2SC8010 – Sparse representations of signals

Instructors: Stephane Rossignol
Department: CAMPUS DE METZ
Language of instruction: FRANCAIS
Campus: CAMPUS DE METZ
Workload (HEE): 60
On-site hours (HPE): 34,50

Description
The parsimonious representation of signals is one of the fundamental concepts in data science. Parsimonious representations make it possible to represent complex signals (such as sounds) by a small number of non-zero coefficients, this in very large spaces. They thus make it possible to find structures or regularities in very large spaces. These representations are at the heart of the mathematical understanding of the effectiveness of recent algorithms and techniques of supervised or unsupervised learning and scattering transformations.

The lecture introduces some mathematical tools used in signal analysis and their properties (complements about the Fourier transform, subsampling, oversampling, harmonic signal, STFT, multi-resolution analysis, Paley-Littlewood wavelet decompositions, and bi-orthogonal analysis, perfect reconstruction filter banks) as well as signal decomposition methods (Matching Pursuit, Basis Pursuit, Independent Component Analysis).

Quarter number
ST7

Prerequisites (in terms of CS courses)
Probability, statistics, signal processing (1CC4000 and 1CC5000) and first year algorithmic lectures (1CC1000); a good knowledge of a programming environment (Matlab/Octave, Python).

Syllabus

Harmonic analysis: reminders and complements on the Fourier transform (under/over-sampling, DFT, filter banks, harmonic signal, Hilbert transform, short term Fourier transform (STFT)).

Multi-resolution analysis: Paley-Littlewood wavelet decomposition, bi-orthogonal, perfect reconstruction filter banks.

Decomposition of a signal: dictionary, parsimonious representation, matching pursuit, orthogonal matching pursuit, basis pursuit.

Independent component analysis: notions of entropy, entropy rate of a random signal, mutual information, independent component analysis (ACI), ACI in an orthonormal basis, blind deconvolution.

Concepts of supervised learning: introduction to basic notions of learning, test basis, over-learning, empirical risk, real risk (or generalization)

Class components (lecture, labs, etc.)
17.5h Lecture
9h Tutorials
8h Labs. A single topic.

Grading
Continuous monitoring (50%, 2/3 MCT at the beginning of the tutorials; individual score) and oral presentation at the very end of the labs (50%). Labs : grading by pair; differentiated in the event of an anomaly in a pair.

Course support, bibliography
A wavelet tour of signal processign, Stéphane Mallat

https://www.di.ens.fr/~mallat/papiers/WaveletTourChap1-2-3.pdf

Resources
Teacher : Stéphane Rossignol

Room size for tutorials : 34
Max room size for labs : 34

Software : Matlab (34 licences)/Octave (Python)

Rooms for labs : rooms on Metz campus

Learning outcomes covered on the course

- Being able to design a complete signal processing chain.
- Being able to compare the performances of the various tools at our disposal for the analysis of complicated time series, in order to

choose the one which will be best suited for this or that signal to be analyzed.

- Being able use correctly the basic and advanced principles of analog signal processing and digital signal processing.

Description of the skills acquired at the end of the course

C2. Develops in-depth skills in an engineering field and a family of professions.
C6. Be operational, responsible, and innovative in the digital world.