2EL6100 – Communication Systems Engineering

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

Description

All communications today (mobile communication, satellites, local area networks, ADSL wired networks, etc.) offer higher bit rates thanks to digital processing whose fundamentals have been stated from the information theory of *Claude Shannon* (1948) based on the the two following principles:

- Source Coding trying to remove unnecessary redundancies in the transmitted messages and to gain in information rates.
- Channel coding to protect the transmission of the compressed information toward the receiver aiming to minimize errors for the detected signal.

For ideal transmission over a Gaussian channel, joint source / channel coding is the appropiate way to approach the theoretical limit of the maximum achievable date rate predicted by information theory.

On the other hand, for a wide spectrum of applications, the channel can be much more restrictive with phenomena such as selectivity, multi-path transmission, the Doppler effect ... However, even for this type of channel, there are, fortunately, other ways of protecting the information (besides channel coding) mainly using the notion of diversity (temporal, spectral, spatial ...)

Quarter number

SG6

Prerequisites (in terms of CS courses)

- Notions of probabilities
- Digital Signal Processing (Fourier Transform, Spectral Analysis)

These knowledges are learned from signal processing (1CC4000) and modelisation (1CC3000) courses.

Syllabus

Part 1 : Information theory

- What is information? Mutual information? Entropy?
- Channel capacity
- Shannon 's theorems (channel and source coding)

Part 2 : Source coding

- Codes with fixed and variable lengths
- Huffman codes
- Applications (JPEG, MPEG, MP3, H264)

Part 3 : Redundancy for information protection (Channel coding, Diversity and retransmission protocols)

- Block codes
- Convolutional codes
- Viterbi decoding
- Applications: video broadcasting, mobiles communications, etc.
- To go further: LDPC codes, turbo codes, polar codes, ….
- Diversity concept (temporal, spectral, spatial, cooperation)
- Retransmission protocols (ARQ, HARQ, IR)

Class components (lecture, labs, etc.)

The fundamentals are presented in lectures with specific examples. Exercices ensure a good understanding of the course and correct the misinterpretations of the course. Personal works are additional courses requested from students (applications and extensions).

Grading

Final exam : coefficient 0,5 Laboratory exam : coefficient 0,25 Personnal work : coefficient 0,25 In case of a justified absence to one of the intermediary examinations, the grade of this latter is replaced by the grade of the final examination.The grade of the laboratiry exam is based primarily on the level of involvement provided during the sessions and secondarily on the mandatory report.

Course support, bibliography

- Lectures notes provided to students
- G. Battai, "*Théorie de l'information - Application aux techniques de communication*", Ed. Masson, 1997.

- W. Peterson, E. Weldon, "*Error corrcting codes*", Ed. MIT Press, 1972.
- S. Lin, D. Costello, " *Error control coding: Fundamentals and Applications*", Ed. Prentice Hall, 1983.
- G. Cohen, J. L. Dornstetter, P. Godlewski, "*Codes correcteurs d'erreus*", Ed. Masson, 1992.
- J. Proakis, "*Digital communications"*, 4e édition, Ed. McGraw-Hill, 2001.
- J. C. Bic, D. Duponteil, J. C. Imbeaux, "*Eléments de communications numériques*", Ed. Dunod, 1986.
- R.Boite, M. Kunt, "*Traitement de la parole*", Ed. Polytechniques et Universitaires Romandes, 1987.
- J. Deller, J. Hansen, J. Proakis, "*Discrete time processing of speech signals*", Ed. IEEE Press, 1999.
- T. M. Cover, J. A. Thomas, "*Elements of Information Theory*", Wiley New York, 1991.

Resources

- Teaching staff (instructor(s) names): Haïfa Farès, Yves Louët, Georgios Ropokis.
- Maximum enrollment (default 35 students): 20
- Software: MatLab
- Equipment-specific classrooms

Learning outcomes covered on the course

The first objective of this elective is to provide elements regarding the information theory by covering channel and source coding. The second objective is to detail what a digital transmission is and what are the different requirements to target expected performance.

For instance, the students will be able to:

- understand a digital communication chain
- understand the different chain blocks
- understand the metrics of performance evaluation of a digital transmission
- optimize the dimensioning of a transmission chain under constraints (performance trade-offs)
- generate, analyze, process digital signals with Matlab

Description of the skills acquired at the end of the course
In terms of skills:

- The first three course outcomes aim to acquire the C1.2 skill "Develop and use appropriate models, choosing the correct modelling scale and simplifying assumptions when addressing a problem"
- The outcomes 4 and 5 contribute to the core of C1.3 skill "Apply problem-solving through approximation, simulation and experimentation. / Solve problems using approximation, simulation and experimentation"
- The outcome 5 adresses the C1.4 skill "Design, detail and corroborate a whole or part of a complex system"
- Tutorials and personal work contribute to develop both C8.1 skill "Work collaboratively in a team" and C3.1 skill "Be proactive and involved, take initiatives"
- The personal work, for instance, helps to deepen the C7.1 skill "Persuade at core value level; to be clear about objectives and expected results. To apply rigour when it comes to assumptions and structured undertakings, and in doing so structure and problematise the ideas themselves. Highlight the added value"