ECE 2372 - Pattern Recognition

Course Objective : This course will provide an introduction to the theory of statistical learning and pattern recognition with applications. We will study both practical algorithms for statistical inference and theoretical aspects of how to reason about and work with probabilistic models. We will consider a variety of applications, including classification, prediction, regression, clustering, modeling, and data exploration/visualization.

Topical Outline:

- **Concentration inequalities and multiple hypothesis testing**
- **The Bayes classifier and nearest neighbor classification**
- **Naive Bayes and linear discriminant analysis**
- **SVM and Kernel Trick**
- **Theory of Generalization**
- **The VC Dimension**
- **Bias-Variance Trade-off**
- **Over-fitting, Regularization and Validation**
- **The LASSO, kernel methods in regression, regularization in classification**
- **Density estimation and k-means clustering**
- **GMMs and the expectation-maximization algorithm**

Prerequisites :

We will stick with a statistical perspective in this class, which will require familiarity with basic concepts in probability (e.g., random variables, expectation, independence, joint distributions, conditional distributions, Bayes rule, and the multivariate normal distribution). We will also be using the language of linear algebra to describe the algorithms and carry out any analysis, so you should be familiar with concepts such as norms, inner products, orthogonality, linear independence, eigenvalues/vectors, eigenvalue decomposition, etc. as well as the

basics of multi-variable calculus such as partial derivatives, gradients, and the chain rule. Most homework assignments and the course projects will require the use programming language. You can use Python, R, MATLAB, or other scientific programming language that I may able to compile.]

Reference Textbooks:
The material for this course sourced from several different texts. I will not require you to purchase any specific text, but the primary sources for the course are:

- **The Elements of Statistical Learning, Hastie, Tibshirani, and Friedman, 2009. This book covers most of the material we will be covering in the class and is probably the best overall resource that is freely available on the internet. (Free online version, Amazon)**
- **Pattern Recognition and Machine Learning, Bishop, 2006. This is a classic (I will use it as a question bank).**
- **Learning from Data, Abu-Mostafa, Magdon-Ismail, and Lin, 2012. This book is short and fantastic. It doesn't cover everything we will talk about, but has clear overview of VC theory. (It is also a keeper if you are interested in ML).**
- **Pattern Classification, Duda, Hart, and Stork, 2000. This used to be the main textbook for the previous offerings of this class and you may be referred to it in your upcoming machine learning classes. I would recommend to keep a copy of it for your won reference, it has a good coverage of the field.**
- **Introduction to Machine Learning, 4th edition, Ethem Alpaydin. Once I was a young student at Bosphorus University, and Ethem was teaching Machine Learning. He is one of the smartest people I know. Introductory yet living coverage of the field.**

Grading Weights:

- **Homework (20%)**
- **Midterm (30%)**
- **Project Proposal (15%)**
- **Final Project (30%)**
- **Participation (5%)**