Course guide
240659 - 240659 - Introduction to Biomedical Signals

Last modified: 15/06/2023

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

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

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

LECTURER

Coordinating lecturer: Miquel Angel Mañanas Villanueva

Others: Miquel Angel Mañanas Villanueva

PRIOR SKILLS

Ability with complex calculations, mathematical theory and theory of continuous systems

REQUIREMENTS

Calculus I, Calculus II, System Dynamics, Automatic Control

TEACHING METHODOLOGY

In the sessions at the classroom, the lecturer will introduce the learning process through theoretical explanations and illustrative examples, concepts, methods and results of the subject. In the problem-solving sessions, the lecturer will guide the students in exercises and problems related to the topic. In the laboratory sessions students will put into practice the concepts, methods and results of the subject with the lecturer's help and working directly on real biomedical signals from different biological systems. Students, independently, should study to assimilate concepts and solve exercises, and work on an application case group.

Finally, another component of the learning process is based on the development in groups of a final work on a topic of biomedical engineering where students will apply the techniques learnt in class.

LEARNING OBJECTIVES OF THE SUBJECT

THIS IS A VERY IMPORTANT AND BASIC SUBJECT FOR THOSE WHO WISH TO CONTINUE WITH BIOMEDICAL POSTGRADUATE STUDIES, EITHER AS A BIOMEDICAL SPECIALTY AT THE MUEI, THE MUNR OR THE MEB GIVEN AT THE ETSEIB. LEARNING THE CONTENTS OF THIS SUBJECT WILL ALLOW THE UNDERSTANDING OF OTHERS IN THE AFOREMENTIONED MASTERS

Main objective is that student knows basic tools of signal processing and their applications to the field on Biomedical Engineering.

Specific Objectives are that student:

* Knows and classify signals depending on their nature.
* Has ability for changing signals by filters in discrete-time.
* Knows relationships between time and frequency domains, and to be able to extract relevant information from biomedical signals in both domains.
* Designs simple filters and applies basic techniques for artifact reduction and for biological events detection of interest.

STUDY LOAD

Type	Hours	Percentage
Self study	72,0	61.54
Hours large group	27,0	23.08
Hours small group	18,0	15.38

Total learning time: 117 h

CONTENTS

INTRODUCTION

Description:
* Signals, systems and signals processing
* Signals classification
* Concept of frequency (continuous and discrete time)
* Examples of biomedical signals

Specific objectives:
* To explain the origin and characteristics associated with biomedical signals.
* To know and classify the signals according to their nature

Related activities:
Lectures of theoretical explanations and laboratory

Full-or-part-time: 7h 30m
Theory classes: 2h
Laboratory classes: 2h
Self study : 3h 30m

Discrete time signals and systems

Description:
* Discrete time signals. Sampling Theorem
* Discrete time systems and signals convolution
* Correlation de discrete time signals

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

Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 2h
Self study : 10h

Z TRANSFORM

Description:
* Definition
* Properties of Z transform
* Rational Z transforms
* Analysis of LTI systems in Z domain

Specific objectives:
* To identify the properties of a discrete-time system.
* To explain the particular characteristics of a linear time invariant system (LTI).
* To represent the transfer function and the block diagram of a LTI system.
* To interpret Z Transform, and to associate the poles and zeros of a LTI system with the filter effect over the biomedical signal input

Related activities:
Lectures of therotical explanations with problems
Resolution and correcting problems in groups through puzzle technique

Full-or-part-time: 8h
Theory classes: 2h
Self study : 6h

Signals Frequency Analysis

Description:
* Frequency analysis of continuous time signals (periodic and non-periodic)
* Frequency analysis of discrete time signals (periodic and non-periodic)
* Properties of Discrete time Signals Fourier Transform
* Discrete Fourier Transform (DFT).

