Course guide
240IBI11 - 240IBI11 - Biomedical Signals

Last modified: 15/06/2023

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

Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN NEUROENGINEERING AND REHABILITATION (Syllabus 2020). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer: Mañanas Villanueva, Miguel Angel

Others: Miquel Angel Mañanas Villanueva
Rojas Martínez, Mónica Marlene

PRIOR SKILLS

To facilitate the comprehension of the content and to reach the objectives of the subject, it is necessary to have the knowledge of basics on signal processin, and discrete-time signal signals and Systems

REQUIREMENTS

Calculus I, Calculus II, System Dynamics, Automatic Control and Introduction of Biomedical Signals from GETI

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEEBIO3. Identify and extract information of interest in the biomedical signs.

TEACHING METHODOLOGY

The learning of the theory and problems of the course will be carried out using different materials such as lectures, presentations, reference books and videos of each section and content of the syllabus available at the Atenea (Virtual Campus). It is preferred interactive sessions with the students to monitor their progress and solve doubts apart from possible tutorial sessions at the student's request.
Half of the sessions are Lab ones carried out in pairs at the Computer Room. They will be based on the use and coding algorithms in Matlab for biomedical signal processing: electrocardiographic, electromyographic, electroencephalographic, evoked potentials, etc. A report with the code, results, and comments will be delivered after each Lab session via Atenea before starting the following one.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective is that student knows new tools of signal processing and their applications to the field of Neuroengineering and Rehabilitation.

Specific Objectives are that student:
- Identifies and extracts information of interest in biological signals.
- Designs, performs, and validates advanced algorithms of biomedical signals processing.
- Has the ability to change signals by time-variant filters in discrete-time.
- Designs filters and applies techniques for noise reduction and biological events detection of interest.

STUDY LOAD

Type	Hours	Percentage
Hours large group	20,3	18.03
Hours small group	20,3	18.03
Self study	72,0	63.94

Total learning time: 112.6 h

CONTENTS

INTRODUCTION TO BIOMEDICAL SIGNAL PROCESSING

Description:
• Discrete-time signal processing
• Signals sampling
• Discrete-time system: convolution and correlation
• Discrete Fourier Transform
• Time window
• Frequency variables
• LTI filters

Specific objectives:
• To review the basic contents on signal processing.
• To know more aboout the interest of these contents on biomedical Applications
• To filter ECG and detecting premature ventricular contractions (PVC)

Related activities:
Lectures of theoretical explanations and laboratory

Related competencies :
CEEBIO3. Identify and extract information of interest in the biomedical signs.

Full-or-part-time: 21h
Theory classes: 3h
Laboratory classes: 3h
Self study : 15h

SPECTRAL ESTIMATION IN STATIONARY SIGNALS

Description:
• Stationary signals
• Testing signals
• Non-parametric methods
* Periodogram
* Welch Periodogram
* Correlogram
• Parametric methods
* Transfer Function models
* AR model
* MA and ARMA models
* Order selection
• Influence of estimator on frequency variables

Specific objectives:
* To list the stages of a recording system of biomedical signals.
* To understand and to know how to apply the sampling theorem.
* To calculate and to interpret the convolution, correlation and autocorrelation signals.

Related activities:
Lectures of theoretical explanations and laboratory

Related competencies :
CEEBIO3. Identify and extract information of interest in the biomedical signs.

Full-or-part-time: 21h
Theory classes: 3h
Laboratory classes: 4h 30m
Self study : 13h 30m

TIME FREQUENCY REPRESENTATION OF NON-STATIONARY SIGNALS

Description:
• Introduction
• Reverse arrangement test
• Short Time Fourier Transform
• Continuous Wavelet
• Discrete Wavelet

Specific objectives:
* To understant the necessity of different spectral estimators under non stationary conditions
* To know a test for a quantitive evaluation of signals stationarity level
* To know different methods to estimate the the spectral contents of a biomedical signal in a time-frequency/scale plain.
* To identify the discrete wavelet as a bank filter

Related activities:
Lectures of therotical explanations and laboratory

Related competencies :
CEEBIO3. Identify and extract information of interest in the biomedical signs.

