BIOROB
EPFL Biorobotics Laboratory

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Feedback for stabilization during swimming in lamprey and salamander robots

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Midterm Presentation

Minor Project (8 credits)

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Introduction

- Postural stabilization method against

Roll tilt

Pitch tilt

- Bio-imitated response based on the vestibular system

"Any deviation from this orientation evokes a corrective motor response to restore the initial orientation. This response may include a lateral flexion of the ventrally deviated tail, a lateral deviation of the dorsal fin and a body twisting (…) Postural corrective reflexes in the lamprey are driven by vestibular inputs. "

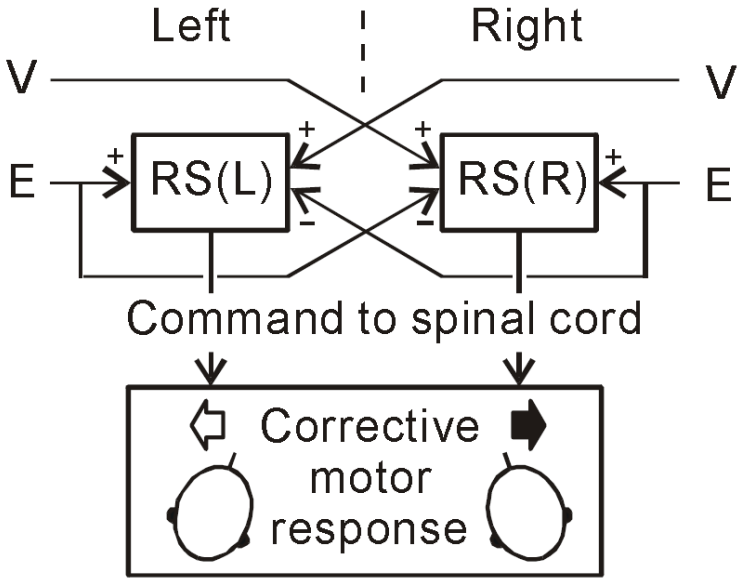
A.K. Kozlov et al, *Modeling postural control in the lamprey* (2001)

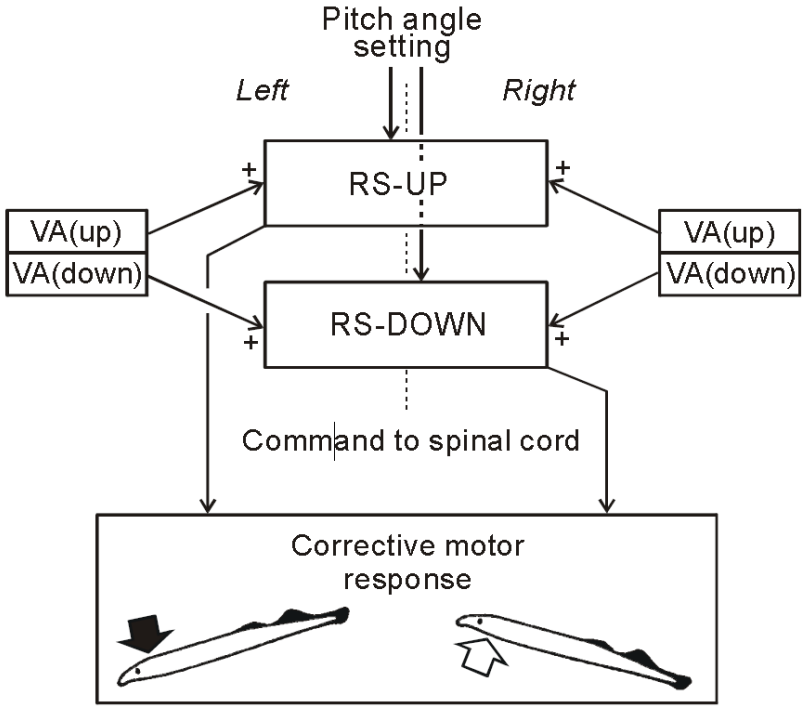
- Feedback sensor

Accelerometer (MMA8453Q)

