Subject: Biodevices (BID)
Code: 32427
Institution: Escuela Politécnica Superior
Degree: Master's program in Research and Innovation in Information and Communications Technologies (I^2-ICT)
Level: Master
Type: Elective [Biomedical Informatics]
ECTS: 6

COURSE GUIDE: Biodevices (BID)

Academic year: 2017-2018

Program: Master's program in Research and Innovation in Information and Communication Technologies (I^2-CIT)
Center: Escuela Politécnica Superior
University: Universidad Autónoma de Madrid

Last modified: 2016/05/10

Subject: Biodevices (BID)
Code: 32427
Institution: Escuela Politécnica Superior
Degree: Master's program in Research and Innovation in Information and Communications Technologies (I^2-ICT)
Level: Master
Type: Elective [Biomedical Informatics]
ECTS: 6

1. BIODEVICES / BID

Biodispositivos
Biodevices (BID)

1.1. Programa / program

Máster Universitario en Investigación e Innovación en Tecnologías de la Información y las Comunicaciones (I^2-TIC)

Master in Research and Innovation in Information and Communication Technologies (I^2-CIT) [Officially certified]

1.2. Course code

22427

1.3. Course areas

Computer Science and Artificial Intelligence

1.4. Tipo de asignatura / Course type

Optativa [itinerario: Informática Biomédica]
Elective [itinerary: Biomedical Informatics]

1.5. Semester

Second semester

1.6. Credits

6 ETCS

1.7. Language of instruction

The lecture notes are in English. The lectures are mostly in Spanish. Some of the lectures and seminars can be in English.

1.8. Recommendations / Related subjects

Related subjects are:

- Procesamiento de señales biomédicas y sus aplicaciones [Biomedical signal processing and its applications]
- Neuroinformática [Neuroinformatics]
- Caracterización de redes y topologías biológicas [Characterization of biological networks and topologies]
- Computación Bioinspirada [Bio-inspired computing]
- Procesamiento de imágenes biomédicas y sus aplicaciones [Biomedical image processing and its applications]
- Sistemas de información en biomedicina: integración y gestión del conocimiento [Information systems in biomedicine: integration and knowledge management]

1.9. Lecturers

Add @uam.es to all email addresses below.

Lectures and labs:

Dr. Pablo Varona (Coordinator)
Departamento de Ingeniería Informática
Escuela Politécnica Superior
Office: B-330
Tel.: +34 914972263
e-mail: pablo.varona
Web: http://www.eps.uam.es/~pvarona

Dr. Francisco de Borja Rodríguez
Departamento de Ingeniería Informática
Escuela Politécnica Superior
Office: B-355
Tel.: +34 914972236
e-mail: f.rodriguez
Web: http://www.eps.uam.es/~frodrig

Dr. Kostadin Koroutchev
Departamento de Ingeniería Informática
Escuela Politécnica Superior
Office: B-355
Tel.: +34 914973210
e-mail: k.koroutchev
Web: http://www.eps.uam.es/~kostadin

1.10. Objetivos de la asignatura / Course objectives

En esta asignatura se describen los fundamentos para la interacción bidireccional asistida entre sistemas biológicos y distintos tipos de dispositivos que permiten la implementación de interfaces cerebro máquina, prótesis, dispositivos de uso clínico, de rehabilitación y neurorobótica. La asignatura describe varios paradigmas de biofeedback y neurofeedback utilizados tanto en tareas de extracción de información como en tareas de control (del sistema biológico o de un dispositivo que utilice la señalización biológica). Se introduce el paradigma del observador dinámico en tiempo real para la detección de eventos, control y exploración de estímulos que favorezcan la interacción bidireccional para este tipo de tareas. Se describen varios ejemplos de ciclos cerrados de interacción con sistemas biológicos que revelan aspectos de las señales biológicas, favorecen el control y posibilitan el diseño de nuevos tipos de interfaces hombre-máquina y en general de dispositivos inteligentes para aplicaciones biomédicas y tecnológicas, incluyendo el contexto del *big-data* biomédico.

In this course we study the fundamentals for assisted bidirectional interactions between biological systems and different types of devices enabling the development of brain machine interfaces, prostheses, devices for clinical use, for rehabilitation and neurorobotics engineering. The course describes several paradigms of biofeedback and neurofeedback in biomedical environments for information extraction and control tasks. We introduce the concept of real-time dynamical observer for event detection, control and stimulus exploration. Several examples of closed-loop interactions with biological systems are described for the tasks of revealing information, control and implanting new types of human-computer interfaces in biomedical and technological applications, including biomedical big data.