Full-or-part-time: 18h
Theory classes: 3h
Laboratory classes: 3h
Self study : 12h

ADVANCED FILTERING

Description:
• Matched filter
* Introduction
* Derivation of the Transfer Function of the matched filter
* Examples with synthetic signals and EEG
• Time-domain: synchronized averaging
* Definition
* Examples: ERP, ECG and PCG
• Adaptive filtering
* Definition
* LMS algorithm
* Examples
* Example: cardiac activity reduction in myographic signals

Specific objectives:
* To identify the best filtering depending on the noise characteristics and the type of signal
* To understand the relationship between the correlation and the matched filter
* To identify the necessary conditions to apply the synchonized averaging
* To observe the improvement of extraction of a signal of interest in an event related potential study with electroencephalography
* To apply two artifacts reduction in electromyographic signals.
* To detect Spike-and-wave Complexes in EEG Signals
* To apply synchronized averaging for noise reduction: SEP, ERP and QRS
* To reduce power line in EMG signals by adaptive filtering
* To filter ECG interference in EMG signals with an adaptive filter

Related activities:
Lectures of theoretical explanations and laboratory

Related competencies :
CEEBIO3. Identify and extract information of interest in the biomedical signs.

Full-or-part-time: 39h 30m
Theory classes: 9h
Laboratory classes: 10h 30m
Self study : 20h

ENVELOPE EXTRACTION

Description:
• FIR filter or Moving average
• Analytic signal (Hilbert Transform)
• Empiric Mode Decomposition

Specific objectives:
* To know the interest of amplitude estimation in applications of neuroengineering and rehabilitation.
* To know different methods to calculate the envelope of a biomedical signal
* To calculate the envelope in EMG signals

Related activities:
Lectures of theoretical explanations with problems and examples

Related competencies :
CEEBIO3. Identify and extract information of interest in the biomedical signs.

Full-or-part-time: 13h
Theory classes: 3h
Self study : 10h

GRADING SYSTEM

There are two evaluations during the semester:
• Continuous evaluation of Lab Sessions based on attendance and reports delivered. Score: Nep.
• A final exam based on theoretical questions which need basic qualitative reasoning. A scientific calculator and a page DINA4 with formula can be available. Score: Nef .

The final mark of the subject, Nfinal , will be the following weighted average score:
Nfinal= 0,5 Nef + 0,5 Nep

To apply for the reevaluation will be conditioned to have carried out the Laboratory practices.
The score of reevalution will subtitute the score of Nef

EXAMINATION RULES.

For the final exam the student can have a scientific calculator and a DINA4 page with any notes.

BIBLIOGRAPHY

Basic:
- Rangaraj M. Rangayyan. Biomedical Signal Analysis: A Case-Study Approach [on line]. 2nd ed. Piscataway, NJ: Wiley-IEEE Press, 2002 [Consultation: 15/06/2023]. Available on: https://ieeexplore.ieee.org/servlet/opac?bknumber=5264168. ISBN 9780471208112.

Complementary:
- S. Lawrence Marple Jr . Digital Spectral Analysis with Applications [on line]. 2nd. Dover Publications, 2019 [Consultation: 15/06/2023]. Available on: https://books.google.es/books/about/Digital_Spectral_Analysis.html?id=uEOjngEACAAJ&redir_esc=y. ISBN 978-0486780528.
- Sörnmo, Leif ; Laguna, Pablo. Bioelectrical signal processing in cardiac and neurological applications [on line]. Burlington: Elsevier Academic Press, cop. 2005 [Consultation: 10/09/2014]. Available on: http://www.sciencedirect.com/science/book/9780124375529. ISBN 0124375529.
- Bronzino, Joseph D. The Biomedical Engineering Handbook. Section VI. 3rd ed. Boca Raton: CRC Press, 2006. ISBN 0849321220.
- Philip A. Parker, Roberto Merletti, Philip A. Parker. Electromyography: Physiology, Engineering, and Noninvasive Applications [on line]. 2nd ed. Wiley-IEEE Press, 2004 [Consultation: 15/06/2023]. Available on: https://www.google.es/books/edition/Electromyography/SQthgVMiI3YC?hl=ca&gbpv=0. ISBN 9780471675808.

RESOURCES

Hyperlink:
- www.sciencedirect.com. Database of articles of scientific journals and conferences from the Publisher Elsevier
- www.pubmed.com. Database of sicentific articles and journals in the field of Biomedical Engineering and Medicine
- http://ieeexplore.ieee.org/. Database of articles of scientific journals and conferences from the Society IEEE