ECE5424G/CS5824 Advanced Machine Learning Fall 2022

This course will cover **supervised learning principles**, classification and prediction, various artificial neural networks, support vector machine, feature selection and search strategies, linear regression and Lasso; **unsupervised learning principles**, principle component analysis and APEX algorithm, clustering algorithms (k-means, SOM, mixture modeling, EM algorithm, etc), model selection and information criterion; **latent variable modeling**, autoencoder, independent component analysis, nonnegative matrix factorization; and **performance assessment principles**, cross-validation, ROC analysis, statistical hypothesis testing, bootstrapping and ML uncertainty; with **applications** on the boundaries between machine learning and data sciences. The course is theoretical, practical, and challenging in nature.

Instructor: Dr. Yue Wang (Joseph)
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Lectures: Tuesdays and Thursdays, 3:30pm–4:45pm

Office Hours: by e-mail or zoom

Textbooks (not required): *Pattern Classification* (2nd ed) by R. O. Duda, P. E. Hart and D. G. Stork, John Wiley & Sons, 2001.

Simon Haykin, *Neural Networks: A Comprehensive Foundation*, Prentice-Hall, Inc., 1999.

T Hastie, R. Tibshirani, and J. Friedman**,** *The Elements of Statistical Learning*, Springer, 2001.

Pre-requisite (preferred): A graduate course covering probability theory, random variables, and random processes. Knowledge about signal detection and estimation is desirable (e.g., ECE 5605/5606).

Grading:

Paper reading and homework completion	30%
Term paper proposal (midterm exam)	20%
Final term paper (final exam)	50%

Course Outline: Introduction to statistical and machine learning theory, statistical decision principles, linear discriminant analysis, Fisher criterion and feature extraction, single and multilayer perceptrons (artificial neural networks), radial-basis function RBF-NN, support vector machine, feature selection, cross-validation, bootstrap and permutation re-sampling, principal component analysis, autoencoder, k-means clustering, self-

organizing maps, Gaussian mixture model and the EM algorithm, model selection, matrix factorization methods, Gaussian graphical model and Lasso method.

Honor Code: Adherence to Virginia Tech's honor code is fully expected. Please discuss any questions you may have about what is or is not permitted with the instructor.

The University Honor Code pledge that each member of the university community agrees to abide by states:

"As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."

Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code.

The Virginia Tech honor code pledge for assignments is as follows: "I have neither given nor received unauthorized assistance on this assignment."

The pledge is to be written out on all graded assignments at the university and signed by the student. The honor pledge represents both an expression of the student's support of the honor code and an unambiguous acknowledgment that the student has, on the assignment in question, abided by the obligation that the Honor Code entails. In the absence of a written honor pledge, the Honor Code still applies to an assignment.

All assignments submitted shall be considered "graded work" and all aspects of your coursework are covered by the Honor Code. All projects and homework assignments are to be completed individually unless otherwise specified.

Commission of any of the following acts shall constitute academic misconduct. This listing is not, however, exclusive of other acts that may reasonably be said to constitute academic misconduct. Clarification is provided for each definition with some examples of prohibited behaviors in the

Undergraduate Honor Code Manual: Cheating, Plagiarism, Falsification, Fabrication, Multiple Submission, Complicity, etc.

https://www.honorsystem.vt.edu/

If you have questions or are unclear about what constitutes academic misconduct on an assignment, please speak with me. I take the Honor Code very seriously in this course. The normal sanction I will recommend for a violation of the Honor Code is an **F*** sanction as your final course grade. The F represents failure in the course. The "*****" is intended to identify a student who has failed to uphold the values of academic integrity at Virginia Tech. A student who receives a sanction of **F*** as their final course grade shall have it documented on their transcript with the notation "FAILURE DUE TO ACADEMIC HONOR CODE VIOLATION." You would be required to complete an education program administered by the Honor System in order to have the "*" and notation "FAILURE DUE TO ACADEMIC HONOR CODE VIOLATION" removed from your transcript. The "F" however would be permanently on your transcript.

Academic Integrity Success Module:

A free module through Canvas to educate students on Academic Integrity at Virginia Tech. Many of our faculty will often require students to take this module as a course requirement, or will offer it to students for extra credit. It is a part of the Canvas badging program, so verification that the student has completed it is relatively easy – my office can also verify completion as well. This module provides information on Academic Integrity in various formats directly from the office, provides examples, and does verify that the student did read the material. This module takes no more than 30 minutes to complete, and will open August 20th, and is available throughout the year. Here is a link to the module: **https://canvas.vt.edu/enroll/CE7YK9**

Understanding the Code:

A limited time offering through Canvas for peer to peer education in a video format. This module is put together by the Undergraduate Honor Council delegates and addresses different Academic Integrity scenarios and answers frequently asked questions. Completion of UTC can also be verified through Canvas. UTC also takes students no longer than 30 minutes to complete. UTC will be open on Canvas from August 31st – September 3rd. Many of our faculty will often require students to take this module as a course requirement, or will offer it to students for extra credit. Here is a link to Understanding the Code: **https://canvas.vt.edu/enroll/7HR4PF**