

Course Unit	Signal Processing Applications	Field of study	Telecommunications and Signal Processing		
Master in	Industrial Engineering - Electrical Engineering	School	School of Technology and Management		
Academic Year	2022/2023	Year of study	1	Level	2-1
Type	Semestral	Semester	2	ECTS credits	6.0
Code	9572-355-1201-00-22				
Workload (hours)	162	Contact hours	T -	TP 30	PL 30
			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. Feature Selection Processes
 - Selection criteria;
 - Selection methods;
 - Search direction;
 - Dimension reduction (PCA).
5. Data pre-processing
 - Treatment of outliers;
 - Normalization.
6. Application of Intelligent Classification Methods to Signal Processing
 - MLP Neural Networks;
 - Deep-Learning (LSTM e CNN);
 - Support Vector Machines;
 - Ensemble.
7. Rating Evaluation Metrics
 - Accuracy, Precision, Recall rate, F1-score, AUC.
8. 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 Alexandre de Carvalho Gonçalves	José Carlos Rufino Amaro
27-02-2023	11-03-2023	12-03-2023	17-03-2023