

Course Unit	Signal Processing Applications	Field of study	Signal Processing
Master in	Electrical and Computers Engineering	School	School of Technology and Management
Academic Year	2023/2024	Year of study	1
Type	Semestral	Semester	2
Level	2-1	ECTS credits	6.0
Code	5070-792-1201-00-23		
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) João Paulo Ramos Teixeira

### Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:

1. Use signal acquisition boards and develop tools for visualization and processing/filtering in real time;
2. Know and use the principles and techniques of speech processing, namely models of speech production, analysis, synthesis and speech and speaker recognition;
3. Knowing the characteristics of signals and knowing how to extract them from different types of signals;
4. Know feature selection and dimensionality reduction methods. Use tools to apply them;
5. Know and apply methods of identification and treatment of outliers and normalization methods;
6. Know various methods based on Artificial Intelligence for classification and prediction processes. Know tools for applying these methods;
7. Know and apply evaluation metrics of classification/prediction models;
8. Apply and understand the information contained in the Continuous and Discrete Wavelet transforms;

### Prerequisites

Before the course unit the learner is expected to be able to:

1. programme under Matlab environment;
2. process signals under Matlab environment;
3. understand the dual representation of signals in time-domain and frequency-domain.
4. Signal Processing competencies.

### Course contents

Acquisition of biosignals. Speech signal analysis and synthesis. Characteristics of s signals and respective algorithms. Application to speech signals and biosignals. Pre-processing processes and selection of signal characteristics for application in classification systems. Application of Intelligent Classification Methods to Signal Processing. Rating Evaluation Metrics. Wavelet Transform.

### Course contents (extended version)

1. Acquisition and Processing of Biosignals
  - Acquisition of ECG, EMG and EEG signals;
  - Transmission, processing and visualization.
2. Speech Signal Analysis and Synthesis
  - Anatomy and physiology of the vocal tract;
  - Introduction to the speech signal processing techniques and models;
  - Temporal, spectral, cepstral and parametric analysis by linear prediction;
  - Speech synthesis models;
  - Speech and Speaker Recognition.
3. Signal Features
  - Cross-correlation/autocorrelation, SNR, Entropies, Spectral moments, Kurtosis;
  - HNR, Jitter, Shimmer, F0, Formants, MFCC, LPC, spectrogram, moving average, energy, ZCR;
  - Extraction algorithms.
4. Data pre-processing
  - Treatment of outliers;
  - Normalization.
5. Application of Intelligent Classification Methods to Signal Processing
  - MLP Neural Networks;
  - Deep-Learning (LSTM e CNN);
  - Support Vector Machines;
  - Ensemble.
6. Rating Evaluation Metrics
  - Accuracy, Precision, Recall rate, F1-score, AUC.
7. Wavelet Transform
  - Continuous and discreet.

### Recommended reading

1. Michael Weeks, 'Digital Signal Processing Using Matlab And Wavelets', Jones & Bartlett Learning (2006), ISBN-13: 978-0977858200;
2. João P. Teixeira, 'Análise e Síntese de Fala – Modelização Paramétrica de Sinais Para Sistemas TTS', Editorial Académica Espanhola (2013), ISBN: 978-3-659-06206-3;
3. Guyon, I., & Elisseeff, A., 'An introduction to variable and feature selection'. In L. P. Kaelbling (Ed. ) (2003), Journal of Machine Learning Research - JMLR (Vol. 3);
4. Stanley Cohen. 'Artificial Intelligence and Deep Learning in Pathology', 1st Edition (2020), Elsevier.
5. Paul R. Hill, 'Audio and Speech Processing With Matlab', CRC Press (2018), ISBN: 9781498762748;

### Teaching and learning methods

In the classes, a brief presentation of each chapter will be made, accompanied by application examples and followed by integrative mini-project to be developed. The mini-projects will be development out during non-face-to-face hours and accompanied in the classes. A report will be prepared for each mini-project. The students' mini-projects will be presented and evaluated by their peers.

### Assessment methods

- Single - (Regular, Student Worker) (Final, Supplementary, Special)
- Practical Work - 100% (The developed works are subject to a report and a formal presentation.)

**Language of instruction**

1. Portuguese
2. Portuguese, with additional English support for foreign students.

**Electronic validation**

João Paulo Ramos Teixeira	José Luís Sousa de Magalhaes Lima	José Carlos Rufino Amaro
21-02-2024	27-02-2024	02-03-2024