Mathematical foundations of signal processing

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**Summary**

Signal processing tools are presented from an intuitive geometric point of view which is at the heart of all modern signal processing techniques. Student will develop the mathematical depth and rigor needed for the study of advanced topics in signal processing.

**Content**

- **From Euclid to Hilbert applied to inverse problems** (vector spaces; Hilbert spaces; approximations, projections and decompositions; bases)
- **Sequences, Discrete-Time Systems, Functions and Continuous-Time Systems** (flipped class review of discrete-time Fourier transform; z-transform; DFT; Fourier transform and Fourier series).
- **Sampling and Interpolation** (sampling and interpolation with finite-dimensional vectors, sequences and functions).
- **Computerized tomography fundamentals** (line integrals and projections, Radon transform, Fourier projection/slice theorem, filtered backprojection algorithm, algebraic reconstruction techniques).
- **Array signal processing fundamentals** (spatial filtering and beamforming, adaptive beamforming, acoustic and EM source localization techniques).
- **Compressed sensing and finite rate of innovation** (overview and definitions, reconstruction methods and applications)
- **Euclidean Distance Matrices** (definition, properties and applications).

**Learning Prerequisites**

- Required courses
  - Circuits and Systems
  - Signal processing for communications (or Digital signal processing on Coursera)

**Learning Outcomes**

By the end of the course, the student must be able to:

- Master the right tools to tackle advanced signal and data processing problems
- Develop an intuitive understanding of signal processing through a geometrical approach
- Get to know the applications that are of interest today
- Learn about topics that are at the forefront of signal processing research

**Teaching methods**
Ex cathedra with exercises
One week of flipped class

**Expected student activities**
Attending lectures, completing exercises

**Assessment methods**
Homeworks 20%, midterm (written) 30%, final exam (written) 50%

**Supervision**
- Office hours: Yes
- Assistants: Yes
- Forum: No

**Resources**
- Virtual desktop infrastructure (VDI): No

**Bibliography**

**Ressources en bibliothèque**
- Signal Processing: Foundations / Vetterli

**Websites**
- http://lcav.epfl.ch/SP_Foundations

**Moodle Link**