COM-514

Mathematical foundations of signal processing

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Cursus	Sem.	Type
Communication systems minor	H	Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computer and Communication Sciences		Obl.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.
Systems Engineering minor	H	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Courses	3 weekly
Exercises	2 weekly
Number of positions	

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)
Approximation and compression (polynomial and spline approximation, transform coding and compression)
Localization and uncertainty (time and frequency localization for sequences and functions, tiling the time-frequency plane)

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

M. Vetterli, J. Kovacevic and V. Goyal, *"Signal Processing: Foundations"*, Cambridge U. Press, 2014. Available in open access at http://www.fourierandwavelets.org

Ressources en bibliothèque

- Signal Processing: Foundations / Vetterli

Websites

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

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=13431