MACHINE LEARNING FOR ENGINEERING AND SCIENCE APPLICATIONS

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INTENDED AUDIENCE: Postgraduate students in all engineering and science disciplines. Mature senior undergraduate students may also attempt the course.

PREREQUISITES: Familiarity with Multivariable Calculus, Linear Algebra, Probability, Statistics. Comfortable with basic programming.

INDUSTRY SUPPORT: Should be of interest to companies trying to employ engineers familiar with Machine Learning

COURSE OUTLINE
Recent applications of machine learning have exploded due to cheaply available computational resources as well as wide availability of data. Machine Learning (ML) techniques provides a set of tools that can automatically detect patterns in data which can then be utilized for predictions and for developing models. Developments in ML algorithms and computational capabilities have now made it possible to scale engineering analysis, decision making and design rapidly. This, however, requires an engineer to understand the limits and applicability of the appropriate ML algorithms. This course aims to provide a broad overview of modern algorithms in ML, so that engineers may apply these judiciously. Towards this end, the course will focus on broad heuristics governing basic ML algorithms in the context of specific engineering applications. Matlab will be used in this course but students will also be trained to implement these methods utilizing open source packages such as TensorFlow.

ABOUT INSTRUCTOR
Prof. Balaji Srinivasan is a faculty member in the Mechanical Engineering Department at IIT-Madras. His areas of research interest include Numerical Analysis, Computational Fluid Dynamics and applications of Machine Learning.
Prof. Ganapathy Krishnamurthi is now an Professor in the Department of Engineering Design at IIT-Madras. His research work is primarily in the area of medical image analysis and image reconstruction.

COURSE PLAN
Week 1 : Mathematical Basics 1 – Introduction to Machine Learning, Linear Algebra
Week 2 : Mathematical Basics 2 -- Probability
Week 3 : Computational Basics – Numerical computation and optimization, Introduction to Machine Learning packages
Week 4 : Linear and Logistic Regression – Bias/Variance Tradeoff, Regularization, Variants of Gradient Descent, MLE, MAP, Applications
Week 5 : Neural Networks – Multilayer Perceptron, Backpropagation, Applications
Week 6 : Convolutional Neural Networks 1 – CNN Operations, CNN architectures
Week 7 : Convolutional Neural Networks 2 – Training, Transfer Learning, Applications
Week 8 : Recurrent Neural Networks RNN, LSTM, GRU, Applications
Week 9 : Classical Techniques 1 – Bayesian Regression, Binary Trees, Random Forests, SVM, Naïve Bayes, Applications
Week 10 : Classical Techniques 2 – k-Means, kNN, GMM, Expectation Maximization, Applications
Week 11 : Advanced Techniques 1 – Structured Probabilistic Models, Monte Carlo Methods
Week 12 : Advanced Techniques 2 – Autoencoders, Generative Adversarial Networks