Biological stabilization

- Vestibular system

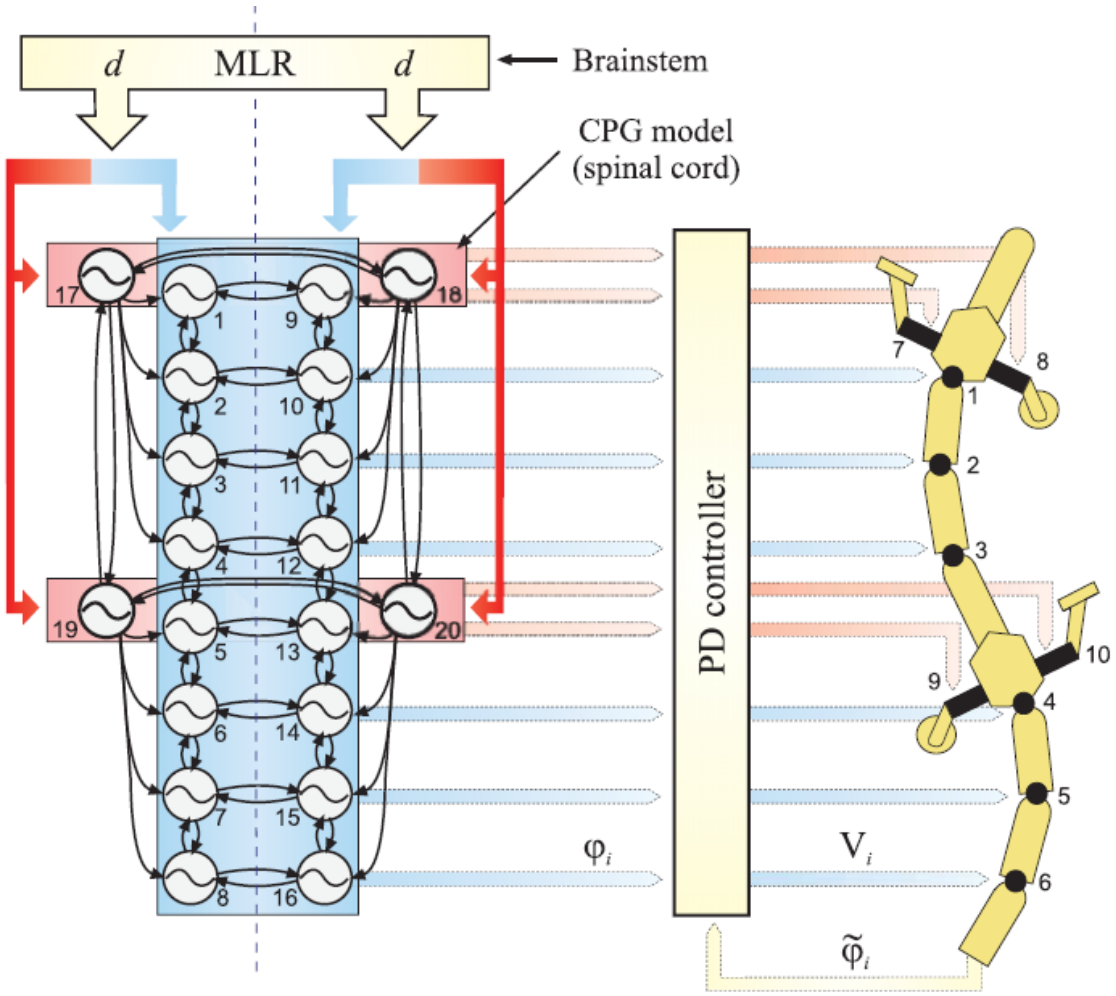




Vestibular system is also taking part to lateral body controls

E. Pavlova, Vestibular control of body orientation in lamprey, Nobel Institute for Neurophysiology, Department of Neuroscience, Karolinska Institute, Stockholm, Sweden, 2004

