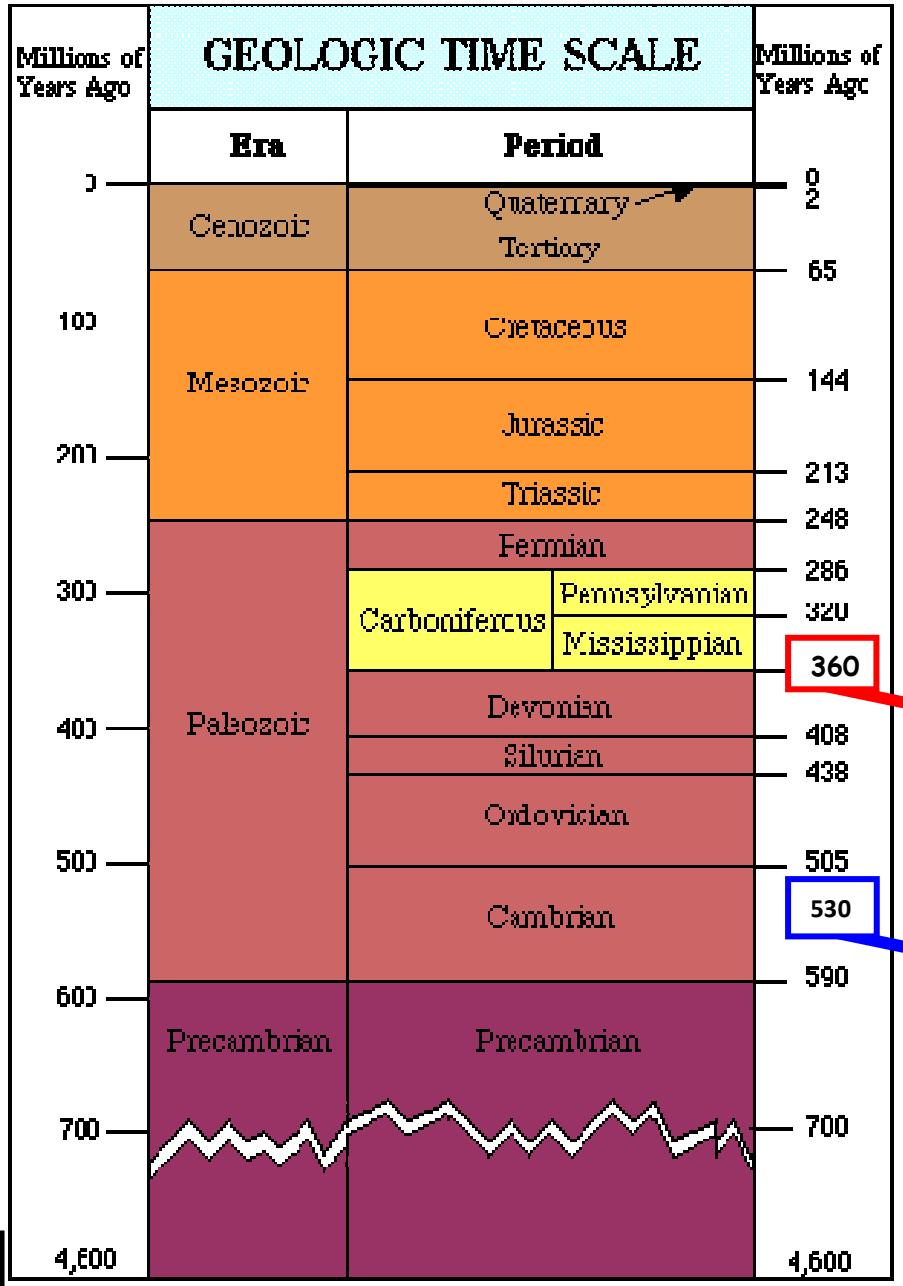
Diverged from the main vertebrate line 450 million years ago





Developed all basic features of the vertebrate nervous system

From aquatic to terrestrial locomotion



Phylogenetic tree

Salamander

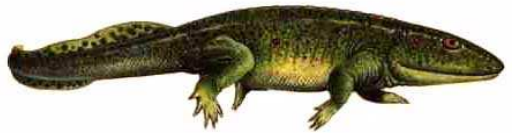
End of the Dinosaurs

First Dinosaurs, Mammals, Birds

First Reptiles

First Amphibians

Ichtyostega



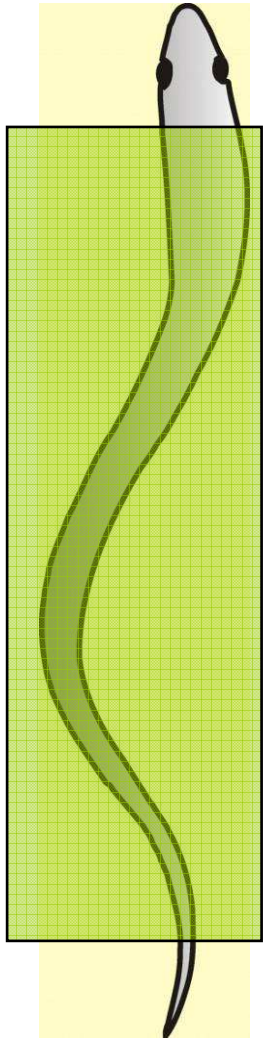
First Land Plants

First Fishes

First Invertebrates

Lamprey

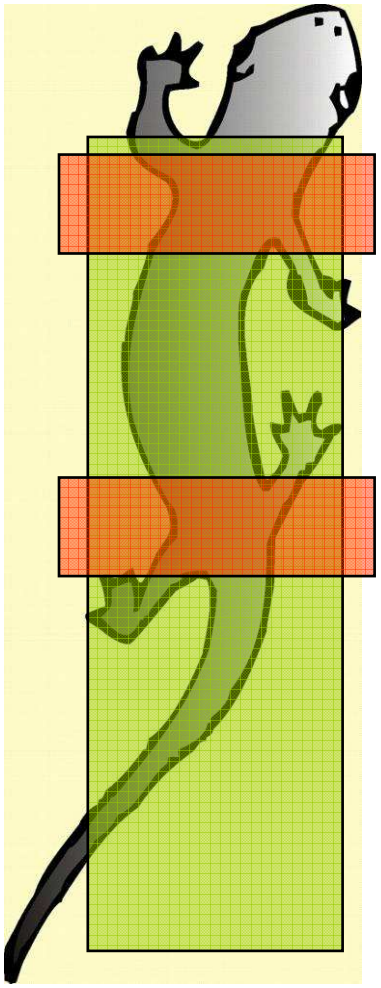
Working hypothesis



Forelimb CPG

Axial CPG

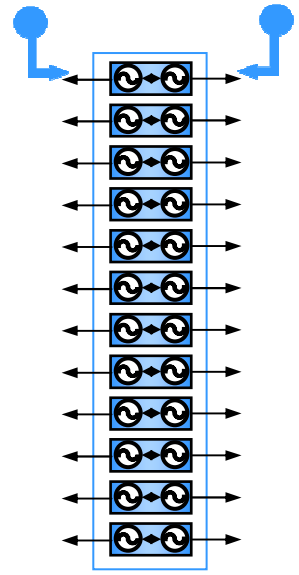
Hindlimb CPG



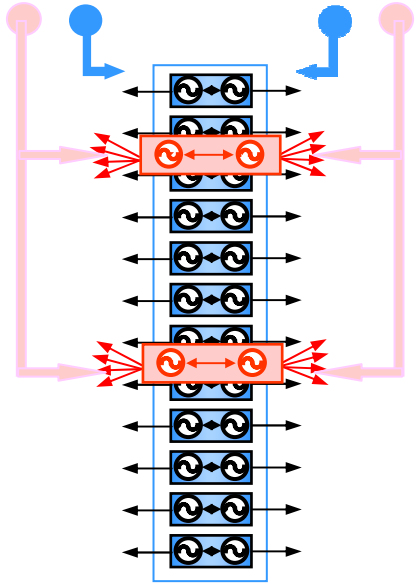
Salamander CPG = Lamprey-like axial CPG
extended with 2 limb CPGs

