Course guide
240315 - 240NR022 - Human-Machine Interfaces

Last modified: 16/04/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: MASTER'S DEGREE IN NEUROENGINEERING AND REHABILITATION (Syllabus 2020). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer: Romero Lafuente, Sergio

Others: Bachiller Matarranz, Alejandro
Jordanic, Mislav

REQUIREMENTS

Students must pass the subject Biomedical Signals. Students must also pass or take simultaneously the subject Data Analysis in Rehabilitation.

TEACHING METHODOLOGY

· Receive, understand and synthesize knowledge.
· Consider and solve problems, and analyze results.
· Perform a teamwork about developing an application of a BCI system. At the end of the course, the students will defend their project orally.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective is to introduce the field of human-machine interface (HMI) and in particular to the systems that translate a measure of a user's brain activity into messages or commands for an interactive application (BCI, brain-computer interfaces). Other objectives include:
· To introduce brain and muscular recording and stimulation technologies.
· To present the basic components of an HMI system.
· To review the major applications of BCIs considering some ethical aspects.
At the end of the course, the student must be able to design, program and develop a BCI communication system.

STUDY LOAD

Type	Hours	Percentage
Self study	72,0	64.00
Hours small group	18,0	16.00
Hours large group	22,5	20.00

Total learning time: 112.5 h

CONTENTS

Topic 1. Introduction to human-machine interfaces

Description:
Basic neuroscience. Invasive and noninvasive brain signals. Brain stimulation technologies. Overview to signal processing. Artifact reduction techniques.

Full-or-part-time: 6h 30m
Theory classes: 2h
Self study : 4h 30m

Topic 2. Evoked related potentials (ERP)

Description:
Visual, auditory, somatosensorial and motor ERP. Most important waveforms. Applications in neurologic disorders.

Full-or-part-time: 18h 30m
Theory classes: 2h
Practical classes: 7h 30m
Self study : 9h

Topic 3. Brain computer interfaces (BCI)

Description:
Design, implementation and operation of a BCI system. Signal acquisition, processing, feature extraction and classification. Types of BCI: invasive, semi-invasive and non-invasive.

Full-or-part-time: 43h
Theory classes: 4h
Practical classes: 12h
Self study : 27h

Topic 4. Motor imagery

Description:
BCIs based on movement intention for rehabilitation. High-density EMG signals (HD-EMG): acquisition and processing.

Full-or-part-time: 146h 30m
Theory classes: 4h
Practical classes: 7h 30m
Self study : 135h

Topic 5. Applications and ethical issues

Description:
Medical and non-medical applications. Ethical issues. Future perspectives on BCIs.

Full-or-part-time: 6h
Theory classes: 1h 30m
Self study : 4h 30m

GRADING SYSTEM

The final mark is the weighted sum of the following marks:
Nfe: Final exam mark
Nlabs: Mark of the laboratory sessions (attendance, participation)
NpBCI: Mark obtained in the group project on a BCI application (work and oral dissemination).
Nfinal = 0.3 Nfe + 0.2 Nlabs + 0.5 NpBCI
Students who do not submit the final exam or do not perform the BCI project will be denoted as "Not taken".

EXAMINATION RULES.

Students who do not submit the final exam or do not perform the BCI project will be denoted as "Not taken".

BIBLIOGRAPHY

Basic:
- Wolpaw, Jonathan R.; Winter Wolpaw, Elizabeth. Brain-computer interfaces : principles and practice. New York: Oxford University Press, 2012. ISBN 9780195388855.

Complementary:
- Nam, Chang S.; Nihjolt, Anton; Lotte, Fabien. Brain-computer interfaces handbook : technological and theoretical advances [on line]. Boca Raton: CRC Press, Taylor and Francis Group, 2018 [Consultation: 13/12/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5216314. ISBN 9781351231930.
- Merletti, Roberto ; Dario Farina. Surface Electromyography : Physiology, Engineering, and Applications [on line]. New York: Wiley-IEEE Press, 2016 [Consultation: 21/04/2023]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781119082934. ISBN 9781119082873.
- M. Simao, N. Mendes, O. Gibaru and P. Neto. "A review on electromyography decoding and pattern recognition for Human-Machine Interaction". IEEE Access [on line]. Vol. 7 (2019) pp. 39564 - 39582 [Consultation: 17/07/2020]. Available on: https://ieeexplore.ieee.org/document/8672131.- I. Lazarou, S. Nikolopoulos, P.C. Petrantonakis, I. Kompatsiaris and M. Tsolaki. "EEG-based brain-computer interfaces for communication and rehabilitation of people with motor impairment: A novel approach of the 21st century.". Frontiers in Human Neuroscience [on line]. 2018 Jan 31;12:14 [Consultation: 17/07/2020]. Available on: https://pubmed.ncbi.nlm.nih.gov/29472849/.- Hari, Riita ; Aina Puce. MEG-EEG Primer [on line]. New York: Oxford University Press, 2017 [Consultation: 21/07/2022]. Available on: https://oxfordmedicine-com.recursos.biblioteca.upc.edu/view/10.1093/med/9780190497774.001.0001/med-9780190497774. ISBN 0190497793.