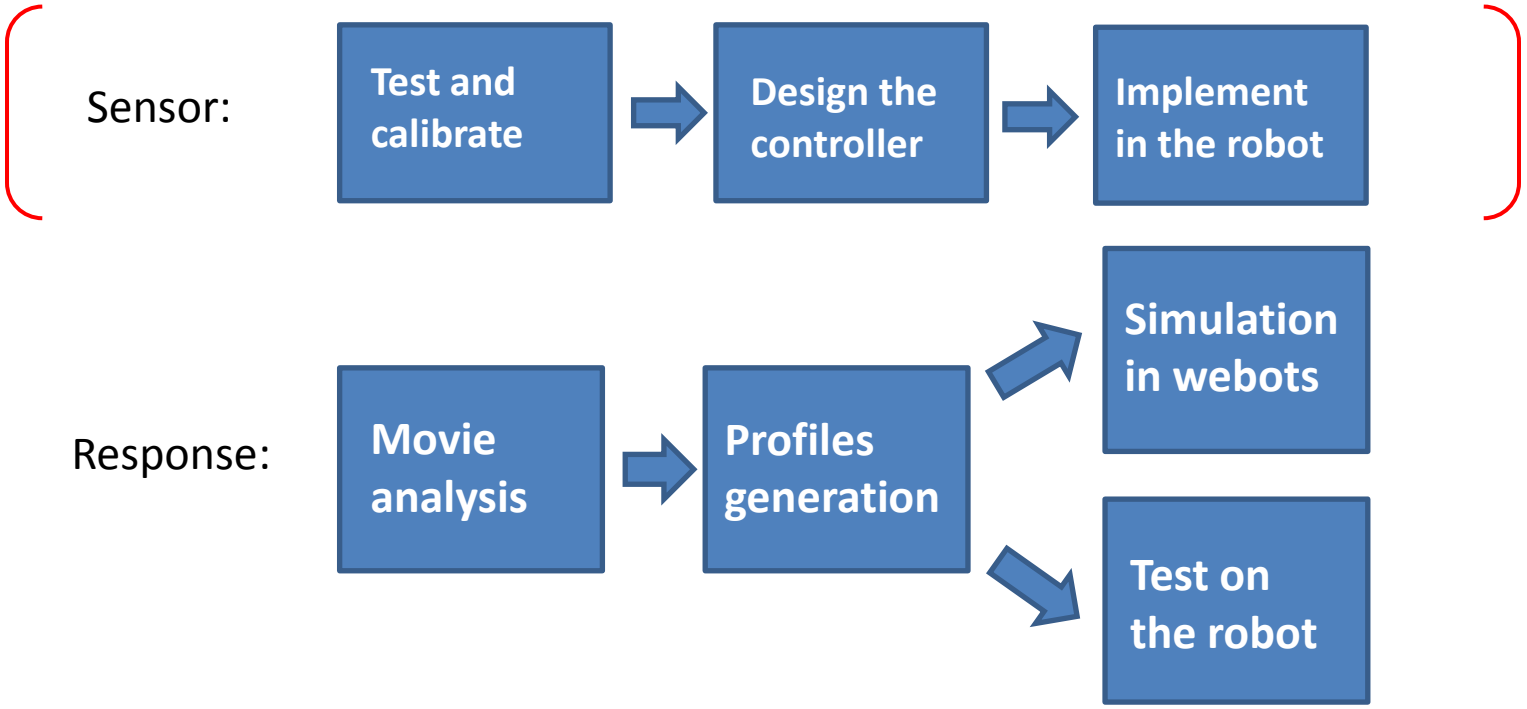
Integrating body control in CPG network



Auke Jan Ijspeert et al., From Swimming to Walking with a Salamander Robot Driven by a Spinal Cord Model, Science 315, 1416 (2007)

