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 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 C, 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 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
• Writing short scientific reports describing the models and analyzing the results of the simulations

Assessment methods

Oral 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