Master's Department of Engineering Sciences

MSc in Automation Engineering and Robotics

Name of the unit: Neuroengineering and biomedical signals

Lecturer: Véronique Marchand-Pauvert (veronique.marchand-pauvert@inserm.fr)
Course code:
Student workload: 15 h of lectures, 8 h of tutorials, 6 h of labs
Credits: 3 ECTS
Specialization tracks: ☐ ROBOT ☐ SI ☒ MeDH
Semester offered: ☐ S1 ☐ S2 ☒ S3 ☐ S4
Language of instruction: ☐ French ☒ English
Targeted audience: ☒ Engineering Sciences students ☐ Other (specify):
Localization : ☒ PMC Campus ☐ Other (specify):

Course Overview

This course aims to introduce engineering students to the fundamental concepts of neurophysiology, electrophysiology and movement anatomy, with a focus on their clinical applications in rehabilitation. The first part will cover key topics in neurosciences and neurological conditions affecting motor function, providing the physiological and pathophysiological foundations necessary to understand electrophysiological signals. The second part will focus on the clinical applications of these signals, exploring their role as assessment and intervention tools — including biomarkers, neurofeedback, and non-invasive neurostimulation techniques."

Keywords: Neurophysiology, Electrophysiology, Neurological Disorders, Rehabilitation, EMG, EEG, Neurostimulation, Neurofeedback, Biomarkers, Motor Function

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Digital Signal Processing
- Python

Intended Learning Outcomes

By the end of this course, students will be able to:

1. Understand Neurophysiology Fundamentals: Grasp the concepts of neuroplasticity, neuroanatomy, and neural signal transmission, including the physiological interpretation of EMG and EEG signals.
2. Identify Neurological Conditions Affecting Motor Function: Recognize acquired lesions (stroke, spinal cord injuries) and neurodegenerative diseases (Parkinson's, ALS) and understand their pathophysiological mechanisms.
3. Interpret Electrophysiological Signals: Use EMG and EEG as assessment tools to understand muscle and brain activity in both healthy and pathological contexts.
4. Apply Non-Invasive Neurostimulation Techniques: Understand the principles of PNS, TMS, rTMS and tDCS and their clinical applications in rehabilitation.
5. Exploit Clinical Applications of Signals: Use electrophysiological signals for pathophysiological understanding, biomarker identification, and neurofeedback interventions.
6. Analyse Open Neurophysiological Databases: Process and interpret real electrophysiological data through hands-on exercises on open databases, including signal acquisition and neurostimulation protocols.

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1	Neuroscience applied to signals. Fundamentals of neuroscience: anatomy, neural signal transmission and neuroplasticity. Physiological interpretation of EMG and EEG signals. Fundamentals of non-invasive stimulation: PNS, TMS, rTMS and tDCS. Acquired lesions: stroke and spinal cord injury. Contribution of electrophysiological signals to pathophysiological knowledge. Neurodegenerative diseases: Parkinson's disease and ALS.		
S2	C2			
S3	C3			
S4	C4			
S5	C5			
S6	TD1	Clinical applications of signals (1/3) — Pathophysiological understanding (2 hours).		
S7	TD2	Clinical applications of signals (2/3) — Biomarkers (2 hours).		
S8	TD3	Clinical applications of signals (3/3) — Neurofeedback (4 hours).		
S9	TP1	Technical-platform visit (1/2) — Signal acquisition and neurostimulation.		
S10	TP2	Technical-platform visit (2/2) — Exercises using open databases.		

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
	Group	In-person	Critical analysis of a scientific article		50 %
	Group	Remote	Project		50 %

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Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %

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