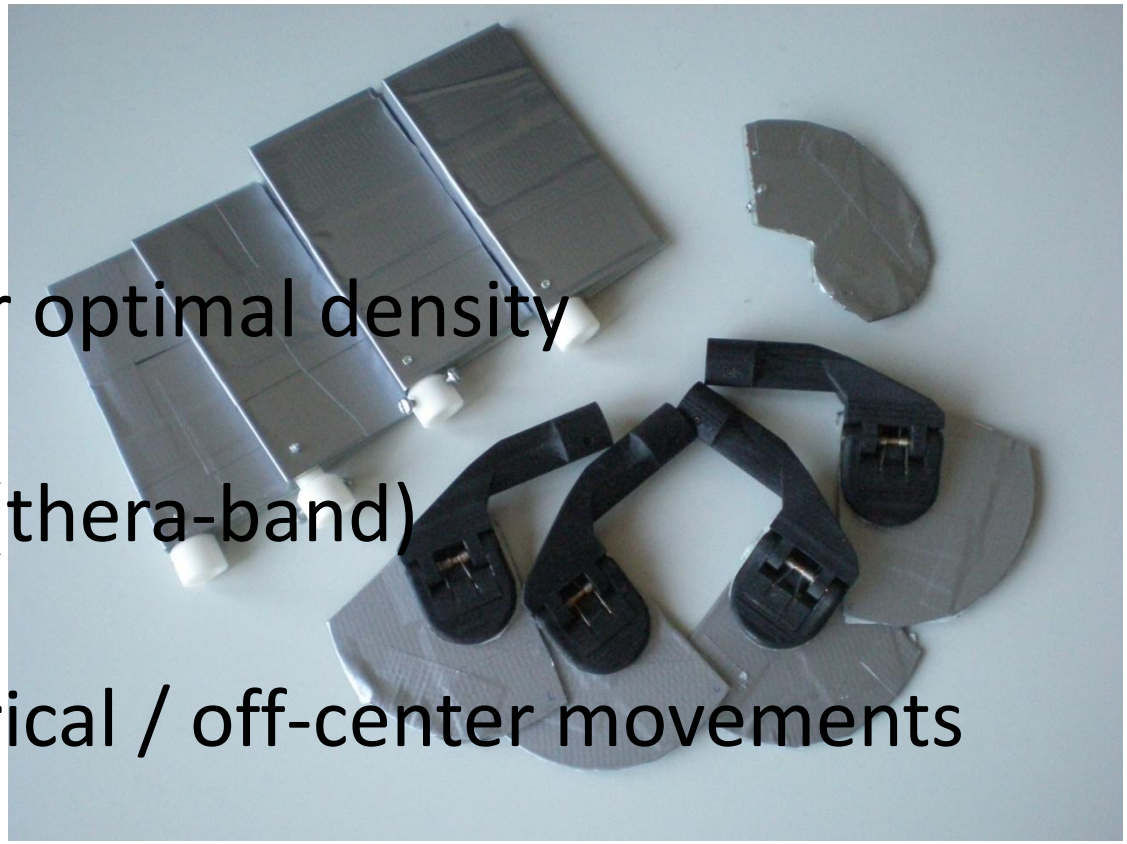
Objectives

- Stabilization during swimming (2 parallel prospecting)



Robot improvements

- Asymmetrical caudal fin
- Limbs

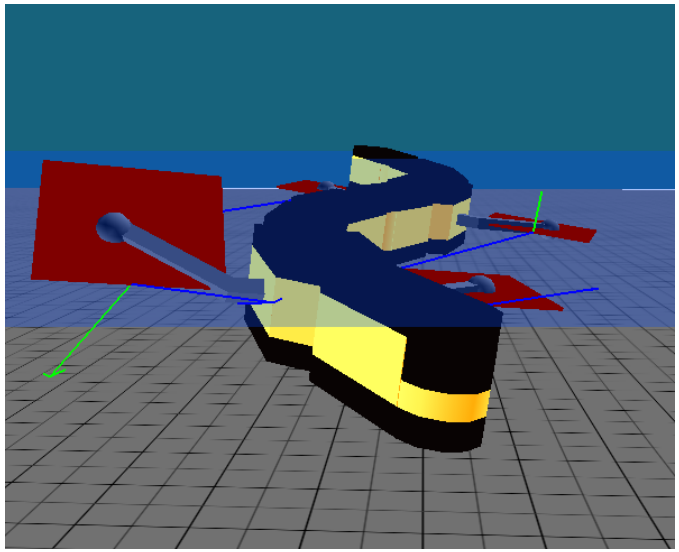


- Weight for optimal density
- Swimsuit (thera-band)
- Asymmetrical / off-center movements