Evolution of spinal locomotor CPG for locomotion

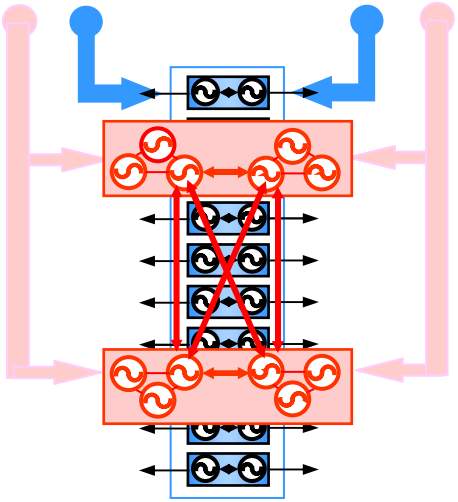
Lamprey



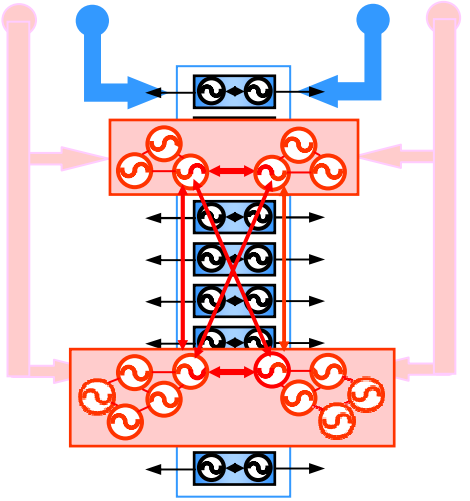
Salamander



Cat

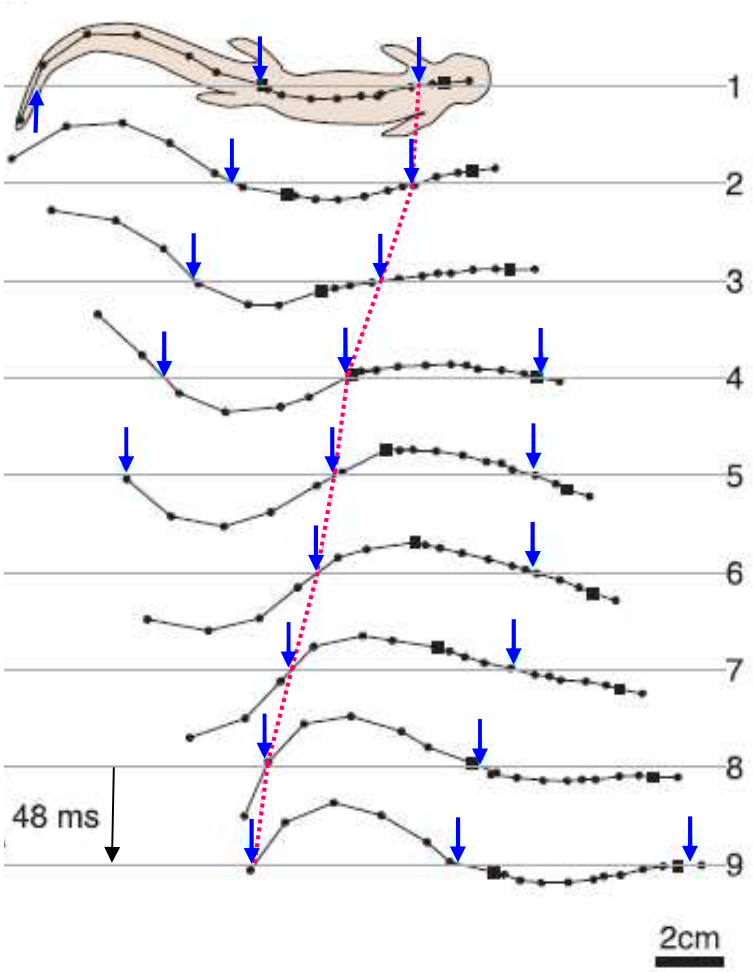


Human



Salamander in anguilliform (lamprey-like) swimming

FORWARD SWIMMING
(« lamprey like »)

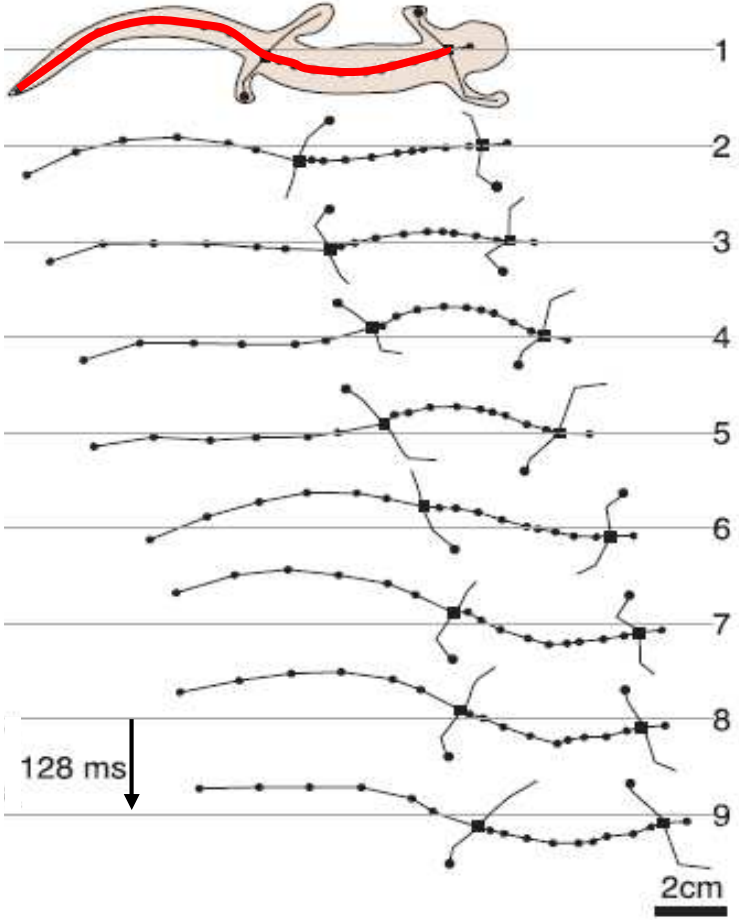


Ijspeert et coll., 2007

- **Traveling waves** of lateral displacement passing down the body (link).

