

Academic Year: ( 2022 / 2023 )

Review date: 27-05-2022

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: ALVAREZ PEREZ, LORENA

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 1

**REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)**

Systems & Circuits  
Calculus II  
Statistics

**OBJECTIVES**

After this course students will understand the principles of estimation and decision problems. Students will understand that, for the correct understanding of these problems, it is necessary to master three basic probability theory elements: 1) the likelihood, 2) the difference between a priori and a posteriori uncertainty, and 3) Bayes' Theorem. They will also understand the concepts of generalization and sufficient statistics. Finally, it will become apparent the advantages (both analytical and computational) inherent to Gaussian problems and linear solutions.

From a practical point of view, students will learn to identify the convenience of following an analytical or machine approach for concrete situations. They will acquire the necessary knowledge to face an analytical resolution of a decision or estimation problem when complete statistical information is available, knowing also some semianalytical approaches for scenarios with partial information. When no statistical information is available, they will know how to design a regression or classification model, using data sets for learning its parameters: splitting the available data into training, validation and test sets, and applying algorithms for model order selection and parameter adjustment. Furthermore, different criteria for measuring the quality of deciders and estimators, as well as their generalization capabilities, will be introduced. Finally, students will study how these tools for estimation and detection can be adapted to deal with temporal series, and to implement adaptive solutions.

During the course, students will study the previous concepts from a theoretical point of view, and will also apply them for the resolution of several study cases in practical sessions. During these sessions, students' work will help them improve the following general skills:

- \* Ability to identify and understand particular estimation and decision problems, and to propose practical solutions taking into account the characteristics of such problems (availability of historic data, possible computational constraints, etc.).
- \* Ability to design the experiments for the evaluation of the implemented estimators and deciders.
- \* Knowledge of a programming language widely used for simulation and mathematical modeling in engineering: Python and Scikit-learn (Sklearn) is the most useful and robust library for machine learning in Python.

**DESCRIPTION OF CONTENTS: PROGRAMME**

Block 0 - Review of basic statistical concepts

- Random variables. Distribution functions.
- Definition of expected value, variance and covariance.
- Transformations of random variables

Block 1 - Estimation

- General view of the estimation problem
- Design of estimators under an analytical approach
  - Quality measures in estimators
- Design of estimators under a machine approach

Block 2 - Decision

- General view of the decision problem.
- Design of classifiers under an analytical approach

- Characteristics of decisors
- Design of classifiers under a machine approach

### Block 3 - Temporal Series Filtering

- Introduction to filtering
- Design of optimal filters

## LEARNING ACTIVITIES AND METHODOLOGY

### THEORY

Theory sessions consist of lectures in which the basic concepts of the course will be introduced, illustrating them with a large number of examples.

### PROBLEMS

Exercises and problems similar to those to be proposed in the exam will be solved. Students will have problem statements available at the beginning of the course, so that they can work on them before they are solved in class.

### PRACTICAL SESSIONS

Sessions in which students will apply the concepts presented in the course with the help of a computer. Students will deal with estimation and classification problems with real data, and will have to evaluate the performance of the implemented systems. During these practical sessions students will use Python as the simulation tool.

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The tutorial hours will be published in Aula Global according to the class time.

## ASSESSMENT SYSTEM

Students will be graded according to:

The assessment system consists of two parts: a continuous assessment (60% of the final mark of the course) and a final exam (40% of the final mark).

The continuous assessment is distributed as follows:

- Exercises and theory questions to be solved by the students by taking two intermediate exams (20% of the final mark of the course)
- Submission and evaluation of practical mini-software projects (40% of the final mark of the course)

The final exam has a weight of 40% of the final mark and will include some questions related to the machine learning part (10% of the final mark of the course) and some short exercises and analytic problems (30% of the final mark of the course).

Students who do not follow the continuous assessment procedure, will be evaluated according to the general policy established by the University.

Note: The date of the intermediate evaluations will be adjusted according to the progress of the master classes.

<b>% end-of-term-examination:</b>	40
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	60

## BASIC BIBLIOGRAPHY

- C. M. Bishop Neural Networks for Pattern Recognition, Oxford University Press, Oxford (United Kingdom), 1995
- C.M. Bishop Pattern Recognition and Machine Learning, New York, NY: Springer, 2006
- C.M. Bishop Neural Networks for Pattern Recognition, Oxford, UK: Oxford Univ. Press, 1995
- H. L. Van Trees Detection, Estimation, and Modulation Theory (vol. I), New York, NY: Wiley, 1968
- R.O. Duda, P.E. Hart, D.G. Stork Pattern Classification, New York, NY: Wiley, 2001
- S. Haykin Adaptive Filter Theory, Prentice Hall, 2002

#### ADDITIONAL BIBLIOGRAPHY

- A. Papoulis Probability, Random Variables, and Stochastic Processes, New York, NY: McGraw-Hill, 2002
- H. V. Poor An Introduction to Signal Detection and Estimation, Springer, 1998
- M. H. Hayes Statistical Digital Signal Processing and Modelling, Wiley, 1996
- S.M. Kay Fundamentals of Statistical Signal Processing. Detection Theory, Englewood Cliffs, NJ: Prentice-Hall, 1998