Modern theory of detection and estimation

Academic Year: (2020 / 2021) **Review date: 11/09/2020 13:47:02**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: PARRADO HERNANDEZ, EMILIO

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Statistics, Calculus II, Systems & Circuits

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. (PO a)

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. (PO b)

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) (PO e)
* Ability to design the experiments for the evaluation of the implemented estimators and deciders. (PO b)
* Knowledge of a simulation and mathematical modeling software application, which is widely used in engineering (Matlab) (PO k)

DESCRIPTION OF CONTENTS: PROGRAMME

Block 0 - Review of basic statistical concepts
- Random variables. Distribution functions.
- Definition of expected value, variance and covariance.
- Change of random variables

Block 1 - 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 2 - 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 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 (POs a and e)

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. (POs a and e)

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 (PO b). During these practical sessions students will use python as the simulation tool. (PO k)

ASSESSMENT SYSTEM

% end-of-term-examination/test:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

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:

a) Exercises and theory questions to be solved by the students by taking an intermediate exam (30% of the final mark of the course)

b) Submission 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 practical sessions (10% of the final mark of the course) and a theory part with questions and short exercises, followed by several problems (50% of the final mark of the course).

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

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

BASIC BIBLIOGRAPHY

- C. M. Bishop Pattern Recognition and Machine Learning, Springer, 2006

- H. L. Van Trees Detection, Estimation and Modulation Theory (vol. 1), Wiley, 1968.

- R. O. Duda, P. E. Hart, D. G. Stork Pattern Classification, Wiley, 2001.

- S. Haykin Adaptive Filter Theory, Prentice-Hall, 2002.

ADDITIONAL BIBLIOGRAPHY

- A. Papoulis Probability, Random Variables and Stochastic Processes, 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. Estimation Theory., Prentice-Hall, 1993.

- S. M. Kay Fundamentals of Statistical Signal Processing. Detection Theory., Prentice-Hall, 1998.