First tests in small pool

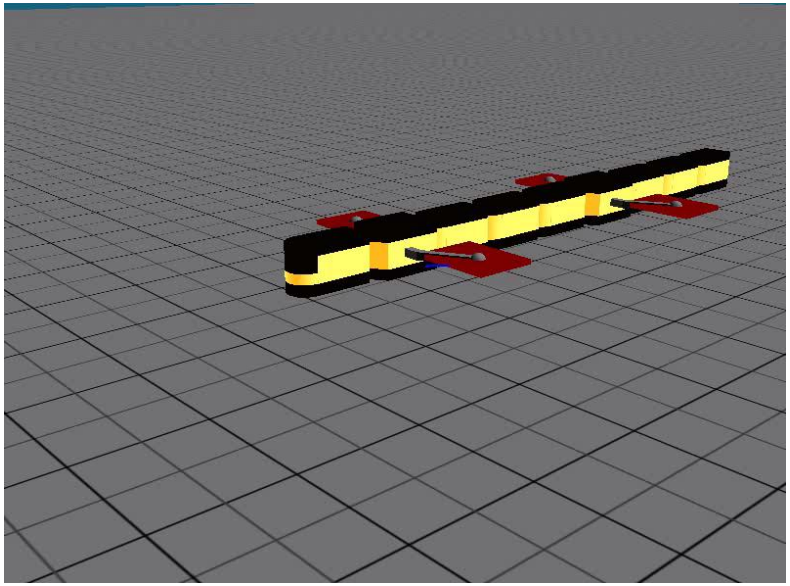
- Moving legs is more relevant than fixing the position
- Ailerons rotation allows:
  - to plunge (fin up)
  - to surface (fin down)
- Legs and fins slow down swimming and act only little (in real life, salamander doesn’t use its legs during swimming)

Webots simulation

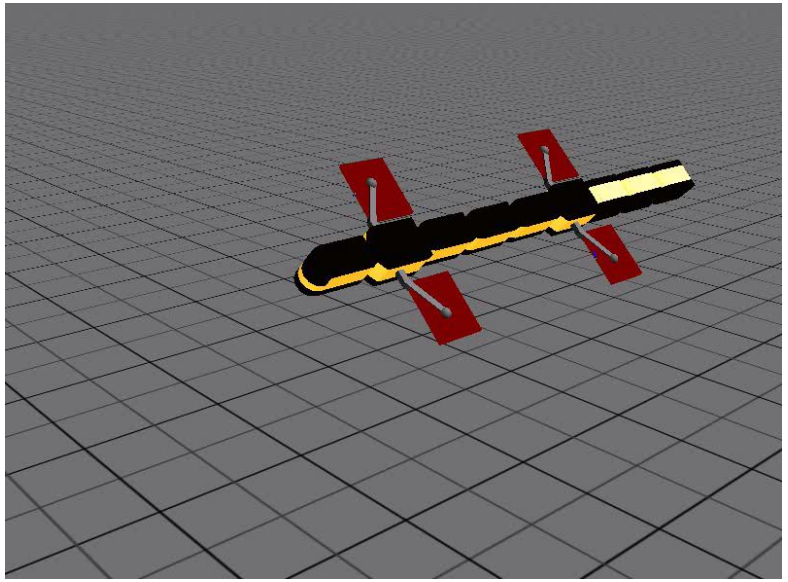


- Again legs and fins slow down swimming and act little (and here also ailerons)
- Asymmetrical tail oscillation stabilizes against rolling

