CS-432

Computational motor control

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Cursus	Sem.	Type
Biocomputing minor	E	Opt.
Computational Neurosciences minor	E	Opt.
Computational biology minor	E	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Mechanical engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Neuro-X minor	E	Opt.
Neuro-X	MA2, MA4	Opt.
Neuroprosthetics minor	E	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	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, gait classification, applications to bio-inspired robots.
- Numerical models of arm movements: invariants of human arm movements, different hypotheses about human motor control: inverse models and equilibrium point hypothesis. Muscle synergies.
- 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 and in a dynamical robot simulator (with weekly sessions with assistants and the professor).

Teaching methods

Lectures and numerical exercises on a computer using Python, Matlab and FARMS, a dynamic simulator of animals and 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 Python and FARMS

- Writting short scientific reports describing the models and analyzing the results of the simulations

Assessment methods

50% of the grade comes from the modeling projects (by groups of 3 students), and 50% comes from a written exam during the semester.

Resources

Moodle Link

- https://go.epfl.ch/CS-432