FS23 MTH994-001: Machine Learning

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Office hours: Fri. 2:00-5:00pm and by appointment

Course Description: Artificial intelligence (AI), including machine learning (ML), has fundamentally changed the landscape of science, technology, industry, and social media in the past few years. It is one of the most transformative technologies and promises the fourth industrial revolution. AI is regarded by many as the fourth method of scientific research following experiments, theoretical models, and computer simulations. In this course, we will not only discuss the theoretical framework of ML algorithms and architectures but also put an emphasis on programming skills so that each student is able to implement advanced ML algorithms for real-world problems. The course starts with linear regression (LR), logistic regression (LR), k-nearest neighbors (KNN), k-means, principal component analysis (PCA), support vector machine (SVM), kernel learning (KL), and decision trees (DT), including random forest (RF) and gradient boosting tree (GBT). After discussing these elementary materials, more advanced methodologies, such as artificial neural networks (ANNs), back-propagation, and transfer learning. Then we will work on convolutional neural networks (CNNs) and recurrent neural networks (RNNs). The vanishing gradient problem will be addressed with long-short term memory (LSTM), gated recurrent unit (GRU), variational autoencoder (VAE), encoder, decoder, transformer, generative adversarial network (GAN). We will discuss research topics, such as analyzing the intrinsic dimensionality of dataset encoding, making deep learning more transparent (less a black-box), more efficient, and more robust in the selection of hyperparameters, designing new machine algorithms and reformulating DL algorithms from the mathematical point of view. This course draws on a variety of mathematical subjects, including algebra, topology, geometry, analysis, differential equation, graph theory, optimization, statistics, and probability. This course will involve active research topics in DL.

Prerequisites: None but assuming a student knows advanced calculus, linear algebra, and has good coding skill.

Text: There is no required textbook for this course (A full set of lecture notes and tutorial materials will be provided at no cost.).