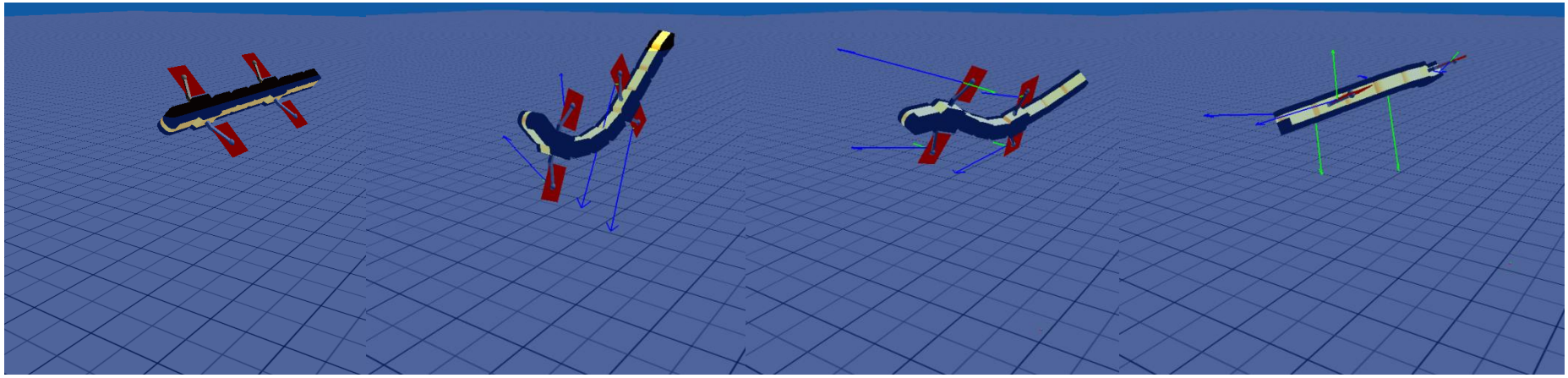
Webots simulation: an example



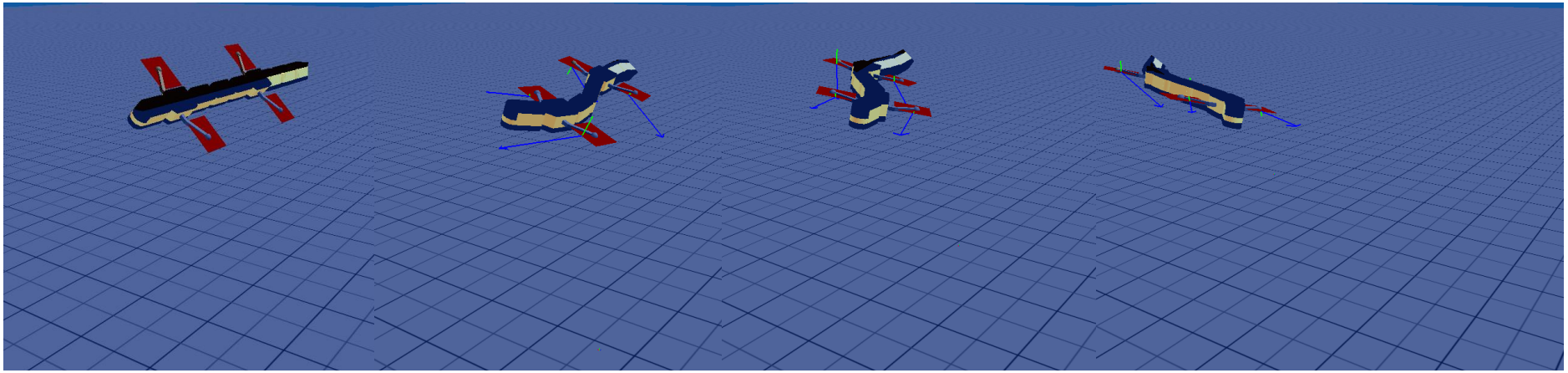
Failed case



Stabilized case

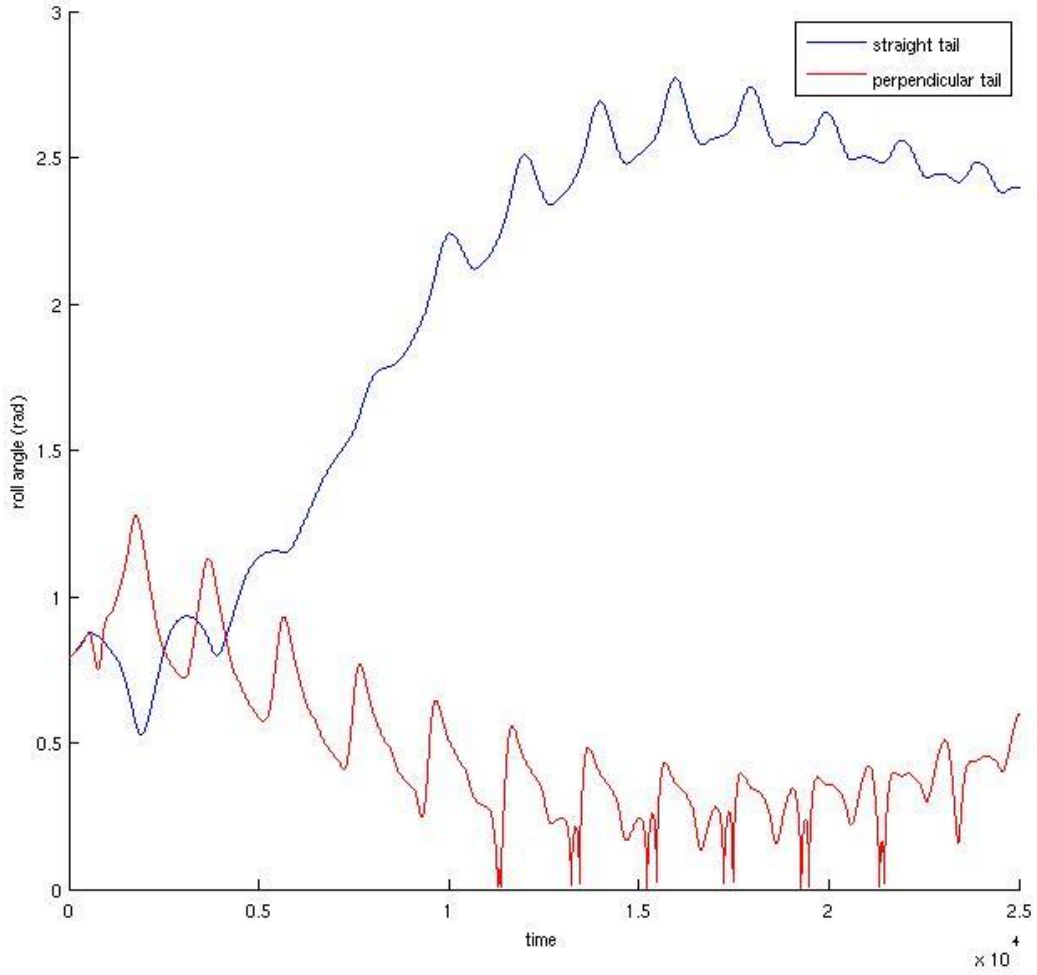


Initial perturbation (π/4) situation followed by robot rolling (straight tail)



Initial perturbation (π/4) situation followed by robot stabilization (perpendicular tail)

Accelerometer in the controller



Example:

