Course number and name: **CS 07556: Machine Learning I**

Credits and contact hours: 3 credits / 3 contact hours

Instructor's or course coordinator's name: Shen-Shyang Ho

Instructional materials:
1. Abu-Mostafa, Yaser S., Malik Magdon-Ismail, and Hsuan-Tien Lin. Learning from data. New York, NY, USA, 2012. http://amlbook.com
2. Lecture notes.

Catalog description: This course introduces students to fundamental concepts in machine learning tasks and techniques. Topics covered include understanding the learning problem, VC-dimension, Bias & Variance, Overfitting, Regularization, Generalization, similarity-based learning, probabilistic learning (naive Bayes', Bayesian network), Linear models (perceptron, linear regression, logistic regression), Support Vector Machine, Neural Network (and Convolutional Neural Network), Data Preprocessing, Experimental Design and Performance evaluations.

Prerequisites: Linear Algebra, Probability, Calculus II, or permission of instructor

List of topics to be covered:

1. History of Machine Learning
2. Learning Problem & Formulation
3. Linear Models
    a. Perceptron
    b. Linear Regression
    c. Logistic Regression
4. Theory of Generalization
    a. Growth Function
    b. Hoeffding Inequality / PAC Learning
    c. VC-dimension Analysis
    d. Bias-Variance Analysis
5. Overfitting, Regularization, and Validation
6. Bayesian Learning
    a. Maximum A Posteriori Prediction
    b. Naïve Bayes
    c. Bayesian Network
7. Introduction to Optimization
    a. Unconstrained/Constrained Optimization
    b. Convex Optimization

    c. Solving Constrained Optimization Problem with Inequality Constraints - Karush-Kuhn-Tucker conditions
8. Support Vector Machines
    a. Hard Margin SVM formulation
    b. Soft Margin SVM formulation
    c. Kernelization
9. Data/Feature Representation and Related Issues
    a. Dimensionality Reduction - Principal Component Analysis
    b. Data Transformation
    c. Concept of Representation Learning
10. Neural Network
    a. Fully Connected Neural Network - Backpropagation
    b. Gradient Descent Methods & Stochastic Gradient Descent
    c. Convolutional Neural Network and its variant
    d. Recurrent Neural Network – Backpropagation through time
    e. Transformer
11. Introduction to Reinforcement Learning