Introduction to Harmonic Analysis and its Applications Spring 2019

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Office hours	Mondays at 5:15pm
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Synopsis of course content

Introduction to Fourier analysis. On the circle: basic properties, convolutions, Poisson kernel, convergence (mean squared, pointwise), regularity and Fourier coefficients. Fourier analysis on the real line: the Schwartz space, Fourier inversion, Plancherel formula, Poisson summation formula, Heisenberg uncertainty principle. Fourier transform in d dimensions.

Introduction to Wavelet analysis. Time meets frequency: Windowed Fourier Tranform, Wavelet Transforms. Frames. Wavelet Bases.

Introduction to Approximation theory. Linear and nonlinear approximations. Image Approximation with Wavelets, adaptive basis selection, approximation with pursuits. Image compression and transform coding.

Estimation and Approximation and Inverse Problems. Denoising, thresholding. Radon transform: Fourier analysis, vaguelets and curvelets.

Applications to Statistical Learning and Machine Learning. Parametric and non-parametric techniques for density estimation and regression.

Signal Processing on Graphs: random walks and Laplacian on graphs, spectral graph theory, Fourier and wavelet analysis on graphs, applications.

Grading

Grade to be based on weekly assignments (30%), one midterm (30%) and a final project (40%).
Weekly problem sets will include theory, analysis and computational projects.

Prerequisites

Linear algebra will be used throughout the course, as will multivariable calculus and basic probability (discrete random variables). Ability to write basic proofs (e.g. from a course in real analysis). Basic experience in programming in C or MATLAB or R or Octave will be helpful in several homework sets.

Additional Information

Students from all areas of science, engineering, computer science, statistics, economics and quantitative studies that need advanced level skills in solving problems related to the analysis of data, signal processing, or statistical modeling are encouraged to enroll.