Subject: Biomedical Signal Processing and its applications (BSP)
Code: 32424
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: Biomedical Signal Processing and its applications (BSP)

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: 2017/06/12
Status: Approved 2017/07/11

1. ASIGNATURA / COURSE (ID)

Procesamiento de Señales Biomédicas y sus aplicaciones Biomedical Signal Processing and its applications (BSP)

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

32424

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

First semester

1.6. Credits

6 ECTS

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

Basic knowledge of data analysis processing should be useful to follow the course.

Related subjects are:

- Neuroinformática [Neuroinformatics]
- Biodispositivos [Biodevices]
- Caracterización de redes y topologías biológicas [Characterization of biological networks and topologies]
- Procesamiento de imágenes biomédicas y sus aplicaciones [Biomedical image processing and its applications]
- Aprendizaje Automático: teoría y aplicaciones [Machine Learning: theory and applications]

1.9. Lecturers

Add @uam.es to all email addresses below.

Lectures and labs:

Dr. Francisco de Borja Rodríguez Ortiz (Coordinator)
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1.10. Objetivos de la asignatura / Course objectives

Las señales biomédicas son las observaciones de las diversas actividades fisiológicas de los organismos vivos, como pueden ser actividad neuronal, actividad cardiaca, actividad respiratoria, etc. El análisis y caracterización de estas, es fundamental para entender la fisiología el funcionamiento y el procesamiento de la información que tiene lugar en estos sistemas. Por lo tanto, el estudio a través de algoritmos por computador de estas señales es fundamental para el entendimiento del funcionamiento y la observación clínica de los organismos vivos. El objetivo fundamental de este curso es entender y trabajar con los principales métodos y algoritmos existentes para el análisis de señales biomédicas, para así poder extraer la información más relevante de las mismas.

Biomedical signals are the observations of the various physiological activities of living organisms, such as neuronal activity, cardiac activity, respiratory activity, etc. The analysis and characterization of these data is fundamental to understand the physiological function and information processing that occurs in these systems. Therefore, the study and extraction of relevant information through computer algorithms for these signals is essential for the clinical observation of living organisms in order to infer the underlying biological functions. The main goal of this lecture is to understand and work with major existing methods and algorithms for the analysis of biomedical signals, in order to extract the most relevant information from them.

After this course, the student should be able to:

UNIT BY UNIT SPECIFIC OBJECTIVES	
UNIT 1.- Introduction to the analysis of bioelectric activity	
1.1.	Describe the different types of bioelectric activity
1.2.	Describe the experimental techniques of recording biosignals
UNIT 2.- Various paradigms of information processing through bioactivity	
2.1.	Understand and study the stochastic nature of bioelectric activity
2.2.	Understand and study the information processing derived from analysis of the biological signals
UNIT 2.- Techniques for analysis of bioelectric signals and other biomedical data	
3.1.	Describe the major existing methods and algorithms for analysis of biomedical signals
3.2.	Understand and apply the major existing methods and algorithms for analysis of biomedical signals

1.11. Course contents

UNIT 1.-Introduction to the analysis of bioelectric activity

1. Introduction to different types of bioelectric activity and its diversity
2. Introduction to experimental techniques for registration of biosignals

UNIT 2.-Various paradigms of information processing through bioactivity

1. Stochastic nature of bioelectric activity
2. Processing information through neural activity
    a. Neural Code
    b. Encoding and decoding systems
3. Other physiological bioelectric signals

UNIT 3.-Techniques for analysis of bioelectric signals and other biomedical data

1. Time domain versus frequency domain analysis
2. Biosignals filtering
3. Correlation Analysis
4. Fourier analysis
5. Wavelet analysis
6. Information Theory
7. Detection and characterization of bioelectric events
8. Causality analysis
9. Independent component analysis (ICA)

1.12. Course bibliography

1. Fundamentals of Computational Neuroscience, Thomas P. Trappenberg. Oxford University Press. 2002.
2. Signal Processing for Neuroscientist. Wim van Drongelen
3. ELEMENTS OF INFORMATION THEORY. THOMAS M. COVER JOY A. THOMAS. Wiley- Interscience
4. Fundamentals of Signals and Systems Using MATLAB. Edward W. Kamen, Bonnie S. Heck. Prentice-Hall.
5. Biophysics of Computation. Information Processing in Single Neurons. C. Koch. Oxford University Press: New York, Oxford
6. Theoretical Neuroscience Computational and Mathematical Modeling of Neural Systems. Peter Dayan and LF Abbott. MIT 2001.

7. Spikes: Exploring the Neuronal Code. F. Rieke and D. Warland and R. de Ruyter van Steveninck and W. Bialek. A Bradford Book. MIT Press. Cambridge, Massachusetts, London, England, 1997.
8. Information Theory, Inference and Learning Algorithms. David J.C. MacKay.
9. Adaptive Filtering Algorithms and Practical Implementation. Paulo S.R. Diniz Medical Statistics at a Glance. Aviva Petrie, Caroline Sabin. Blackwell Science.
10. Adaptive Signal Processing. Bernard Widrow and Samuel Stearns. Englewood Cliffs, New Jersey : Prentice-Hall, 1985
11. Biomedical Signal Processing and Signal Modeling. Eugene N. Bruce. 2001.
12. Advanced Biosignal Processing. Nait-Ali, Amine (Ed.). 2009.
13. Biomedical Signal Analysis: A Case-Study Approach. Rangaraj M. Rangayyan. 2002.
14. MATLAB for Neuroscientists: An Introduction to Scientific Computing in MATLAB. Pascal Wallisch, Marc Benayoun, Michael Lusignan, Adam Seth Dickey, Nicho Hatsopoulos, Tanya I. Baker
15. Cohen, M. X. (2014). Analyzing neural time series data: theory and practice. MIT Press.

1.13. Coursework and evaluation

The course involves lectures, assignments and a seminar presentation.

In both the ordinary and the extraordinary exam period, it is necessary to have a grade ≥ 5 to pass the course.

In the ordinary exam period, the evaluation will be made according to the following scheme:

1. Exercises and class participation 20%.
2. Presentation of a research paper with innovation own work on the topic 40%.
3. Lab assignments 40%.

In case of a fail grade in the ordinary exam period, in the extraordinary exam period, the student has the opportunity to

1. Turn in all the exercises 20%.
2. Turn in a report on a research paper with innovation own work on the topic 40%.
3. Turn in all lab assignments 40%.