INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Biomedical Signal Processing			Field of study	Instrumentation and Biomedical Signals		
Bachelor in	Biomedical Technology			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	3	Level	1-3	ECTS credits	6.0
Type	Semestral	Semester	1	Code	9600-752-3103-00-23		

Workload (hours)	162	Contact hours	T	-	TP	60	PL	-	TC	-	S	-	E	-	OT	-	O	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Fernando Jorge Coutinho Monteiro, Felipe Lage Teixeira, Rui Vitor Pires Fernandes

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. express himself in the oral and written form on problems of Signal Processing using adequate language and terminology;
2. perform basic operations with signals;
3. create and represent, under Matlab environment, signals in original and transformed domains using the FFT;
4. sample a continuous time signal respecting the Nyquist theorem;
5. interpret the spectral representation of signals;
6. interpret and represent the transfer function / frequency response of a system;
7. project and implement digital filters;
8. recognize the characteristics of typical biologic signals.

Prerequisites

Before the course unit the learner is expected to be able to:
1. have knowledge about mathematical summation;
2. have knowledge about integral calculus;
3. work with complex numbers and complex functions.

Course contents

Signals. Signal representation in time and frequency domains. Relation between those representations. Operations with signals. Discrete-time systems; discrete convolution. Fourier transform of discrete-time signals. Sampling. The z transform. Discrete Fourier transform (DFT). Project and implementation of FIR and IIR digital filters. Characteristics of biologic signals such as EEG, ECG, EMG, EOG and voice.

Course contents (extended version)

1. Introduction to Digital Signal Processing
2. Signals
   - Continuous and discrete-time signals
   - Basic operations with signals
   - Properties of the signals: even signals; odd signals; periodicity
   - Elementary signals: exponential; sinusoidal; complex exponential; step function; impulse function
3. Discrete Systems
   - Model of a system
   - Properties of systems
   - Impulse response
   - Discrete convolution
   - Frequency response of a system
   - Fourier transform of a discrete-time signal
   - Properties of the Fourier transform
   - Differences equation to the transfer function
4. Sampling of continuous-time signals
   - Introduction
   - Nyquist sampling theorem
   - Aliasing
   - Reconstruction of a signal from its samples
   - Interpolation
   - Decimation
5. The z-Transform
   - Definition
   - Region of convergence
   - Relation with Fourier transform
   - Z-transform properties
   - Inversion of z-transform
6. The Discrete Fourier Transform - DFT
   - Definition
   - Properties of DFT
   - Relation with z-transform
   - Linear convolution using the discrete Fourier transform
   - Fast Fourier transform algorithms - FFT
   - Inverse discrete Fourier transform
7. Digital Filters
   - Filters characteristics specification
   - FIR digital filters project
   - IIR digital filters project
   - Frequency transformations
   - Digital filter implementation under Matlab
8. Biological Signals
   - Acquisition process of voice EEG, EKG and EMG signals
   - Characteristics of the voice signal: spectrogram, F0, Jitter and Shimmer
   - Characteristics of the EEG signal: frequency bands alpha, theta, beta, delta and gamma
   - Characterization of events in a cycle of ECG signal

Recommended reading

1. A. V. Oppenheim, R. W. Schafer e J. R. Buck, “Discrete-Time Signal Processing”, 2nd edition, Prentice-Hall, 1999.

Recommended reading

2. Paulo Sérgio Diniz, Eduardo Silva e Sérgio Netto, “Processamento Digital de Sinais – Projecto e Análise de Sistemas”, Bookman Editora, 2002.
3. Ortigueira, Manuel Duarte, “Processamento Digital de Sinais”, Fundação Calouste Gulbenkian, 2005.
4. Metin Akay, 'Biomedical Signal Processing', Academic Press, 1994.
5. J. P. Teixeira, Caderno de Exercícios para PSB + Conjunto de transparências para PSB, 2020.

Teaching and learning methods

Sessions for presentation of the course contents, accompanied by practical exercises in “paper and pencil” and in Matlab. The non-presence 4 weekly hours must be used for study, for realization of a set of exercises and for the development of 2 short-projects.

Assessment methods

- Unique - (Regular, Student Worker) (Final, Supplementary, Special)
  - Final Written Exam - 75%
  - Projects - 25% (2 short projects.)

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

Fernando Jorge Coutinho Monteiro	José Luís Sousa de Magalhaes Lima	Joana Andrea Soares Amaral	José Carlos Rufino Amaro
10-10-2023	11-10-2023	31-10-2023	04-11-2023