FS20 MTH994: Machine Learning

Instructor: Guowei Wei – wei@math.msu.edu
Office: D301 Well Hall
Course Description: Machine Learning (ML) is a powerful technique widely used in many data science areas such as finance, insurance, economics, biology, bioinformatics, drug discovery, engineering, language processing, face recognition, image segmentation, etc. 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, manifold learning, statistic learning (SL), probabilistic classifies (PC), Naïve Bayes (NB), and Boltzmann machine (BM) will be explored. The course will try to help graduate students with their research needs in ML.

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.).

SS21 MTH994: Deep Learning

Instructor: Guowei Wei – wei@math.msu.edu
Office: D301 Wells Hall
Course Description: The second semester course will be focused on deep learning (DL). I will start with basic methodologies, such as artificial neural networks (ANNs), back-propagation, and transfer learning. Then we will work on convolutional neural networks (CNNs) and recurrent neural network (RNNs). The vanishing gradient problem will be addressed with long-short term memory (LSTM), gated recurrent unit (GRU), residual network (ResNet), deep belief network (DBN), etc. The next set of major topics includes generative network complexes (GNC), such as autoencoder, variational autoencoder (VAE), encoder, decoder, transformer, generative adversarial network (GAN), transformer, and U-Net. Another main emphasis will be on various reinforcement learning (RL) algorithms and application. 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: A student must have passed a one-semester course on ML.
Text: There is no required textbook for this course (A full set of lecture notes and tutorial materials will be provided at no cost.).