EPFL

BIOENG-404

# Analysis and modelling of locomotion

Aminian Kamiar, Courtine Grégoire, Ijspeert Auke

| Cursus | Sem. | Type |
|---|---|---|
| Bioengineering | MA4 | Opt. |
| Life Sciences Engineering | MA2, MA4 | Opt. |
| Neuroscience | | Opt. |
| Robotics, Control and Intelligent Systems | | Opt. |
| Robotics | MA2, MA4 | Opt. |

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| 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:

- Assess / Evaluate human locomotion
- Formalize the underlying biomechanical and neural components
- Design models of human locomotion

## Teaching methods

Ex cathedra lectures. The practical work including three series of assigments that involve programming with MATLAB, recording human locomotion, followed by kinematic, kinetic, and EMG data analyses. The student should provide a separate report for each part for evaluation. Grades are based on the practicals.

## Expected student activities

- Attending lectures
- Processing and analysing of motion data
- Testing numerical models
- human experiments

## Assessment methods

Obligatory continuous grading of practical reports

## Supervision

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| Assistants | Yes |

## Resources

### Bibliography

Research Methods in Biomechanics, Gordon Robertson et al., Human Kinetics

### Ressources en bibliothèque

- Research Methods in Biomechanics
- Biomechanics and motor control of human movement / Winter