Salamander in stepping locomotion

FORWARD STEPPING
(« crocodile like »)



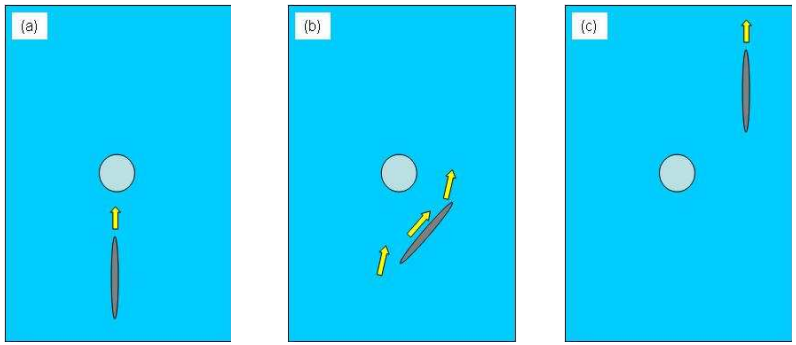
Ijspeert et coll., 2007

- **Standing waves** of lateral displacement with fixed nodes at pectoral and pelvic girdles (link).

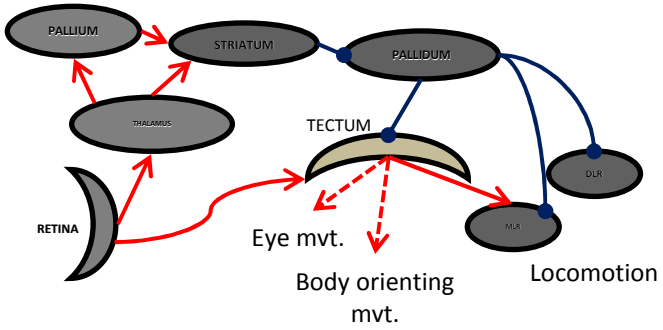
Joint experimental investigation

Salamander - Task no. 1: Obstacle Avoidance

Schematic: obstacle avoidance by steering and recovery of the original direction

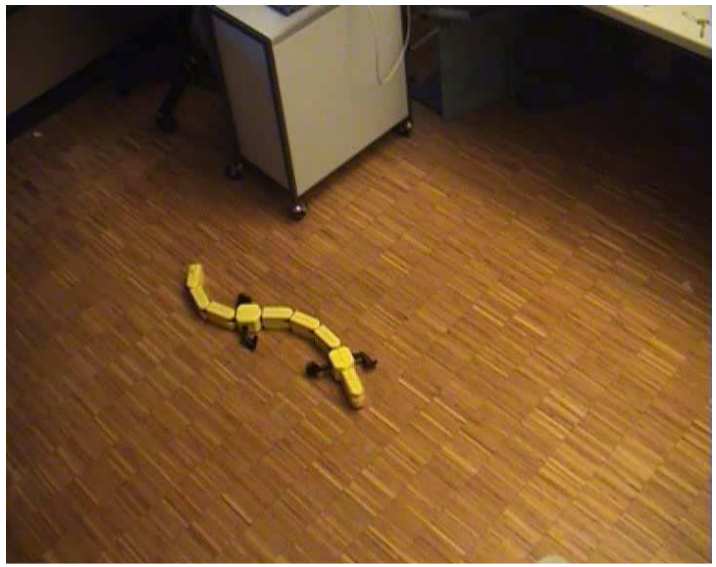


Involved forebrain structures



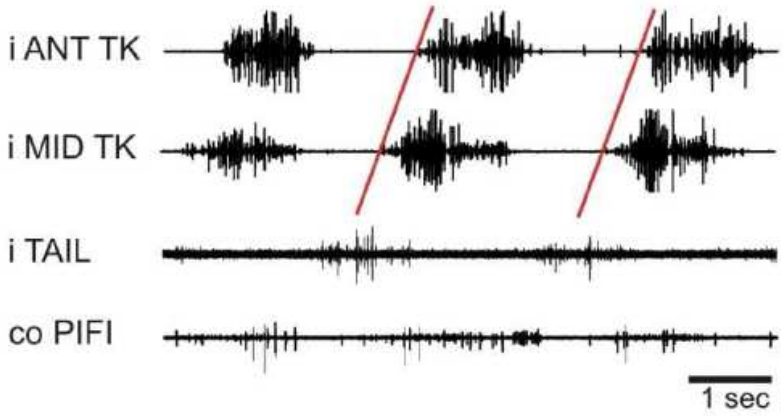
Activation sequence: retina; thalamus; pallium and striatum; pallidum; tectum-eye mvt.; tectum-body orienting mvt.; MLR-DLR.