Initial perturbation ($\pi/4$) situation

Straight tail robot rolls while asymmetrical tail robot stabilizes

Retained body responses

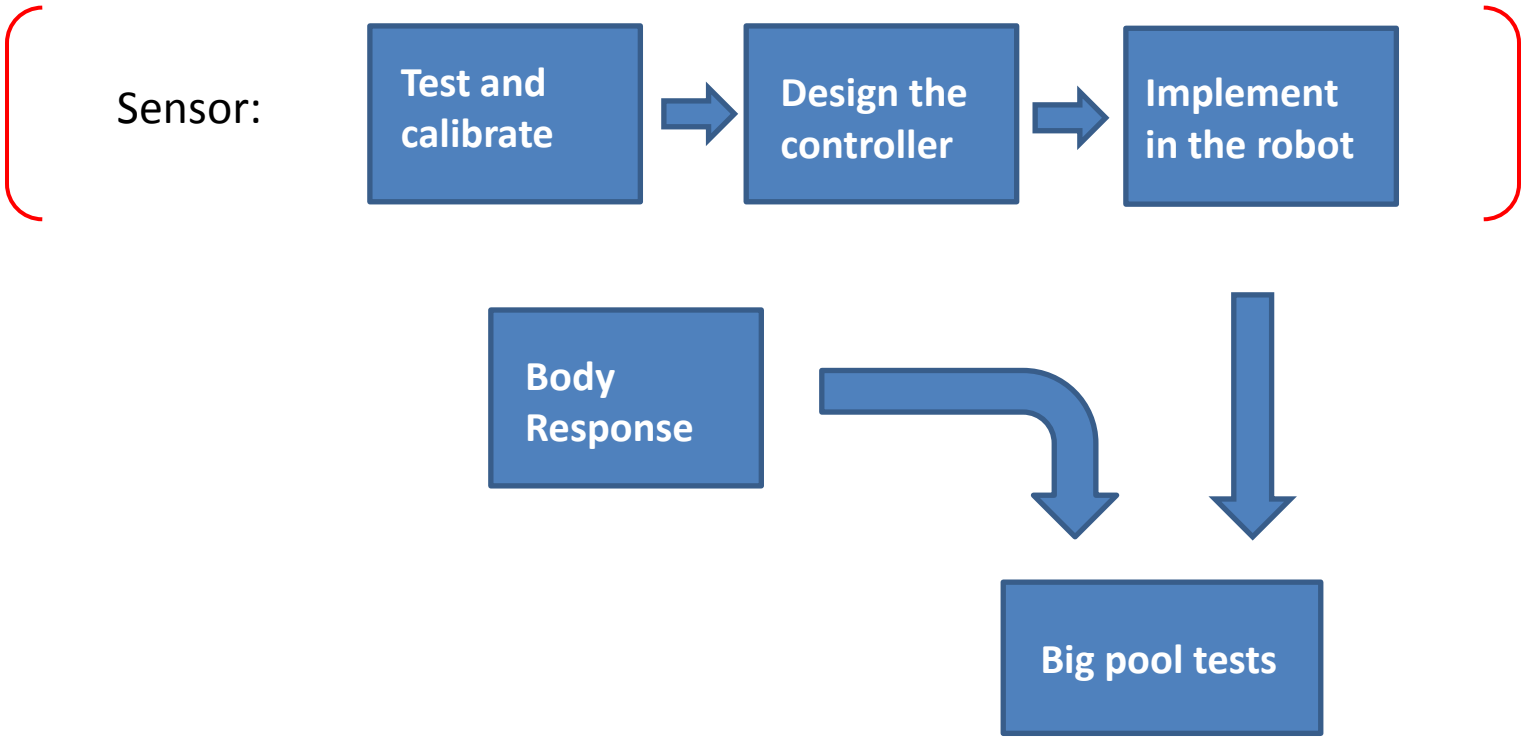
To rolling:

- Asymmetrical movements of tail

To pitch tilt:

- Ailerons correction

Next steps


Sensor:
Test and calibrate
Design the controller
Implement in the robot
Body Response
Big pool tests

Questions ?

References

- Auke Jan Ijspeert et al., *From Swimming to Walking with a Salamander Robot Driven by a Spinal Cord Model*, Science 315, 1416 (2007)
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- K. Seo et al., *CPG-based control of a turtle-like underwater vehicle*, Auton Robot 28: 247–269 (2010)