COURSE DATA

DATA SUBJECT

Code: 46572
Name: Signal analysis
Cycle: Master's Degree
ECTS Credits: 4.5
Academic year: 2026-27

STUDY (S)

Degree	Center	Acad. year	Period
2262 - Master's Degree in Data Science	Escola Tècnica Superior d'Enginyeria	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2262 - Master's Degree in Data Science	Signal analysis	COMPULSORY

COORDINATION

FERNANDEZ MORAN ROBERTO

SUMMARY

This course introduces advanced mathematical methods for the analysis of signals commonly encountered in data science, particularly one-dimensional signals (such as audio), two-dimensional signals (such as images), and N-dimensional signals (such as hyperspectral data).

The first part of the course will present the fundamentals of information theory, which underpin data analysis when working with large volumes of information. Subsequently, the course will cover the extraction of temporal and frequency features from a signal, with emphasis on the concepts of Fourier and wavelet transforms. Students will learn how to design filters to isolate signals of interest from noise, as well as how to apply digital signal processing techniques to extract relevant features.

Later, the mathematical tools taught will be applied to the processing of audio signals, images, videos, and hyperspectral data. In addition, specific techniques for text processing and streaming data will be introduced. Students will learn to use appropriate software tools for processing both one-dimensional and two-dimensional signals.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

OTHER REQUIREMENTS

COMPETENCES / LEARNING OUTCOMES

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Ability to access and manage information in different formats for subsequent analysis in order to obtain knowledge from data.

Be able to assess the need to complete their technical, scientific, language, computer, literary, ethical, social and human education, and to organise their own learning with a high degree of autonomy.

Extraer características propias de señales N-dimensionales para ser usadas en diferentes algoritmos de análisis de datos.

Extraer conocimiento de conjuntos de datos en diferentes formatos.

Ser capaces de acceder a herramientas de información (bibliográficas y de empleo) y utilizarlas apropiadamente.

Ser capaces de asumir la responsabilidad de su propio desarrollo profesional y de su especialización en uno o más campos de estudio, aplicando los conocimientos adquiridos en la identificación de salidas profesionales y yacimientos de empleo.

Students should demonstrate self-directed learning skills for continued academic growth.

DESCRIPTION OF CONTENTS

1. Introduction to signal analysis

Autocorrelation and cross correlation.
Information Theory. Entropia.
Mutual Information.
Kullback-Leibler divergence.

2. Basic mathematical tools

Fourier transform.
Gabor transform.
Generalized Transforms.
Wavelets.

3. Extracting frequency features

Spectral analysis of signals.

4. Engineering Features for audio, images and video

Feature extraction in audio, image and video signals.

5. Hyperspectral data

Basics concepts on analyzing data from multiple frequencies and treated as n-dimensional signals.

6. Técnicas de procesado de texto

Basic techniques of text analysis. Frequency of words, word clouds, etc

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	23,00
Theoretical and practical classes	4,00
Laboratory	18,00
Total hours	**45,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	10,00
Independent study and work	14,00
Preparation of lessons	22,00
Preparation for assessment activities	12,00
Resolution of case studies	10,00
Total hours	**68,00**

TEACHING METHODOLOGY

Theoretical Activities: Expository development of the subject matter with student participation in the resolution of specific questions. Completion of individual assessment quizzes.

Practical Activities: Learning through problem-solving, exercises, and case studies to acquire competencies related to different aspects of the subject.

Laboratory and/or Computer Classroom Work: Learning through individual or small-group activities carried out in computer labs.

EVALUATION

The evaluation of students¿ knowledge and competencies will consist of the following components (applicable to both the first and second examination periods):

1. Individual assessment through a final exam (55%)

2. Final group project, presented as a written report and delivered orally (35%)

3. Assessment based on participation and student engagement in the teaching-learning process, considering regular attendance at scheduled in-person activities and the resolution of questions and problems (10%)

To pass the course, students must obtain a score higher than 4 out of 10 in component 1 and an overall weighted average of more than 5 out of 10 across all three components. Grades obtained in components 2 and 3 will only be valid during the teaching period and will be retained for both examination periods of the academic year in which they were earned.

REFERENCES

Alpay, D. (2024). *Exercises in applied mathematics: With a view toward information theory, machine learning, wavelets, and statistical physics* (1st ed.). Springer International Publishing: Birkhäuser.

Camps-Valls, G., Malo, J., Tuia, D., & Gomez-Chova, L. (Eds.). (2011). *Remote sensing image processing*. In A. Bovik (Ed.), *Synthesis Lectures on Image, Video, and Multimedia Processing* (Vol. 1, pp. 1¿173). Morgan & Claypool Publishers.

Das, A. (2015). *Guide to Signals and Patterns in Image Processing*. Ed. Springer

Derryberry, D. R. (2014). *Basic data analysis for time series with R* (1st ed.). Wiley.

Farouk, M. H. (2018). *Application of wavelets in speech processing* (2nd ed.). Cham: Springer International Publishing.

Frery, A.C., Perciano, T., (2013). *Introduction to image processing using R: learning by examples*. Ed. Springer.

Gibson, J. D. (2023). *Fourier transforms, filtering, probability and random processes: Introduction to communication systems* (1st ed.). Springer Nature Switzerland AG.

Gonzalez, R. C., & Woods, R. E. (2017). *Digital image processing* (4th ed., Global Edition). Pearson Education.

Principe, J.C., (2010). Information Theoretic Learning. Ed. Springer

Shumway, R. H., & Stoffer, D. S. (2017). *Time series analysis and its applications: With R examples* (4th ed.).

Stankovic, S., Orovic, I., Sejdic, E., (2016). *Multimedia Signals and Systems*, Ed. Springer.