Real salamander performing the task

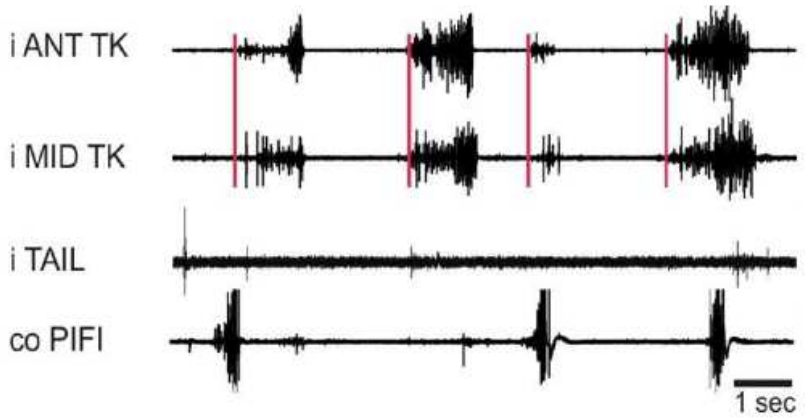


Neural Recordings on goal-directed locomotion

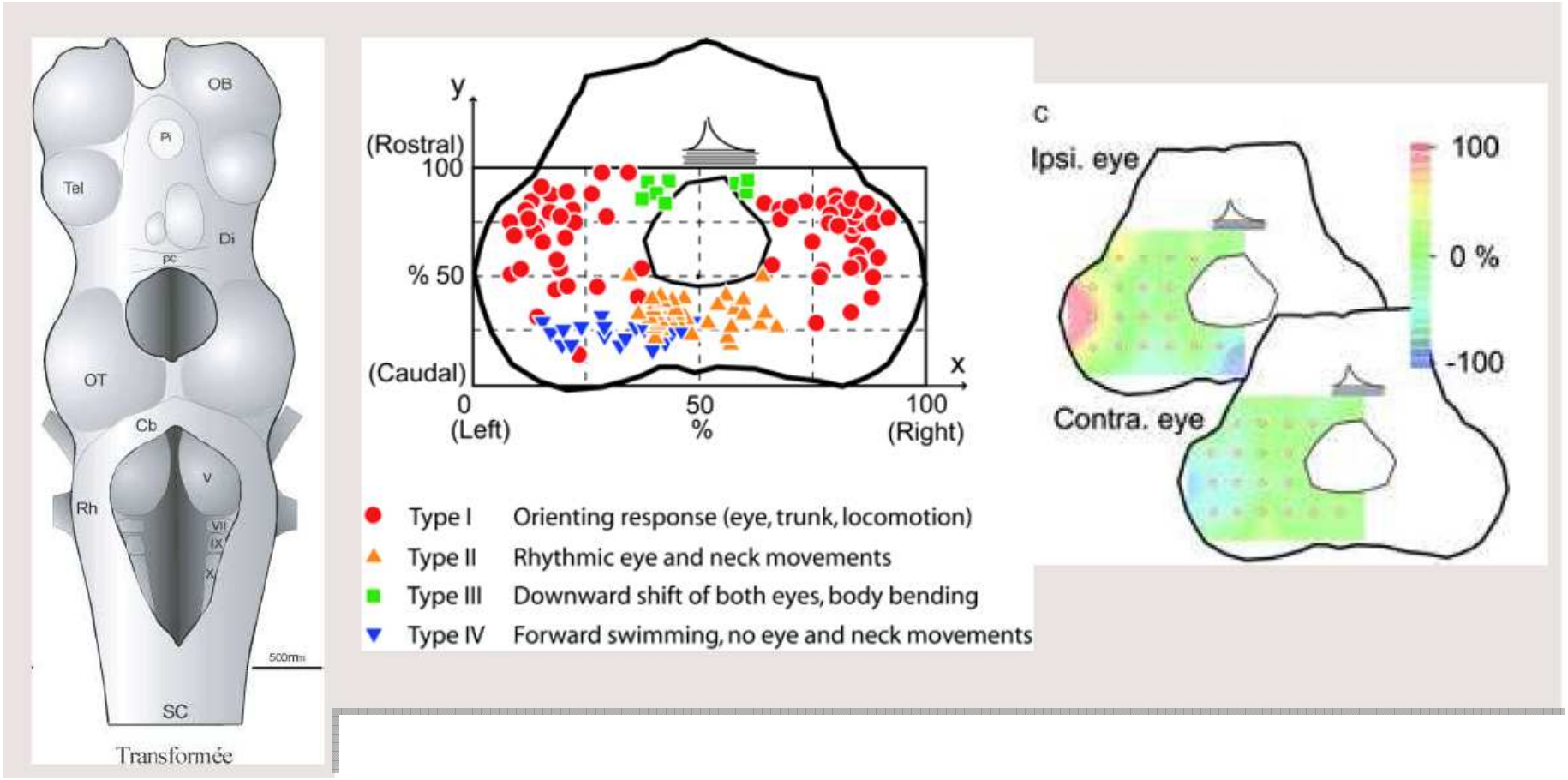
Pelvis-induced struggling



Head-induced struggling

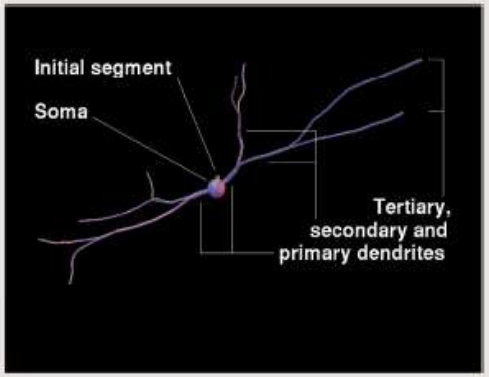


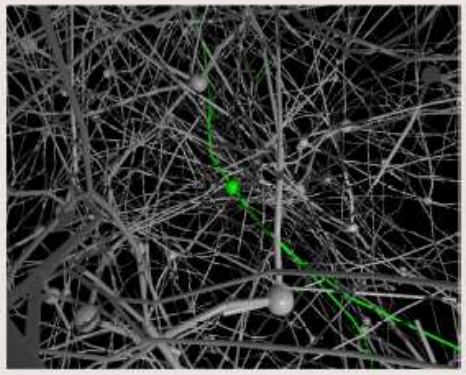
Tectum controls in goal directed behavior

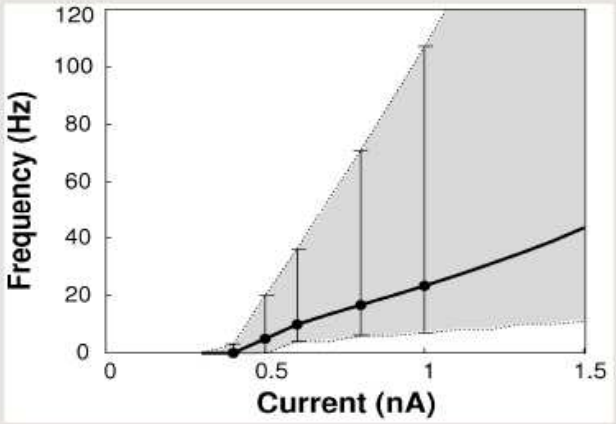


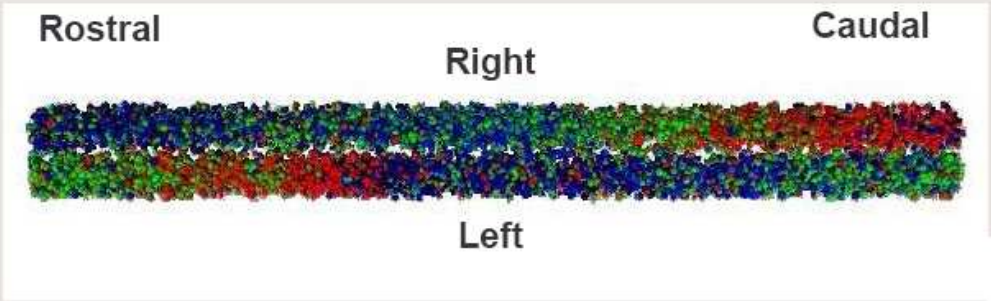
Bio-Hybrid enabling models

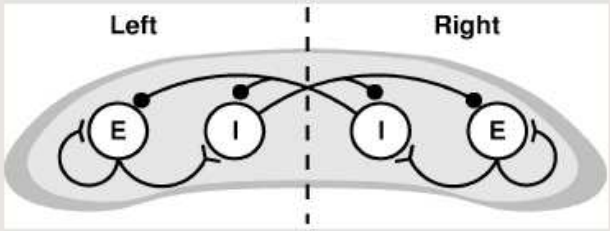
Large Scale modelling of goal-directed locomotor network

