Pré-visualização da Ficha de Unidade Curricular Fundamentals of Signal Processing

Instance: 2024/2025 - 1S

Teaching language

Portuguese and english

Objectives

This course aims to motivate students to the fundamental concepts, techniques and tools of analysis and design in the field of Signal Processing (SP). A particular emphasis is given to specific topics, notably sampling and reconstruction of signals; the Z-Transform; the design and realization of FIR and IIR filters; the Discrete Fourier Transform (DFT) and its fast computation through the FFT; practical applications of the DFT mainly in correlation studies and spectral analysis; introduction to linear adaptive filtering. A central objective is to empower students to solve signal processing-related problems and to motivate them to laboratory experimentation through the design, testing, and practical validation of solutions for selected challenges by following a "hands-on", "learning-by-doing", and "active learning" approach.

Learning outcomes and competences

Attendance and successful completion of this course will enable students

-to understand the process of sampling and signal reconstruction and to anticipate its implications when applied to real signals;

-to design, implement and test digital FIR and IIR filters according to specific operation and signal conditioning requirements, including in adaptive filtering;

-to fully understand the DFT, its circular properties, and fast implementation alternatives (FFT);

-to be able to identify and realize potential applications of the DFT, particularly in fast FIR filtering, correlation studies, and in spectral analysis.

Working method

Presencial

Pre-requirements (prior knowledge) and co-requirements (common knowledge)

Signals and Systems (L.EEC015), or equivalent

Program

1. Characterization and representation of discrete-time signals and systems. Discrete-time deterministic and random signals.
2. The discrete-time Fourier Transform. Properties and transform pairs.
3. Sampling and reconstruction of signals. The sampling theorem and aliasing. Discrete-time processing of

continuous-time signals.
4. The Z-Transform. Causality and stability conditions. Characterization in the Z domain of FIR and IIR discrete-time systems.
5. Inverse systems, all-pass systems, minimum-phase, linear-phase, and maximum-phase systems. FIR linear-phase systems.
6. Design of discrete-time IIR and FIR filters and their realization structures
7. Introduction to linear adaptive filtering.
8. The Discrete Fourier Transform (DFT) and its periodic properties.
9. The computation of the DFT using the Fast Fourier Transform (FFT).
10. Application of the FFT in FIR fast-convolution, in correlation studies, and in spectral estimation.

Mandatory literature

Alan V. Oppenheim; Discrete-time signal processing. ISBN: 0-13-083443-2

Complementary Bibliography

Sanjit K. Mitra; Digital signal processing. ISBN: 0-07-122607-9
John G. Proakis; Digital signal processing. ISBN: 0-13-187374-1

Teaching methods and learning activities

The teaching methodology is based on lectures -T (2h/week) and laboratory classes -PL (2h/week).

Lectures are not intended for the classical presentation of the course contents. Instead, they assume an "active learning" attitude on the part of the students given that, whenever possible, these classes will adopt the "flipped classroom" principle, according to which the theory presentation of the course topics will be made available on video and for viewing outside the classes.

The focus of lectures will therefore be i) the summary of the theory related to the course topics and, whenever appropriate, their discussion and illustrative application, ii) the introduction to problems illustrating the application of the theory, and the themes of laboratory assignments, and iii) the motivation for Verification Questions as a form of distributed assessment.

The laboratory classes include two components, both with an impact on distributed assessment (DA): i) the discussion of conventional or Matlab-based exercises, especially from a "peer-to-peer learning/teaching" perspective (25% weighting on the DA), and ii) the realization of laboratory experiments in groups of 4 students using a real-time digital signal processing platform (50% weighting on the DA).

The assessment resulting from laboratory classes (PL) is weighted at 75% in the final distributed assessment at the end of the semester. The remaining 25% comes from the response to quick micro-tests (quizzes), for 10 minutes each, to be answered via Moodle at an extra-class time to be decided with students. The distributed assessment score is combined (50% weight) with the final exam score (50% weight) to produce the final grade.

Software

Matlab

Evaluation Type

Distributed evaluation with final exam

Evaluation Components

Designation	Weight (%)
Participação presencial	12,50
Exame	50,00
Trabalho laboratorial	37,50
Total:	**100,00**

Amount of time allocated to each course unit

Designation	Time (hours)
Estudo autónomo	60,00
Frequência das aulas	52,00
Trabalho laboratorial	26,00
Trabalho de campo	24,00
Total:	**162,00**

Eligibility for exams

Attending T and PL classes and obtaining an attendance grade is essential for admission to the final exam.

The attendance grade (F) is given to students who do not exceed the absence limit (according to the FEUP General Assessment Regulation) and who have taken the online quizzes and prepared and performed the practical and laboratory work requested for distributed assessment (DA).

Online quizzes are carried out individually and some practical work, as well as laboratory work, are carried out in groups of 4 students.

Online quizzes (Verification Questions) are answered via Moodle at an extra-class time to be decided with students and represent 25% of DA.

Exercises will be proposed in PL classes to be solved individually, but evaluated in groups, in a “peer-to-peer” perspective, and are weighted at 25% in DA. Laboratory work is assessed in PL classes by the Instructor and is weighted at 50% in DA.

Calculation formula of final grade

The final exam consists of a written exam lasting 2 hours. This exam is closed book but a formulae sheet will be provided.

The final grade (C) is obtained by combining the participation score (F>=10.0) corresponding to the DA score, and the score of the written exam (E> = 6.0) using the formula

C = 0.5×F + 0.5×E.

The final grade is conditional on a minimum score of 6.0/20 in the written exam and a minimum score of 10.0/20 in the DA component.

All scores/grades presume the [0, 20] range.

Special assessment (TE, DA, ...)

No student enrolled in the course is exempt from participating in the various distributed assessment components. If, due to justified and force majeure reasons, a student benefiting from a special status is not able to participate in those components, he/she is subject to the development of a mandatory project based on the signal processing platform adopted in laboratory classes and whose theme and realization objectives must be agreed with the principal instructor of the course. This project must be documented through a report and its operation must be demonstrated through a practical laboratory exam.

Classification improvement

Due to the fact that the participation score (F) is based on several components evaluated in different types of classes and throughout the semester, the participation score is not subject to improvement through any modality replacing it at the end of the semester. As a consequence, only the final exam score (E) can be improved according to the current rules.
