NX-422

Neural interfaces

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Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Life Sciences Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
Neuro-X minor	H	Opt.
Neuro-X	MA1, MA3	Opt.
Robotics	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Exercises	2 weekly
Number of positions	

Summary

Neural interfaces (NI) are bioelectronic systems that interface the nervous system to digital technologies. This course presents their main building blocks (transducers, instrumentation & communication), reviews current and upcoming materials and technological solutions for implantable & wearable NI

Content

Introduction and key concepts.

- The Human Body. The Nervous System.
- Scales. Biomaterials. Biomechanics.
- Functions. Electrophysiology.
- Neural Recording.
- Communication. Standards.

Case study 1. The Cochlear Implant.

- Electrodes and leads: materials, manufacturing, electrochemical impedance spectrocopy
- Function: neuromodulation: Stimulation parameters.
- Implantable neural system: Packaging.

Case study 2. Brain Computer Interfaces

- Invasive and wearable technologies.
- Electrodes. Scale and density.
- Metallic (macroscopic) electrodes.
- Silicon-based (micromachined) electrodes.
- Flexible probes
- Multimodal probes
- Biointegration
- Implantable electronics
- Miniaturized CMOS-based interfaces
- Neural amplifiers
- Digitization and compression methods and circuits
- Neurostimulation methods and circuits
- Classification of neural data

- BCI systems
- Spike sorting, decoding and control
- Wireless power and data transmission

Keywords

Electrodes
Microfabrication
Biomaterials
Implantable electronics
Circuit design
Low-power electronics
Machine learning
Telemetry
Neural Engineering

Learning Prerequisites

Recommended courses

Sensors MICRO-330, Microfabrication MICRO-301, MICRO-331
Materials MSE-207, MSE-208, BIO315, Analog IC design EE-320
Background in neuroscience BIO311
Background in electronics

Important concepts to start the course

Basic concepts in electronics

Learning Outcomes

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

- Design
- Develop
- Sketch
- Integrate
- Propose
- Plan

Transversal skills

- Communicate effectively, being understood, including across different languages and cultures.
- Keep appropriate documentation for group meetings.
- Give feedback (critique) in an appropriate fashion.
- Make an oral presentation.
- Write a scientific or technical report.

Teaching methods

Ex cathedra lectures
In-class Exercices (once a month)

Team project (throughout the semester)

Expected student activities

attend weekly lectures
read proposed references
develop a team project

Assessment methods

In-class assessment (30%):
3 in-class, graded quizzes during the semester
Team project (70%):

- project report (50%)
- team oral presentation (40%)
- engagement across the semester (10%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Books:
Neuroprosthetics: Theory and Practice (Second Edition)
K.Horch, D. Kipke
Brain computer interface technologies
Claude Clément
Design of Analog CMOS Integrated Circuits, 2nd Edition, B. Razavi, McGraw-Hill

Ressources en bibliothèque

- Brain computer interface technologies / Claude Clément
- Design of Analog CMOS Integrated Circuits / Razavi
- Neuroprosthetics: theory and practice / Horch, Kipke. - 2nd edition

Notes/Handbook

lecture slides on moodle

Moodle Link

- https://go.epfl.ch/NX-422