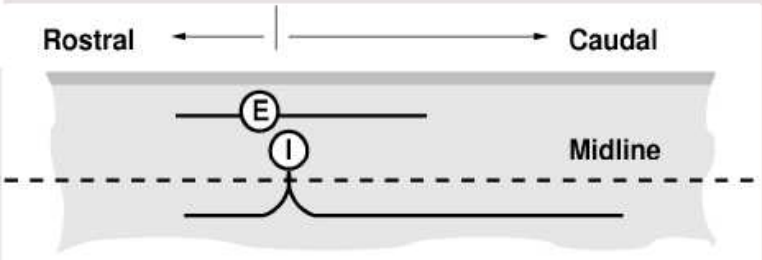






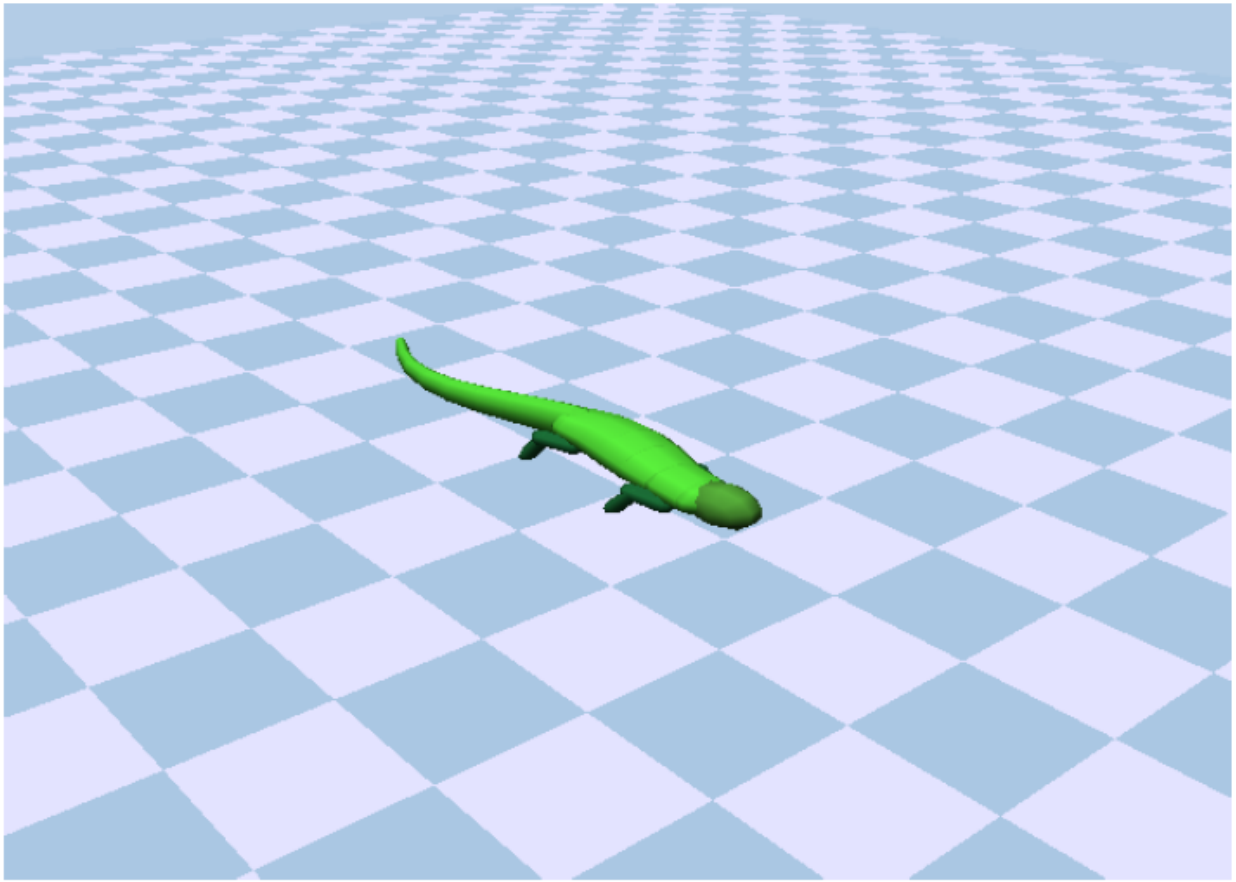






Simulation Platform

- Neuro-Mechanical simulation
- Simplified hydro-dynamic model



- Python — scripting
- NEST — Neural modeling
- OpenDE — Mechanical simulation

Power wireless docking station

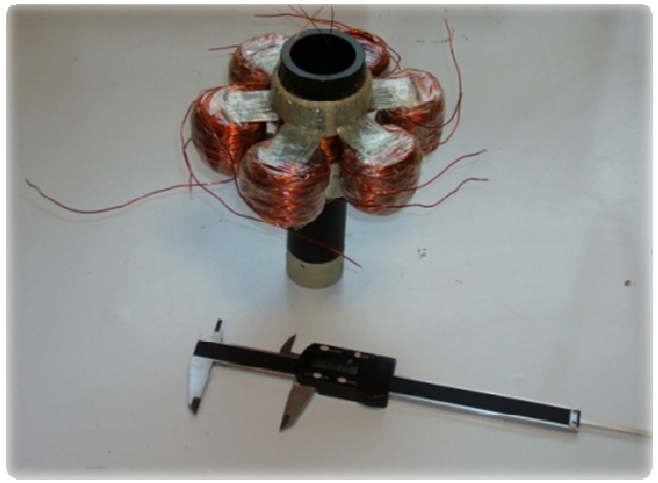
Methods:

The 6 parts was linked using a delrin structure and EPOXY.

The primary was absorbed into a structure of the polyurethane.

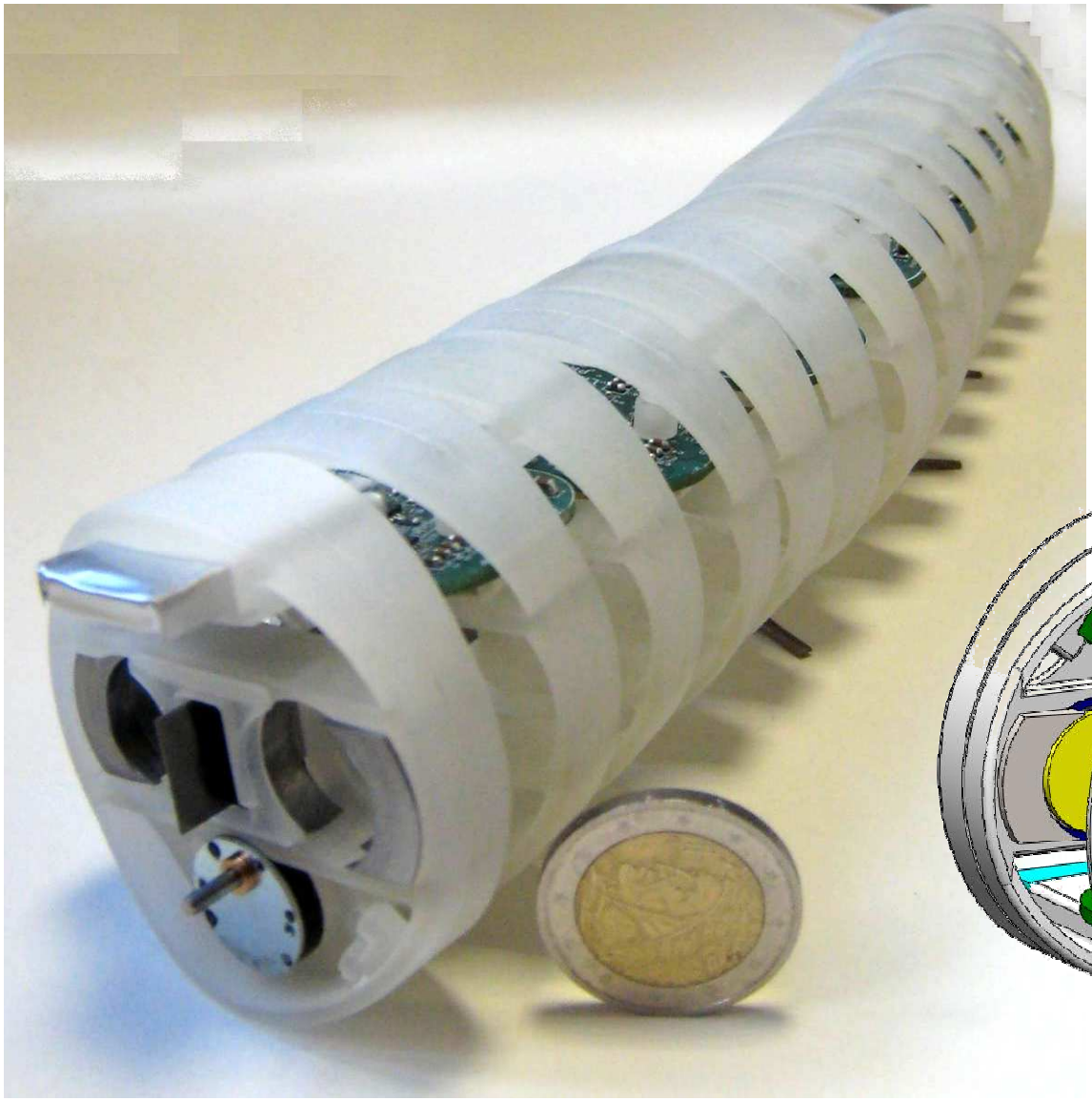
Materials:

