332:525 Optimum Signal Processing (Signal Processing and Machine Learning for Engineers)

Instructor: Professor Athina Petropulu
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Office hours: Tuesday 10-noon or by appointment

Class Schedule: TBD

Course Description:

The course will cover important topics in signal processing and machine learning, such as:

- **Review of linear and matrix algebra, probability and random processes**

- **Spectrum Estimation and applications**
  classical spectrum estimation, parametric modeling, autoregressive models, minimum variance spectral estimation, maximum likelihood estimation, subspace methods for frequency estimation, MUSIC, ESPRIT, array processing, beamforming.

- **Mean-Square Error Linear Estimation**
  normal equations, the orthogonality condition, linear filtering**,** Kalman filtering

- **Stochastic Gradient Descent**
  Steepest descent, the Least-Mean-Squares Adaptive Algorithm, LMS convergence and properties, distributed LMS

- **Least-Squares Estimation**
  Least-squares linear regression, recursive least-squares (RLS), RLS performance analysis

- **Classification**
  Bayesian classification, nearest neighbor rule, logistic regression, Fisher's linear discriminant

- **Sparsity Aware Learning**
  LASSO, learning sparse analysis models

- **Particle Filtering**
  Sequential importance sampling, Kalman and particle filtering, particle filtering

- **Neural Networks and Deep Learning**
  Perceptron, feed-forward multilayer neural networks, backpropagation algorithm, pruning the network, universal approximation property of feed-forward neural networks

Text:
Collection of papers and book chapters, to be assigned by the instructor.
S. Theodoridis, Machine Learning a Bayesian and Optimization Perspective, Second Edition, Academic Press, 2020.

Prerequisites: knowledge of probability and stochastic processes, basic knowledge of linear algebra, familiarity with MATLAB.

Grading:

The final grade is based on:

1. Computer projects (60%)
   There will be 1 computer project

2. Homework assignments (20%)
   There will be a bi-weekly homework assignment

3. Class participation (20%)
   Students will be assigned to read ahead material and share their understanding in class.

Course Web Page:
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