VNIVERSITAT DE VALÈNCIA

Course Guide
34892 Digital signal processing

COURSE DATA

Data Subject	
Code	34892
Name	Digital signal processing
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1403 - Degree in Telematics Engineering	School of Engineering	3	Second term

Subject-matter

Degree	Subject-matter	Character
1403 - Degree in Telematics Engineering	14 - Digital communications	Obligatory

Coordination

Name	Department
DOMINGO ESTEVE, JUAN DE MATA	240 - Computer Science
VEGARA MESEGUER, FRANCISCO	240 - Computer Science

SUMMARY

This course is part of the subject "Digital communications", being preceded by the subjects "Mathematical foundations of communications" and "Communication theory". It is assumed that the student is familiar with the mathematical tools needed (linear, algebra probability and stochastic processes, optimization, signals and linear systems) and with the basic concepts of the theory of communication (source, channel, modulation, coding and decoding). This course represents also a natural continuation of the course of signals and linear systems, where the general assumption is that signals, or inputs to the systems, are deterministic processes. In many real applications, however, it is more appropriate to model the signals as stochastic processes. This does not imply or mean that signals are completely random; they can in fact have much structure, but from the point of view of the design of systems, cannot be described in a deterministic manner. A classic example of such stochastic processes are noisy signals observed in any communication system. This course explores the major signal processing algorithms used in telecommunications systems, analyzing: a) their theoretical foundations, b) the design of different processing functional blocks, c) their application to problems found in practice (communications, voice and image), as well as the most important associated standards.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

It is necessary to carry out one of the following two conditions: a) have previously passed in this degree the areas of Mathematics, the subject of Signals and Linear Systems (of the matter of Signals, Systems and Telecommunication Services), the subjects corresponding to this same matter of Mathematical Foundations of Communications and Communications Theory (Digital Communications), b) have concluded the Telematics Technical Engineering of the formerly in force plan.

OUTCOMES

1403 - Degree in Telematics Engineering

- R4 - Ability to analyze and specify the fundamental parameters of communication systems.
- R5 - Ability to assess the advantages and drawbacks of different technological alternatives for the deployment and implementation of communications systems, from the point of view of signal space, perturbations and noise and analogue and digital modulation systems.
- R1 - Ability for self-learning of new knowledge and techniques appropriate for the conception, development and exploitation of telecommunications systems and services.
- G4 - Ability to solve problems with initiative, decision-making and creativity, and to communicate and transmit knowledge, abilities and skills, understanding the ethical and professional responsibility of the activity of a telecommunications technical engineer.
- G5 - Knowledge to carry out measurements, calculations, assessments, evaluations, loss adjustments, studies, reports, task planning, and other analogous work in the specific field of telecommunications.
- G6 - Ability in the handling of specifications, regulations and norms of compulsory compliance.
- R8 - Ability to understand the mechanisms of propagation and transmission of electromagnetic and acoustic waves, and their corresponding transmitting and receiving devices.
- G1 - Ability to write, develop and sign projects in the field of Telecommunication Engineering aimed - according to the knowledge acquired in section 5 of CIN/352/2009 regulation - at the conception and the development or the exploitation of networks, services and applications of telecommunications and electronics.
- E1 - Ability to construct, exploit and manage telecommunication networks, services , processes and applications, understood as systems for the acquisition, transport, representation, processing, storage, management and presentation of multimedia information, from the perspective of telematics services.

- E5 - Ability to follow the technological progress of transmission, commutation and proccess to improve the telemactic networks and services.

LEARNING OUTCOMES

Skills to acquire:
1 Determine, given a practical problem of statistical signal processing, if it is a problem of modelling, parametric estimation, spectral estimation, optimal filtering, and in the latter case, if it is necessary the use of an Adaptive Filter.

2 Be able to choose among methods covered in the course, which can be appropriate for the resolution of the problem, and know to apply them.

3 Know how to derive models or compact representations of discrete stochastic signals, as well as how to estimate parameters of such model.

4 Know what is and how to estimate spectral density of power of discrete stochastic processes.

5 Know how to derive optimal filters for minimizing average root mean square error (MMSE), making linear prediction, getting noise cancellation or performing channel equalization.