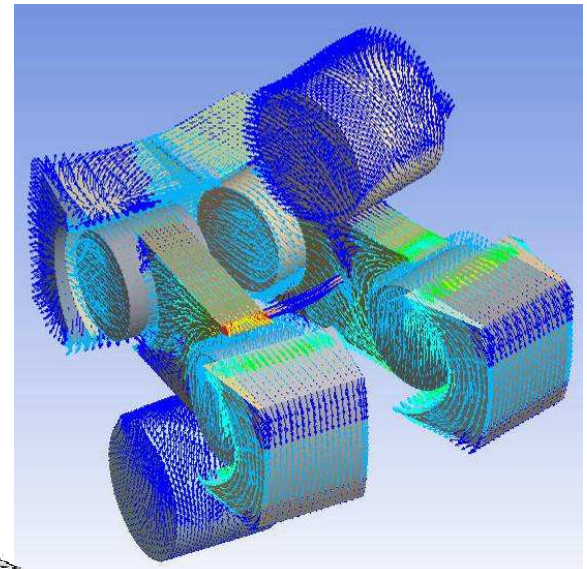
Polyurethane

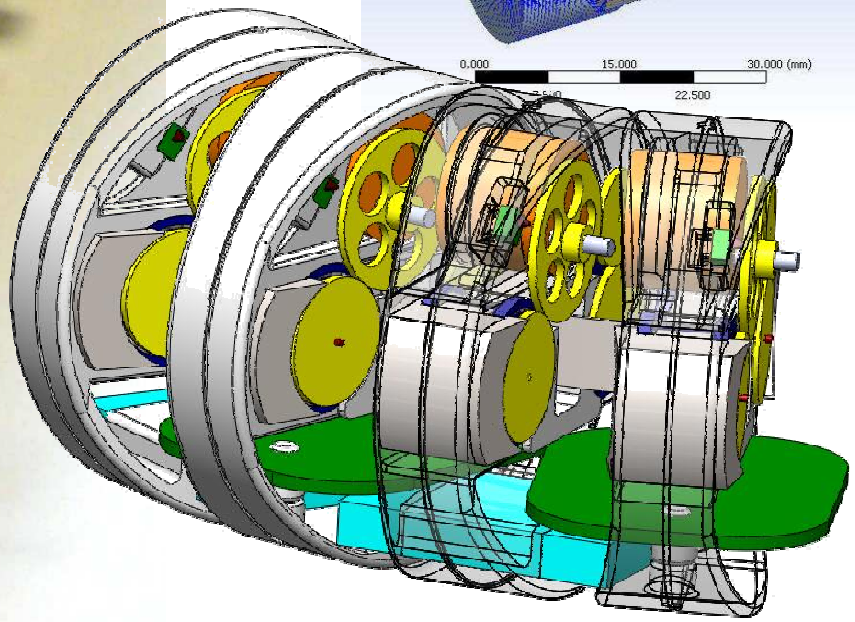


12.7[W]
9.2[V]
1.37[A]

Complaint structure and muscle like actuators. Patented in August 2008.







Vestibular system

1. *Inertial Sensor: Memsens MAG3*
2. *Inertial sensor acquisition*
3. *VOR Implementation*
4. *Head Board: CPG*

