2EL5050 – Estimation methods and introduction to the modern coding theory

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Department: CAMPUS DE METZ
Language of instruction: FRANCAIS
Campus: CAMPUS DE METZ
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Fundamental Sciences
Advanced level : Yes

Description

This course presents two key issues of decision theory: pure estimation and detection. More precisely, the following notions will be presented and implemented numerically: formalization of estimation and detection problems, influence of cost function, Bayesian / non-Bayesian point of view, prior information. The problems of estimating power spectral density and prediction, with finite and infinite past, of a second-order ergodic time series will be studied in detail. Finally, the four fundamental coding theorems for discrete memoryless systems will be presented with their proofs.

Quarter number

SG6

Prerequisites (in terms of CS courses)

- Probability 1A (CIP, 1SL1000),
- Signal processing ST4 (1CC4000)

It is advisable to have also followed:

- Statistics, Machine learning and Data processing ST4 (1CC5000),
- Digital environment, computer and programming SG1 (1CC1000).

Syllabus

- Fundamentals of estimation (6h of course)
  1.1 Introduction (goals of estimation, model, bayesian / non-bayesian point of view, examples)
  1.2 Bayesian estimation (Hilbert space, orthogonal projection theorem, mean square estimations with linear constraint)

1.3 Elements of non-Bayesian estimation (Cramer-Rao inequality, maximum likelihood estimator)

- Estimation of a signal in an additive noise (3h of tutorials)
- Power spectral density estimation (non-parametric methods) (3h of tutorials)
- Detection (3h of course)
  4.1 Test of hypotheses (problem presentation, Bayesian theory, Neyman-Pearson strategy, ROC curves)
  4.2 Application to the detection of a signal in a noise (Karhunen-Loève decomposition, detection of a deterministic signal in a Gaussian noise)
- Detection (3h of tutorials)
- Linear statistical filtering (1h30 of course)
  6.1 Introduction and preliminaries
  6.2 Wiener filtering
- Wiener filtering with linear contraint (3h of tutorials)
- Prediction with infinite past (3h of courses)
  8.1 Case of a signal whose power spectral density is bounded and admits a strong factorization
  8.2 General case, Wold's decomposition
- Interpolation of a stationary signal (3h of tutorials)
- Prediction with finite past (1h30 of course)
- Primitives of the Information theory (3h of course)
  11.1 Introduction (discrete source of information, discrete channel, message)
  11.2 Four key coding issues (channel coding, channel approximation, distributed source coding, random extraction)
  11.3 Fundamental theorems (random coding, random binning)
- Exercises on the four key coding issues (2h of tutorials)

Class components (lecture, labs, etc.)
18h of courses + 17h of tutorials + homeworks

Grading
Evaluation of homeworks and some tutorials an evaluation in binomial (or trinomial) in the form Homework + Tutorials (spectral analysis) + reportan individual evaluation (short qcm)an individual evaluation (short qcm) the absence not excused at an individual evaluation gives the grade 0the absence not excused in tutorials gives the standard penalties of the studies rule final grade = 1/2* grade1 + 1/4*(grade2 + grade3) resit: an oral exam

Course support, bibliography
M. Barret, *Traitement Statistique du Signal*, ELLIPSES, 2009.
M Bloch et J. Barros, *Physical-Layer Security,* Cambridge University Press, 2011.

Resources
Some of the tutorials will be done with a computer (using Matlab or Python)

Learning outcomes covered on the course
At the end of this course, students will be able to deal with a wide range of concrete problems of estimation and detection, encountered in a scientific or industrial context. Starting from such a problem, they will be able:

- to model it by introducing a suitable cost function;
- to propose an adequate solution (adapted to the information a priori)
- to prove the optimality of the solution under certain conditions that they will be able to explain;
- to implement the method on data;
- to criticize the results.

In addition, at the end of the course, students should have acquired basic knowledge of the modern theory of coding for discrete memoryless systems (channel, source with side information to the decoder), where the above estimation and detection methods are applied.

Description of the skills acquired at the end of the course
Skills developed by the course

- C1: Analyze, design and build complex systems with scientific, technological, human and economic components
- C2: Develop an in-depth skills in an engineering field and in a family of professions