EPFL

CS-432

Computational motor control

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Cursus	Sem.	Type
Biocomputing minor	E	Opt.
Bioengineering	MA2, MA4	Opt.
Computational Neurosciences minor	E	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Neuroprosthetics minor	E	Opt.
Robotics	MA2, MA4	Opt.
Sciences du vivant	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The course gives (1) a review of different types of numerical models of control of locomotion and movement in animals, (2) a presentation of different techniques for designing models, and (3) an analysis of the use and testing of those models in robotics and neuroprosthetics.

Content

• General concepts: Importance of numerical models in a scientific approach, introduction to nonlinear dynamical systems and neural network models.

• Numerical models of motor systems : Neural network models of control of locomotion, rhythm generation in central pattern generators, reflexes, force fields, sensory-motor coordination, and balance control.

• Numerical models of the musculo-skeletal system: muscle models, biomechanical models of locomotion, Spring-Loaded Inverted Pendulum (SLIP) model, gait classification, applications to legged and humanoid robots.

• Numerical models of arm movements: invariants of human arm movements, different hypotheses about human motor control: inverse models and equilibrium point hypothesis.

• Numerical models of sensory systems : Proprioception and vestibular system. Visual processing in the retina, salamander and primate visual systems, applications to machine vision.

• Neuroprosthetics: short overview of current developments, analysis of how modeling can be used to improve interfaces between machines and the central nervous system

• Numerical exercises: The course will also involve numerical exercises in which students will develop their own numerical simulations of sensory-motor systems in Python, Matlab and in Webots, a dynamical robot simulator (with weekly sessions with assistants and the professor).

Keywords

Numerical models of animal motor control, locomotion, biomechanics, neural control of movement, numerical models

Learning Prerequisites

Required courses

None

Recommended courses

None

Important concepts to start the course

Programming in Python, Matlab, good mathematical background (dynamical systems)

Learning Outcomes

By the end of the course, the student must be able to:

- Argue about the validity of models
- Formulate models of motor control
- Hypothesize mechanisms of motor control
- Design models of motor control
- Test the models

Transversal skills

- Write a scientific or technical report.
- Access and evaluate appropriate sources of information.

Teaching methods

Lectures and numerical exercises on a computer using Python, Matlab and Webots, a dynamic simulator of robots (with weekly sessions with assistants and the professor)

Expected student activities

- Attending lectures
- Read scientific articles
- Develop numerical models of the locomotor control circuits of a simulated animal in Matlab and Webots
- Writting short scientific reports describing the models and analyzing the results of the simulations

Assessment methods

Written exam (50%) and a series of reports for the numerical exercises (50%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=44