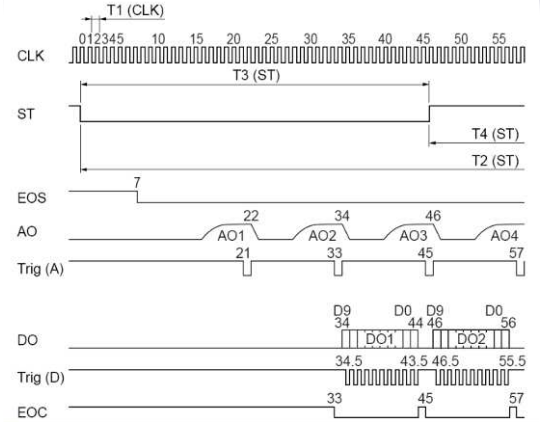
   model implementation,

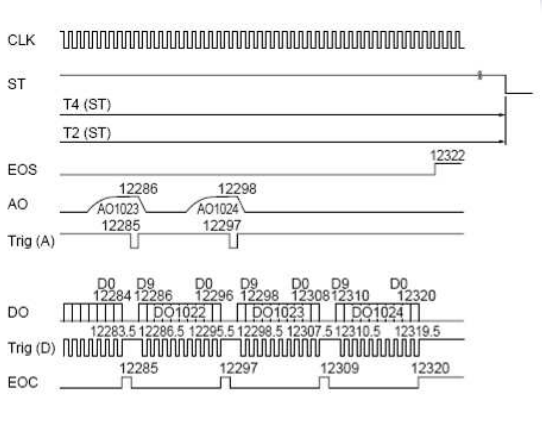
   segment

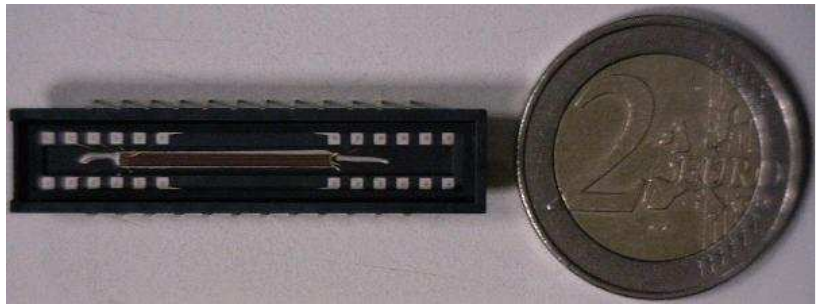
   boards control

   coordination

Vision system

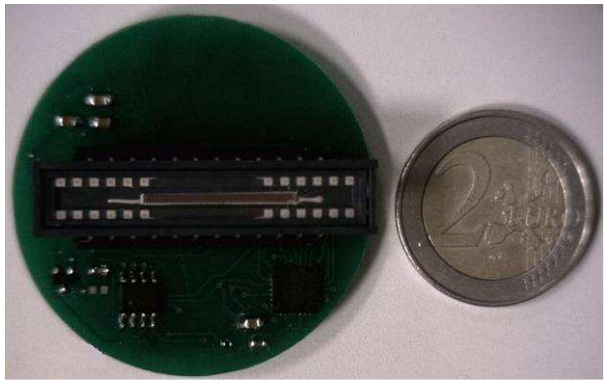






- Acquisition protocol for linear camera
- Image acquisition at 100KHz
- Image processing for target position identification (i.e. centre of mass) at 200 Hz
- *CAN Bus serial communication*

  (1 Mb/s of bandwidth)

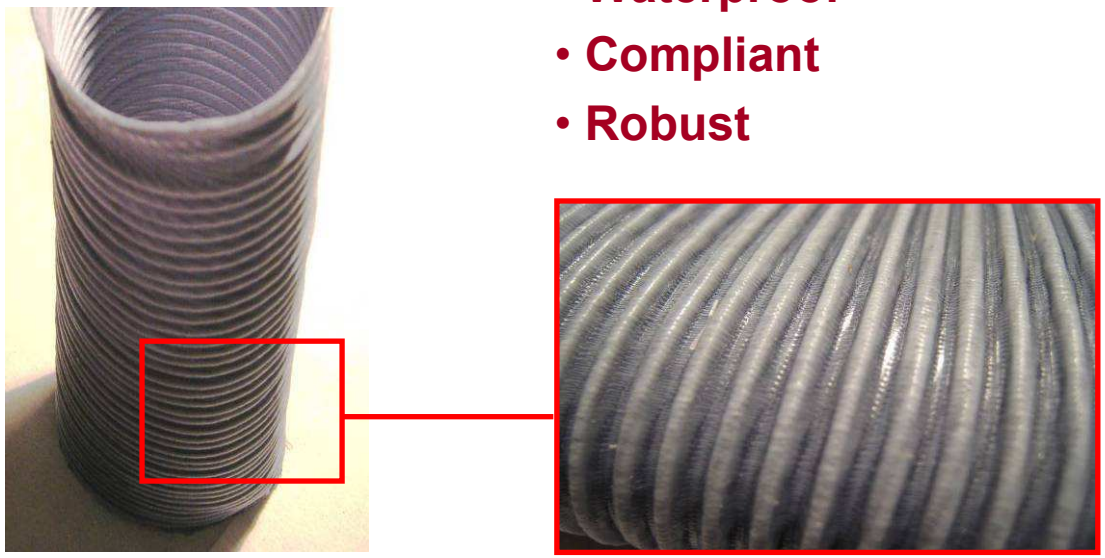


SKIN and Tail

SKIN

Ad hoc fabrication process of a composite material:

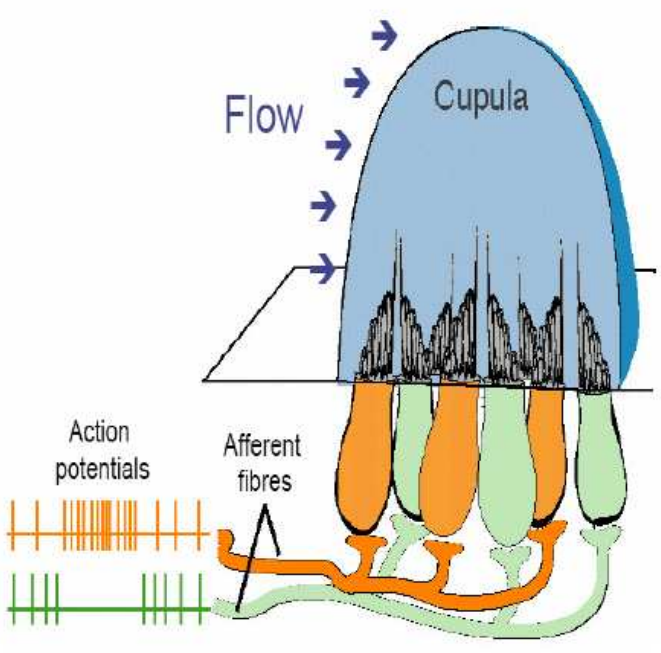
- **Waterproof**
- **Compliant**
- **Robust**