6 Know how to design adaptive filtering algorithms understanding the optimality or efficient updating of the optimal filter coefficients to follow the input signal (temporal variability) changes, adapting these algorithms to specific applications (Adaptive equalization, echo cancellation, noise cancellation, Adaptive Linear predictive coding).

7 Be capable of designing a scheme for appropriate implementation (filtering structure) and choosing the appropriate software to build such implementation.

8 Know how to design and implement basic algorithms of filtering in 2D for spectral analysis and efficient coding of the information tasks.

9 Be able to evaluate the quality of the solution by calculating the appropriate efficiency measures, and where the solution is not satisfactory, so as to correct it. In an extreme case (the system is extremely complex or highly variable) the alumni should be able to explain why the solution does not work properly and find alternatives in the bibliography.

10. Ability to analyze, codify, process and trasmit multimedia information using techniques of analog and digital signal processing.

Social skills: In addition to the specific objectives outlined earlier, the development of various generic skills will be promoted during the course, which include:

10 The identification of existing technological systems capacity as well as the decomposition in various subsystems that make up the whole system.

11 Promotion of teamwork and organizational tasks and subtasks.

DESCRIPTION OF CONTENTS

1. Introduction and motivation

Applications of statistical disgital signal processing. Review of basic concepts of signals and vectors.

2. Sampling and reconstruction of signals

Temporal and frequencial analysis of sampled signals: the sampling theorem. Aliasing. Reconstruction of sampled signals and interpolation types. A/D and D/A conversion. Digital processing of analog signals.

3. Discrete Fourier transform

The F.T. of discrete periodic signals (DFT). Discrete Fourier Series (DFS). Representation of aperiodic discrete signals (DTFT). Correlation and spectrum. Relatuionship among the different transforms. Properties and fundamental theorems. Representation in the frequency domain of linear time invariant discrete systems (LTI). DFT calculation with Matlab (Fast FT algorithm).

4. The Z transform

Definition and basic properties. The Z transform (ZT) of basic signals. Other properties of the ZT. Representation and analysis of discrete systems with the ZT. Inverse ZT. Resolution of difference equations using the ZT.

5. Digital filter design

Types and filter order. Butterworth filters. Basic design from specifications. Digital fiters: basic secifications. IIR and FIR filters. Design of digital filters based on a) Discretization of continuous filters b) windowing. Filtering structures and digital filter implementation.

6. Parameter estimation in discrete processes

Stochastic processes and linear systems, the problem of parameter estimation, MAP and ML estimation, quality of an estimator, rational models of processes (AR, MA and ARMA.

7. Optimal filtering

Estimation based on cuadratic error, Wiener filtering in the frequency domain, Wiener filtering from the data, linear prediction, applications.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Laboratory practices	20,00	100
Classroom practices	10,00	100
Development of group work	9,00	0
Development of individual work	23,00	0
Preparation of evaluation activities	18,00	0
Preparing lectures	26,00	0
Preparation of practical classes and problem	14,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

1 / Presential work consisting of:

1.1 / Theory classes, which consist of the presentation and basic explanation of the corresponding matter. Periodically the lecturer will propose activities of short duration, which require the intervention of the students in order to confirm the understanding of the explained theory. (It develops competences G5, R4, R5, E1 and E5)

1.2 / Exercise classes, designed to solve problems of higher difficulty, either conceptual or temporal.(It develops competences G4 and R1)

1.3 / Laboratory classes designed to experimentally verify some of the most relevant issues seen in the classes of theory. (It develops competences G4, R1 and R4)

2 / Non-presencial work consisting of:

2.1 / Resolution and reporting exercises. These classes are meant to solve bulletins exercises proposed by the teacher and/or exposure in public of the resolution of some of them.(It develops competences G4, R1 and R4)

2.2 / Preparation for the examinations. (It develops competences R1 and R4)

2.3 / Preparation of the laboratory practice, for which the student must have read and assimilated the content of the practice bulletin, as well as having reviewed the relevant theory. (It develops competences E1 and E5)

3 / Tutorials individual and/or collective:

Certain individual unscheduled tutoring hours will be schaduled per week to which students may attend to clarify their doubts, as well as hours of collective scheduled tutoring for the clarification of the doubts raised during exercises classes.