At the end of each unit, the student should be able to:

UNIT BY UNIT SPECIFIC OBJECTIVES	
UNIT 1.- Introduction to bio-signal recordings	
1.1.	Describe the different bio-signal types and recording techniques
1.2.	List the devices and algorithms used to record and characterize bio-signals
1.3.	List the different applications of offline and online biosignal analysis
UNIT 2.- Closed-loop paradigms: biofeedback and neurofeedback	
2.1.	List and explain biofeedback and neurofeedback approaches in the context of biomedical applications
2.2.	List and explain biofeedback and neurofeedback closed-loops in human-computer interfaces

UNIT 3.- Real time dynamical observer	
4.1.	Describe the basic components of a real-time dynamical observer
4.2.	Characterize different methods to implement unimodal and multimodal event detection
4.3.	Describe the basic elements to build and refine an internal representation
4.4.	Characterize the methods to perform goal-driven stimulus exploration
4.4.	List and explain closed-loop performance measurements
UNIT 5.- Biomedical and human-computer interface applications	
5.1.	List and explain closed-loop biomedical applications
5.2.	List and explain closed-loop applications in the context of human-computer interfaces
UNIT 6.- Biohybrid devices and biomimetics	
6.1.	Differentiate between bio-hybrid and biomimetic approaches
6.2.	Describe the elements of bio-inspiration in different devices
6.3.	Characterize the advantages of neurobotic approaches
6.4.	Characterize the use of portable sensors and devices in biomedical big-data

1.11. Course contents

1. Introduction to bio-signal recordings
    a. Bio-signal types
    b. Devices to record bio-signals
    c. Applications of online and offline biosignal analysis

2. Closed-loop paradigms: biofeedback and neurofeedback
    a. Activity-dependent stimulation
    b. Biofeedback
    c. Neurofeedback

3. Real time dynamical observer
    a. Event detection
    b. Internal representation
    c. Goal-driven stimulus exploration
    d. Performance measurements

4. Biomedical and human-computer interface applications
    a. Closed-loop applications in biomedicine
    b. Closed-loop applications in human-computer interfaces

5. Biohybrid devices and biomimetics
    a. Biohybrid devices
    b. Bio-inspired devices
    c. Neurorobotics
    d. Biomedical big data

1.12. Course bibliography

1. Closed Loop Neuroscience, A. El Hady. Elsevier, 2016
2. Brain-computer interfacing: an introduction. Rao, Rajesh P. N. Cambridge University Press, 2013.
3. Brain-Computer Interface Research: A State-of-the-Art Summary. Christoph Guger, Brendan Z. Allison, Günter Edlinger. Springer, 2013.
4. Neural control engineering the emerging intersection between control theoryand neuroscience. Schiff, Steven J. 2012.
5. Neural Engineering. Bin He. Springer, 2013.
6. Handbook of neural activity measurement. Brette, Romain. 2012.
7. Biofeedback: a practitioner's guide. M.S. Schwartz (Ed). 2005. The Guilford Press.
8. Toward Brain-Computer Interfacing. Guido Dornhege, José del R. Millán, Thilo Hinterberger, Dennis J. McFarland, Klaus-Robert Müller. 2007.
9. Neuroengineering. Daniel J. DiLorenzo, Joseph D. Bronzino. 2008.
10. Biomedical Signal Analysis: A Case-Study Approach. Rangaraj M. Rangayyan. 2002.
11. Electric Fields of the Brain: The Neurophysics of EEG. Paul L. Nuñez (Author), Ramesh Srinivasan (Author). 2006.
12. Introduction to Biomedical Engineering. John Enderle, Joseph Bronzino. Academic Press. 2011. 3rd edition.
13. Neural Prostheses for Restoration of Sensory and Motor Function. John K. Chapin, K. A. Moxon (Eds). CREC Press 2000.
14. Introduction to Quantitative EEG and Neurofeedback. Thomas H. Budzynski (Ed). Academic Press 2008.
15. A Practical Guide to Brain-Computer Interfacing with BCI2000. Gerwin Schalk, Jürgen Mellinger. 2010.
16. Dynamic-Clamp: From Principles to Applications. Alain Destexhe, Thierry Bal. 2010.
17. EEG Signal Processing. Saeid Sanei, J. A. Chambers. John Wiley & Sons, 2007.
18. Data-Driven Healthcare, Laura B. Madsen, Wiley, 2014.

1.13. Coursework and evaluation

The course involves lectures, weekly assignments, lab assignments, a seminar presentation and one exam.

In both the ordinary and the extraordinary exam period it is necessary to have a pass grade (≥ 5) in each of these assessments to pass the course.

- In the ordinary exam period, the evaluation will be made according to the following scheme
    - 20 % Exercises and class participation
    - 20 % Lab assignments
    - 60 % Project presentation on a research topic in biodevices

- In case of a fail grade, the student has the opportunity to
    - Turn in all the exercises with corrections
    - Turn in all the lab assignments with corrections.

All assessments are mandatory both in in the ordinary and extraordinary evaluation periods.