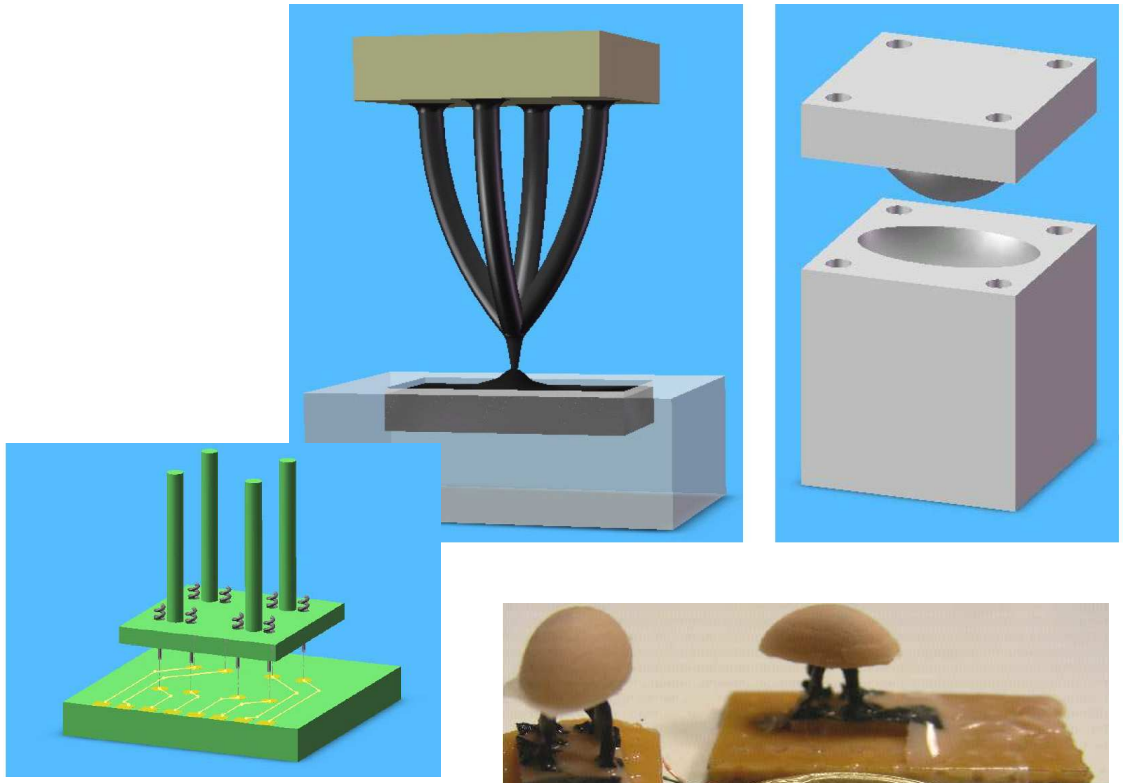
Tail

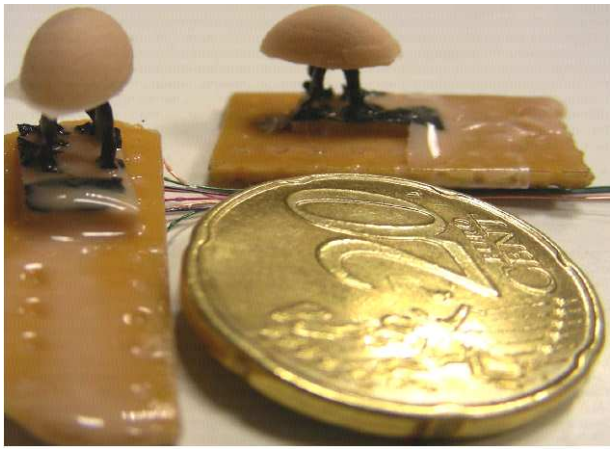
Composite structure for replicating tail biomechanics

Artefact sensors: mechanoreceptors



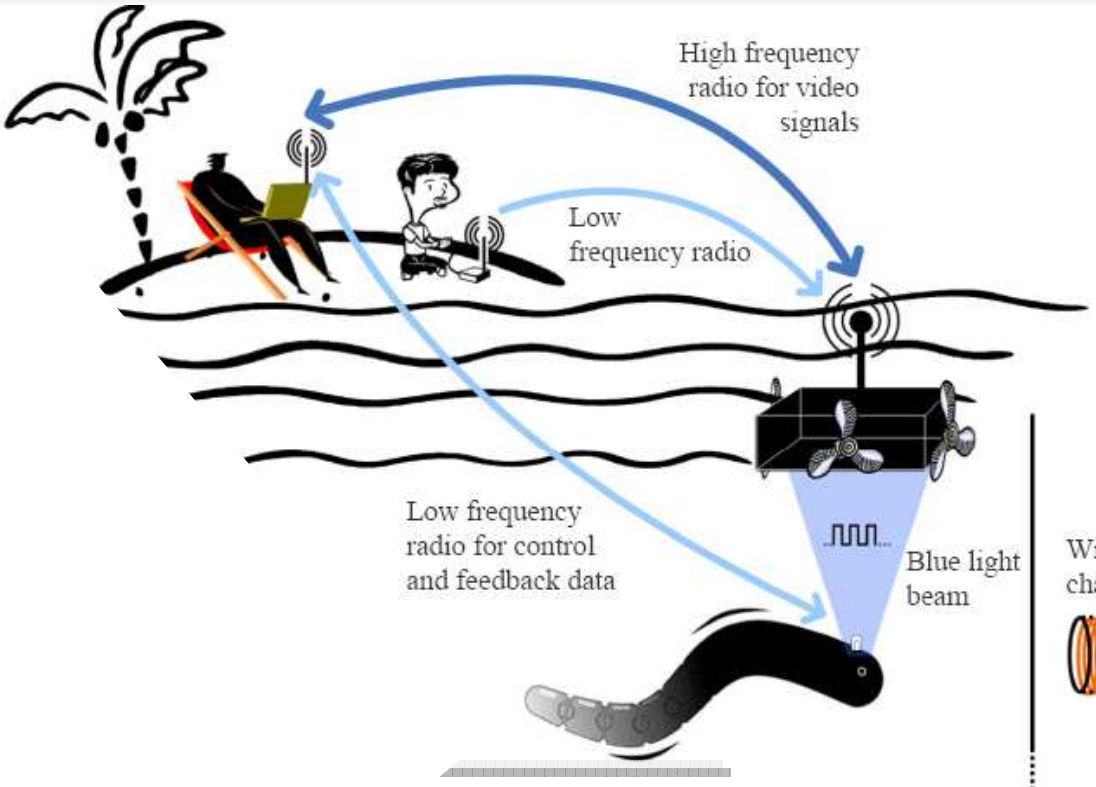
Neuromasts of the lateral line system



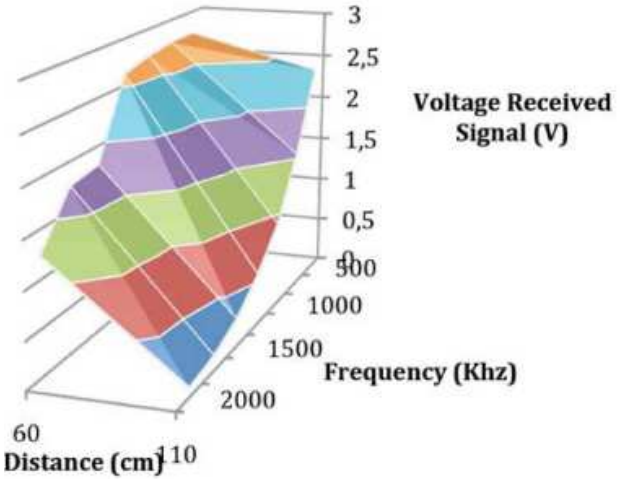


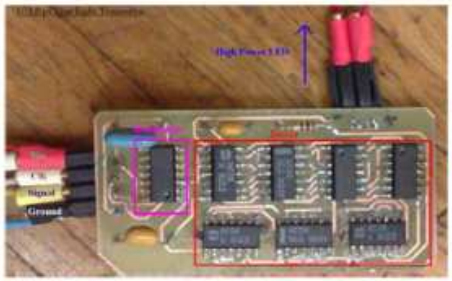
Piezoresistive Artificial sensors

Blue light Underwater communication

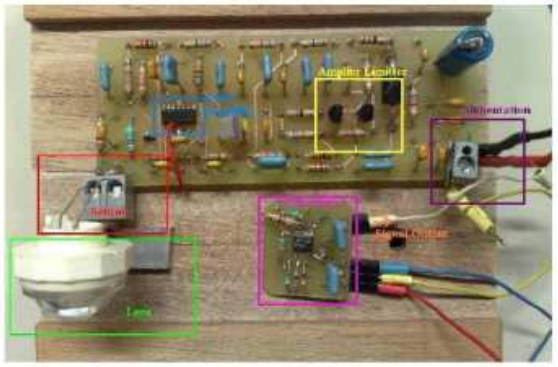


Wireless charger





Transmitter



Receiver

Lampetra @ FET09

Science beyond Fiction
The European Future Technologies Conference
fet09 | 21-23 April 2009 | Prague

”Grand Demo” of LAMPETRA at FET09

4th classified at the

“Best Exhibition Award”

Lampetra

COOPERATION

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