EVALUATION

Key results intended to be achieves as a result of the learning of this matter are essentially practical, and are measured by the degree in which the student has acquired the skills referred to in point VIII. For this purpose, the assessment will be based primarily in the resolution of practical problems, simplified ones in the case of the review or the exercises, and real ones for the proposed main work.

According to the new model, we intend to give the final exam a not excessive prominence, but without arriving to a continuous assessment model. Selected teaching evaluation mechanism consists of the following items and assessments:

Assessment of participation (up to 5% of the final mark)

Assistance, implementation and if appropriate, evaluacion through an exam of the practical work (up to 15% of the final mark)

Resolution of exercises (up to 20% of the final mark)

Final exam (at least 60% of the final mark)

For students unable to attend regular class, an alternative model is offered in which the evaluation of attendance to practical classes and participation are replaced by some additional work and special tutoring assistance, with an equivalent total percentage.

The final alternative for this alternative Assessment is:

Final note (Alternative Assessment) = Note Theory Examination (60%) + Note Laboratory Examination (15%) + Note alternative works (25%)

In the second examination call the final mark will be obtained by averaging the exam with a weight of 80% and an exam on the submitted practical exercises with a weight of 20% in all cases.Furthermore, in the case of having failed the practicals in the first call the alumni will have to submit them again, individually.

The minimum required to overcome the subject will be the equivalent to a 4 out of 10 in the final examination as in the resolution of exercises. Other assessable items are not subject to minimum.

In any case, this subject requires the personal assistance to the laboratory and the execution of exercises in a progressive manner, according to the basic paradigm of the Bolonia's model. Therefore, an alumni cannot be admitted to examination without having performed such tasks because he/she has not been enroled during at least one term. This excludes the possibility of an advanced examination call for these alumni.

The evaluation will be conducted in accordance with the University of Valencia Qualifications Legislation. At the time of writing this teaching guide, the current legislation is the one approved by the Governing Council of the UVEG in January 27, 2004, adjusted as provided for that purpose by the Royal Decrees 1044/2003 and 1125 / 2003. It states basically that the qualifications will be numbered from 0 to 10 with a decimal element and they must be accompanied with the qualitative rating in accordance with the following scale:
From 0 to 4.9: "Failed"
From 5 to 6.9 "Approved"
From 7 to 8.9, "Notable"
9 to 10: "Outstanding" or " Outstanding with honors".

Any copy among students detected in the continuous assessment (C), in the final test (E) or in the laboratory assessment (P) involves loosing the matriculation of first and second call in the current course.

Regarding fraudulent activities:

-The lecturer may expel students form the classroom while they are doing an exam if: 1) They don’t guarantee the authencity and privacy of the exercise. 2) They borrow the identity of another student 3) They have the mobile phone or any other unauthorized electronic device or document.

-The lecturer can stay with the evidence involved in incidents occurred as they are doing an exam and notify by a written stament to the head of studies of the center

The lecturer can qualify with a “zero” mark an exam when: 1) There are indications of fraudulent performance in the exam or part of it. 2) They have the mobile phone or any other unauthorized electronic device or document.

In addition to all these measures, the lecturer may initiate disciplinary proceedings against the student.

In any case, the system of evaluation will be ruled by the established in the Regulation of Evaluation and Qualification of the University of Valencia for Degrees and Masters. (http://www.uv.es/graus/normatives/2017_108_Reglament_avaluacio_qualificacio.pdf).

REFERENCES

Basic

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- Manolakis, D.G., Ingle, V.K. and Kogon, S.M.: Statistical and adaptive signal processing, Ed. Artech House, Boston/London, 2005. ISBN 1-58053-610-7 http://site.ebrary.com/lib/universvaln/detail.action?docID=10081926

Additional

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- Sigmon K., MATLAB Primer, Third Edition, 1993. http://web.mit.edu/6.777/www/downloads/primer.pdf
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