DIGITAL SIGNAL PROCESSING

Mestrado em Engenharia Eletrónica e de Computadores

Code: 26804

Main Scientific Area: Intelligent Systems and Control

Lecturer: João Luís Gomes da Fonseca

Language of Instruction: Portuguese

Regime: S1

Contact Hours: 30h Total Workload: 138h

ECTS: 6,0

Objectives

The objective of this course unit is to equip the student with the fundamental knowledge associated with the implementation of solutions through digital signal processing. In this context, emphasis will be placed on concepts of signal acquisition and analog-digital conversion, signal filtering algorithms, signal spectral analysis algorithms, signal correlation, among others, making use of various frameworks and libraries of signal processing and visualization functions. The student's theoretical training is complemented in the laboratory, through the completion of exercises and practical project that integrate the different concepts addressed and through computing.

Learning Outcomes

Students who successfully complete this curricular unit should be able to:

1. Understand the framework of digital signal processing in different technological sectors of society.

2. Analyze specific problems in the context of the need for signal processing and identify the different theoretical and technological challenges underlying, both at the hardware solutions level and at the algorithms level.

3. Understand and evaluate the different contexts of digital signal processing.

4. Identify, discuss and evaluate different digital signal processing techniques.

5. Design and implement digital signal processing algorithms, both in the time domain and in the frequency domain.

Course Contents

1. Introduction to digital signal processing

1.1. Signal processing

1.2. Analog-Digital Conversion.

1.3. Nyquist-Shannon Theorem, Aliasing

1.4. Effect of sampling in time and frequency domain

1.5. Anti-Aliasing Filter, Subsampling, Sampling of band-limited signals, and Oversampling

1.6. Digital-Analog Conversion

2. Discrete time signals and systems

2.1. Continuous or Analog Signals

2.2. Discrete or Digital Signals

2.3. Causal Signals

2.4. Deterministic and Random Signals

2.5. Digital Functions (Impulse, Step, Ramp, Power, Exponential, Sinusoidal)

2.6. Notation for Digital Signals

2.7. Composite Functions

2.8. Linear, Time-Invariant (LTI), Causal Systems

3. Digital Filters

3.1. Filters

3.2. Common types of filters

3.3. Analog vs. Digital Filters

3.4. Difference equation

3.5. Impulse Response

3.6. Convolution

3.7. FIR and IIR Filters

4. Cross Correlation and Autocorrelation

4.1. Correlation

4.2. Cross Correlation

4.3. Normalized cross correlation

4.4. Autocorrelation

5. Fourier Transform

5.1. Signal Sampling

5.2. Time and Frequency Domain

5.3. Fourier series theorem

5.4. Discrete Fourier Transform (DFT), and Fast Fourier Transform (FFT)

5.5. Power Spectrum

5.6. Periodogram

5.7. Short Term Fourier Transform and Spectrogram.

6. Introduction to Python

6.1. Introduction to the Python language 6.2. Introduction to digital signal processing libraries

Recommended Bibliography

• “Python for Signal Processing”, José Unpingco, Springer, 2014.

• “Signals and Systems for Dummies”, Mark Wickert, John Wiley Sons, 2013.

• “Digital Signal Processing: Fundamentals and Applications”, Li Tan, Jean Jiang, 2nd Edition, Academic Press.

• “Signals and Systems for Bioengineers”, John Semmlow, 2 nd edition, Academic Press, 2012

Learning and Teaching Methods

The syllabus was defined taking into account the objectives of the course unit, as follows: objectives 1, 2 and 3 are addressed in points 1 and 2 of the syllabus; objectives 4 and 5 are addressed in points 3 to 6 of the syllabus. Objectives 4 and 5 will also be developed and explored from a laboratory perspective through group work and presentation of the respective results.

Assessment Methods

The final grade of the students is obtained based on the following elements:

· Practical work – grades from 0 to20 - minimum grade 9.5 - Presentation and oral defence (individual)

· Global test – grades from 0 to20 - minimum grade 9.5

Final grade = Practical work x 0.5 + Global test x 0.50

According to the equation of the normal season, the student shall be approved in the curricular unit when the grade is greater than or equal to 9.5. Otherwise, the student may retake the exam in the recourse or special season if he/she has obtained a minimum grade in the practical work.