Specific objectives:
* To explain what is the frequency representation of signals.
* To develop and plot the power spectral density (PSD) of a discrete signal.
* To understand the relationships of time and frequency domain, and to be able to extract relevant information from biomedical signals in the two domains

Related activities:
Lectures of theoretical explanations with problems and laboratory

Full-or-part-time: 34h
Theory classes: 10h
Laboratory classes: 4h
Self study : 20h

FILTERING AND INTERPRETATION OF BIOMEDICAL SIGNALS

Description:
* LTI systems as frequency selective filters
* FIR Filters
* IIR Filtres

Specific objectives:
* To understand the filter function of a LTI system.
* To calculate and to plot the frequency response of an LTI system.
* To design different types of filters in the discrete domain.
* To apply discrete analysis and interpretation of biomedical signal filters.

Related activities:
Lectures of theoretical explanations with problems and laboratory

Full-or-part-time: 19h
Theory classes: 4h
Laboratory classes: 2h
Self study : 13h

Problems and examples of biomedical signal processing

Description:
* Noise reduction and artifacts removing.
* Detection of events of interest in biomedical signals.

Specific objectives:
* To apply basic techniques for reducing artifacts present in biomedical signals.
* To propose methods for the detection of events of interest and extract relevant information into biomedical signals

Related activities:
Lectures of theoretical explanations with problems and laboratory

Full-or-part-time: 4h
Theory classes: 1h
Laboratory classes: 2h
Self study : 1h

NON-INVASIVE BLOOD PRESSURE MEASUREMENT SYSTEM

Description:
* Project to be done in groups of 4-5 students and submitted at the end of the course
* Estimation of systolic and diastolic pressure from temporal and frequency analysis of the pressure signal and Korotkoff sounds, as well as analysis of the electrocardiographic signal

Specific objectives:
* Teamwork, solving possible conflicts, prioritizing the effectiveness of the team as well as the presentation of the results generated.
* Comparison of the results obtained with different methods and drawing conclusions
* Ability to solve problems, take initiatives and share skills with other team members

Related activities:
* Knowledge of the state of the art in the treatment of systolic and diastolic pressure as well as Korotkoff sounds
* Analysis of the signals and determination of the information to be extracted
* Development of algorithms for signal processing
* Report writing and presentation

Full-or-part-time: 22h
Laboratory classes: 2h
Self study : 20h

GRADING SYSTEM

There are five evaluations during the semester:

* Continuous evaluation from exercises. Score: Nac.
* A mid-term exam during the fourth chapter of the program based on two parts. Score: Npp .
* Evaluation of Lab Sessions based mainly on attendance and reports delivered. Score: Nep .
* Work related to biomedical signal processing developed by three students-groups which will be delivered at the end of the semester. Score: Nt
* A final exam based on two parts. Score: Nef .

The final mark of the subject, Nfinal , will be the following weightened averaged score:

Nfinal= 0,5 Nef + 0,3 NPR + 0,2 Nep

To apply for the reevaluation will be conditioned to have carried out the Laboratory practices and to be presented the final work
The score of reevaluation will replace the score of Nef

EXAMINATION RULES.

For the final exam which will be composed of two parts:

* A first part with theoretic questions which need basic qualitative reasoning, and
* A second part consisting in problems solving. For this part, scientific calculator and class notes will be available.

BIBLIOGRAPHY

Basic:
- Bruce, Eugene N. Biomedical signal processing and signal modeling. John Wiley & Sons: John Wiley & Sons, 2001. ISBN 0471345407.
- Proakis, J.G. ; Manolakis, D.G. Tratamiento digital de señales [on line]. 4a ed. Madrid: Pearson Prentice-Hall, 2007 [Consultation: 18/09/2020]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=3042. ISBN 9788483223475.

Complementary:
- Sörnmo, Leif ; Pablo Laguna. Bioelectrical signal processing in cardiac and neurological applications [on line]. Burlington: Elsevier Academic Press, cop. 2005 [Consultation: 18/09/2020]. Available on: https://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 0849321247.

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