BIOENG-404

Analysis and modelling of locomotion

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Cursus	Sem.	Type
Bioengineering	MA2, MA4	Opt.
Life Sciences Engineering	MA2	Opt.
Neuroscience		Obl.
Robotics	MA2	Opt.

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

Summary

The lecture presents an overview of the state of the art in the analysis and modeling of human locomotion and the underlying motor circuits. Multiple aspects are considered including neurophysiology, gait characterization, biomechanics, numerical modeling, neuroprosthetics, and links to biped robots

Content

- Neural basis of locomotion and its implication for the design of neuroprosthesis. Spinal circuitry underlying locomotion, role of sensory information, modulation through descending systems, cortical circuitry contributing to locomotion, design of gait neuroprosthesis.
- Introduction on the basics in anatomy and physiology of locomotion, kinematics measurement and motion capture. Stereo-photogrammetry, ultrasound and magnetic motion capture. Accelerometers, gyroscopes, magnetometers and inertial-based motion capture systems. Kinematics approach for gait analysis.
- Kinetics of locomotion. forces and moment measurements- Forces transducers and force plates, pressure measuring systems and pressure insoles, combining kinetics with kinematics, energy and power of body segment inverse dynamics, muscular activity. Application to gait analysis
- Spatio-temporal gait analysis. Walking phase detection, measurement of stride length, stride velocity, cadence and other spatio-temporal parameters. Gait symmetry, gait variability and gait coordination measurement. Clinical gait analysis. Practical examples of modeling relevant analogies of equivalents of locomotion
- Numerical models of the mechanics of biped locomotion. Inverted pendulum models. Spring-loaded inverse pendulum models. Links to robotics such as passive and dynamic walkers.
- Numerical models of neural control of locomotion. Reflexes and central pattern generation. Comparison to control methods used in biped robots. Links to neuroprosthetics (e.g. functional electromyographic stimulation and exoskeletons)

Keywords

Neurophysiology, motor system, locomotion, kinematics, gait analysis,MATLAB, numerical modeling, robotics, neuroprosthetics

Learning Prerequisites

Recommended courses

Physics I,II,III,IV, MATLAB, Basic physiology and biology

Learning Outcomes

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

- Generalize concepts seen in the course
- Hypothesize about the neural and mechanical principles underlying human locomotion
- Analyze data from experiments and from simulated models
- Model neuromechanical properties of the human locomotor system
- Test neuromechanical models

Transversal skills

- Access and evaluate appropriate sources of information.

Teaching methods

Ex cathedra lectures, with exercises, modeling session with MATLAB, recording of spinal rats locomotion, followed by kinematic, kinetic, and EMG analyses.

Expected student activities

- Attending lectures
- Solving exercises
- Testing numerical models
- Animal experiments

Assessment methods

Written exam with MCQ and short answer questions

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Bibliography

Biomechanics and motor control of human movement, D.A. Winter

Ressources en bibliothèque

- Biomechanics and motor control of human movement / Winter

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=13822