240IBI11 - Biomedical Signals

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control
Academic year: 2019
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
ECTS credits: 4,5
Teaching languages: English

Teaching staff

Coordinator: Miquel Angel Mañanas Villanueva
Others: Miquel Angel Mañanas Villanueva

Opening hours

Timetable:
Monday 11:30 a 13:00 i 16:30 a 17:30
Wednesday 11:00 a 13:00
Thursday 15:00 a 16:30

Prior skills

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

Requirements

Calculus I, Calculus II, System Dynamics, Automatic Control

Degree competences to which the subject contributes

Specific:
CEEIBIO3. Identify and extract information of interest in the biomedical signs.

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 including its presentation in class.

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 search the state of the art and how the processing of biomedical signals is used either to aid diagnosis, monitoring or patient’s rehabilitation. The work will be presented orally to the rest of the students with the aim of learning different case studies in the subject because all works/topics will be different.

Learning objectives of the subject

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

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours large group: 27h</th>
<th>24.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours small group:</td>
<td>13h 30m</td>
<td>12.00%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>72h</td>
<td>64.00%</td>
</tr>
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</table>
# 240IBI11 - Biomedical Signals

## Content

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<thead>
<tr>
<th>INTRODUCTION</th>
<th>Learning time: 10h 30m</th>
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<tr>
<td>Theory classes: 3h</td>
<td></td>
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<tr>
<td>Laboratory classes: 2h 30m</td>
<td></td>
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<tr>
<td>Self study: 5h</td>
<td></td>
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</table>

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

### Related activities:
Lectures of theoretical explanations and laboratory

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

<table>
<thead>
<tr>
<th>Discrete time signals and systems</th>
<th>Learning time: 19h 30m</th>
</tr>
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<tbody>
<tr>
<td>Theory classes: 7h</td>
<td></td>
</tr>
<tr>
<td>Laboratory classes: 2h 30m</td>
<td></td>
</tr>
<tr>
<td>Self study: 10h</td>
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</tbody>
</table>

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

### Related activities:
Lectures of theoretical explanations and laboratory

### 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.
# Z Transform

**Learning time:** 8h  
Theory classes: 2h  
Self study: 6h

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

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

**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

# Signals Frequency Analysis

**Learning time:** 39h  
Theory classes: 12h  
Laboratory classes: 5h  
Self study: 22h

**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).  
* Signals Frequency Analysis using DFT. Time windows

**Related activities:**  
Lectures of theoretical explanations with problems and laboratory

**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
<table>
<thead>
<tr>
<th>Filtering and interpretation of biomedical signals</th>
<th>Learning time: 19h 30m</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 2h 30m</td>
</tr>
<tr>
<td></td>
<td>Self study : 13h</td>
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</tbody>
</table>

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

**Related activities:**
Lectures of theoretical explanations with problems and laboratory

**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.

<table>
<thead>
<tr>
<th>Problems and examples of biomedical signal processing</th>
<th>Learning time: 16h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
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<td></td>
<td>Laboratory classes: 2h 30m</td>
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<td></td>
<td>Self study : 11h 30m</td>
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**Description:**
* Noise reduction and artifacts removing.
* Detection of events of interest in biomedical signals.

**Related activities:**
Lectures of theoretical explanations with problems and laboratory

**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.
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:

\[ N_{\text{final}} = 0.5 \times N_{\text{ef}} + 0.15 \times N_{pp} + 0.15 \times N_{ep} + 0.1 \times N_{t} + 0.1 \times N_{ac} \]

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 revaluation will substitute the scores of Npp, Nac and Nef.

**Qualification system**

**Regulations for carrying out activities**

For the final and mid term exams 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:


Complementary:


Others resources:

Hyperlink
www.sciencedirect.com
  Database of articles of scientific journals and conferences from the Publisher Elsevier

www.pubmed.com
  Database of scientific 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