NX-436

Advanced methods for human neuromodulation

Hummel Friedhelm Christoph

Cursus	Sem.	Type
Neuro-X minor	H	Opt.
Neuro-X	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Neuromodulation is an expending field especially in human translational neuroscience and neurotechnology. This course will introduce to different approaches / technologies for neuromodulation, their underlying mechanisms of action and application in humans in healthy and pathological conditions.

Content

The students will be introduced to different (invasive and non-invasive) approaches and technologies for neuromodulation, to their underlying mechanisms of action and to their application in humans in healthy and in pathological conditions such as stroke, Parkinson's, Alzheimer's disease or depression. The course will address and elaborate together with the students on neuromodulation approaches based on e.g., electrical (invasive, non-invasive), magnetic stimulation, focussed ultrasound as well as pharmacological or optogenetic modulation. Furthermore, aspects like state-dependent, closed-loop approaches or technologies for home-based self-application, as well as safety, cost-effectivity and ethics will be addressed, as well as important regulatory, neuroethical and R&D aspects.
The course content is organized as follows. Each week 2 x 45 min lectures and 2 x 45 min exercise.

Lecture topics:
History of neuromodulation
Non-invasive brain stimulation
- Transcranial electric stimulation such as transcranial direct current (tDCS), transcranial alternating current (tACS) or transcranial random noise (tRNS) stimulation
- Transcranial magnetic stimulation (TMS)
- Underlying technological and physiological concepts, mechanisms of action
- Behavioral impact with a focus on clinical translation.
- Technological challenges, next steps

Deep brain stimulation
- Invasive deep brain stimulation
- Novel methods of non-invasive deep brain stimulation based on transcranial temporal interference stimulation (tTIS) or focused ultrasound (fUS)
- Underlying technological and physiological concepts, mechanisms of action
- Behavioral impact with a focus on clinical translation.
- Technological challenges, next steps

Spinal cord stimulation
- Invasive and non-invasive spinal cord stimulation
- Underlying technological and physiological concepts, mechanisms of action
- Behavioral impact with a focus on clinical translation.
- Technological challenges, next steps

Neuromodulation of the peripheral nervous system including the vegetative system
- Invasive and non-invasive peripheral nervous system stimulation
- Underlying technological and physiological concepts, mechanisms of action
- Behavioral impact with a focus on clinical translation.

- Technological challenges, next steps

Neuromodulation by Optogenetics
- Underlying technological and physiological concepts, mechanisms of action
- Behavioral impact
- Technological challenges, next steps

Machine learning, simulations and modelling applied in the field of Neuromodulation
- State-dependent, closed loop stimulation
- Biomarkers to determine responsiveness to neuromodulation
- Simulations and modeling of effects of neuromodulation with a focus on brain stimulation,,
- Personalization

Home-based self-application
- Introduction in concept and technologies
- Opportunities, challenges and technological developments

Regulatory, ethical and R&D aspects of Neuromodulation

Learning Outcomes

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

- Contextualise
- Assess / Evaluate
- Discuss
- Present
- Reason
- Hypothesize
- Plan
- Explain

Transversal skills

- Respect relevant legal guidelines and ethical codes for the profession.
- Take account of the social and human dimensions of the engineering profession.
- Demonstrate a capacity for creativity.
- Demonstrate the capacity for critical thinking
- Communicate effectively with professionals from other disciplines.
- Summarize an article or a technical report.
- Use a work methodology appropriate to the task.
- Access and evaluate appropriate sources of information.

Teaching methods

Interactive Lectures, Exercise

Expected student activities

Preparation of lectures including suggested literature review Active Participation in Lectures Active participation in Exercises

Assessment methods

Written Final Exam (60%)
Interims evaluation (30%)
Exercise: Paper review (10%)