2EL2410 – Signal compression and denoising

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

Description

This course is an introduction to signal and image representations, analysis, compression and denoising, fundamentals of modern signal processing for music and video storage, image enhancing in smartphones, processing and medical and astrophysical images, etc.

With the ever increasing quantity of collected and stored data, signal compression (images, sounds, videos...) remains a major challenge in data sciences, limiting the amount of necessary storage, and data transfers on telecommunication networks. Image restoration techniques (of which denoising is a particular example) are used on recent smartphones to mitigate the limitations of photographic sensors in resolution and sensibility.

A common point of the methods introduced in this course is their frugality in computations, energy, and data necessary for their development and use.

After recalling fundamentals of signal processing and harmonic analysis (filters, Fourier transform and series, random processes...), a first overview of signal denoising and compression will be given by Wiener filtering and LPC coding of speech.

The introduction of entropy coding will allow the design of lossless coders for images (PNG) and sounds (FLAC).

Lossy compression algorithms, with superior compression rates, will then be considered (JPEG, MP3, etc.).

Finally, wavelet orthogonal bases will be defined, with applications in image compression (JPEG2000), and non-linear image denoising.

Quarter **number**
SG6

Prerequisites (in terms of CS courses)
1SL1000 CIP
1SL1500 EDP
1CC4000 Signal Processing

Syllabus

1- Introduction

- Filtering, sampling
- Fourier series and transform
- Random processes

2- Wiener filtering and speech coding

- Linear denoising of random processes
- Speech models
- Linear prediction coefficients
- LPC coding

3 - Coding and quantization

- Source coding, entropy
- Lossless image compression (PNG)
- Universal coding and lossless sound compression (FLAC)
- Quantization

4 - Time-frequency representations

- Time-frequency orthogonal bases and frames (Short-time Fourier transform, DCT)
- JPEG image compression
- Audio masking and application to audio coding (MP3, Vorbis, etc.)

5 - Wavelet bases

- Wavelet orthogonal bases and fast wavelet transform
- Daubechies wavelets
- Application to image compression, JPEG2000
- Wavelet thresholding for image denoising

Class components (lecture, labs, etc.)
18h lectures
15h Tutorials/Labs
2h Final exam

Grading

Lab reports 30% Missed lab = 0 points for the lab Final exam 70%. Remedial exam : written exam 2h.

Course support, bibliography

A Wavelet Tour of Signal Processing, Stéphane Mallat, Academic Press

Resources

Personal computers, Python

Learning outcomes covered on the course

At the end of this course, the students will be able to

- Know the mathematical basis of non stationary signals representation
- Analyze signals using time-frequency representations
- Choose an appropriate representation for a given signal model
- Implement signal compression methods
- Recognize the limits of compression techniques
- Design, analyze and implement signal estimation methods

Description of the skills acquired at the end of the course

C1.2 Select, use and develop modelling scales, allowing for appropriate simplifying hypotheses to be formulated and applied towards tackling a problem.

C6.5 Operate all types of data, structured or unstructured, including big data.

C6.7 Understand information transmission.