CS 4824/ECE 4424: Machine Learning

Website:  https://people.cs.vt.edu/dbhattacharya/courses/cs4824/

Piazza:  https://piazza.com/vt/spring2022/cs4824ece4424/home

Canvas:  https://canvas.vt.edu/courses/145327 (CS 4824)
          https://canvas.vt.edu/courses/145383 (ECE 4424)
Are you in the right place?

- This is CS 4824/ECE 4424 (ML): CRN 20573
  - Modality is "Face-to-Face Instruction"

- There is another section of the same course…
  - But with different CRN
Today

- What is Machine Learning, the discipline, about?
  - The *trifecta* of ML

- What is this class about?
  - What to expect?
  - Logistics
What are we here to discuss?

A wide range of topics in Machine Learning covering their intuitions, mathematical foundations, analyses, and applications!
Demo time…

https://openai.com/blog/openai-codex/

Live demo:

https://youtu.be/SGUCcjcHTmGY
Concepts

CS

AI

ML
Intelligence

- **General Intelligence**
  - The ability to navigate in problem space.—Siddhartha Mukherjee, Columbia

- **Artificial Intelligence**
  - The science and engineering of making computers behave in ways that, until recently, we thought required human intelligence. —Andrew Moore, CMU
What is machine learning?

- **Study of algorithms that**
  - improve their performance (P)
  - at some task (T)
  - with experience (E) —Tom Mitchell, CMU
The ML niche is expanding...

- Machine learning is central to
  - Computer Vision
  - Natural Language Processing
  - Speech Recognition
  - Biology
  - Robotics
  - ...

- Machine learning has a conducive environment to grow in the 21st century
  - Accumulation of "Big Data"
  - Demand for Self-customization to User
  - Post Moore's Law Computing
  - ...

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Spam classification

From: cheapsales@buystufffromme.com  
To: ang@cs.stanford.edu  
Subject: Buy now!  
Deal of the week! Buy now!  
Rolex w4tchs - $100  
Medicine (any kind) - $50  
Also low cost M0rgages available.  

From: Alfred Ng  
To: ang@cs.stanford.edu  
Subject: Christmas dates?  
Hey Andrew,  
Was talking to Mom about plans for Xmas. When do you get off work. Meet Dec 22?  
Alf

Spam

Non-spam

Supervised learning
News clustering

Unsupervised learning
Motion planning

Spinkick

Backflip

Cartwheel

Run

Reinforcement learning
The *trifecta* of ML

- **Supervised learning**
  - Perform inductive inference and produce an inferred function to emulate mapping between input and output
  - Supervisory signal in the form of example input-output pairs (a.k.a. labeled training data)

- **Unsupervised learning**
  - Group together data into categories having similar features without requiring pre-assigned category labels
  - Self-discover any naturally occurring patterns in (unlabeled) data sets

- **Reinforcement learning**
  - Collect rewards for "good" actions while avoiding penalty for "bad" actions
  - Take action to explore uncharted territory and exploit experience
What this class is about?

- Introduction to Machine Learning

- Goal
  - After finishing this course, you should be ready to get started on your first ML research project

- Target audience
  - Senior undergrads, BS/MS students
What this class is NOT

○ NOT the target audience
  ◦ Grad students already working in ML area
  ◦ Folks looking to understand the most recent breakthroughs (e.g., AlphaGo, AlphaFold, etc.)

○ NOT the goal
  ◦ Teaching a toolkit (e.g., TensorFlow/PyTorch)
Topics*

*Tentative and subject to change

- **Basics of Statistical Learning**
  - Loss functions, MLE, MAP, Bayesian estimation, bias-variance tradeoff, overfitting, regularization, cross-validation
- **Supervised Learning**
  - Decision Trees, Naïve Bayes, Logistic Regression, Linear Regression, Kernels and Kernel Regression, Support Vector Machines, Neural Networks
- **Unsupervised Learning**
  - EM, Clustering
- **Graphical Models**
  - Bayesian Networks, Hidden Markov Models
- **Deep Learning**
  - Convolutional Neural Networks, Recurrent Neural Networks, Attention and Transformer Networks, Autoencoders, Variational Autoencoders, Generative Adversarial Networks
- **Reinforcement Learning**
  - Markov Decision Process, Value Iteration, Policy Iteration, Q-Learning
Textbook

- None required.

- Optional reference books (freely available online):
  - Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2006
  - The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer, 2009
  - Reinforcement Learning: An Introduction, Richard S. Sutton and Andrew G. Barto, MIT Press, 2018
Prerequisites

- **Probability and Statistics**
  - Distributions, densities, marginalization, moments, typical distributions.
  - Calculus and Linear Algebra
  - Matrix multiplication, eigenvalues, positive semi-definiteness, multivariate derivates.

- **Algorithms**
  - Dynamic programming, basic data structures, complexity.

- **Programming**
  - This is a demanding class in terms of programming skills. HWs will involve a mix of Python and libraries. You are free to choose any programming language for the project.

- **Ability to deal with abstract mathematical concepts.**
Organization and Deliverables

- **Homeworks**
  - Hands-on implementation and analysis, covering various topics that complement and supplement the lecture topics.
  - 4 individual HWs ($15\% \times 4 = 60\%$). Involve a mix of Python and libraries.
  - 2 HWs before Spring break, 2 after Spring break.
  - Start early, Start early, Start early, Start early, Start early, Start early, Start early, Start early, Start early

- **Course Project**
  - The course project is meant for students to (1) gain experience implementing machine learning models; and (2) try machine learning on problems that interest them.
  - The project must be done individually in this semester (i.e., no double counting).
  - Project Proposal (15\%): Due on March 4th
  - Project Final Report (20\%): Due on May 4th
  - Project midway progress check (not graded, but submission is mandatory): Due on April 22

- **Class participation**
  - Contribute to class discussions on Piazza
  - Engage in class: ask questions, answer questions
  - Your class participation grade (5\%) will depend on your overall engagement in the classroom and in Piazza as well as your intellectual contribution.

- **Final letter grade**
  - Computed based on ceiling of the final percentage of points earned. The grade ranges are as follows:
    - A: 90\%-100\%
    - B: 80\%-89\%
    - C: 70\%-79\%
    - D: 60\%-69\%
    - F: Below 60\%
Late policy for deliverables

- **Free late days**
  - 3 days (3 x 24-hour chunks) for the semester
  - Can use for HWs
  - DO NOT use for project related deadlines

- **After free late days are used up for the HWs:**
  - 25% penalty for each late day
Project

- **Goal**
  - Chance to try Machine Learning
  - Encouraged to try out interesting applications of machine learning in various domains such as vision, NLP, speech, computational biology, etc.

- **Computing**
  - Your own/group resources
  - Google colab: jupyter-notebook + free GPU instance
Project

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Policies

- **Collaboration Policy**
  - All assignments are individual assignments
  - You may discuss the questions
  - Each student writes their own answer/code for all assignments
  - Project proposal/report will be plagiarism checked

- **Regarding Policy**
  - Within 1 week of receiving the grades

- **Academic integrity**
  - Students enrolled in this course are responsible for abiding by the Honor Code
  - Zero-tolerance philosophy regarding plagiarism or other forms of cheating

- **Principles of Community**
  - The course will include in-class discussions, and we will adhere to Virginia Tech Principles of Community.

- **Accessibility**
  - If any student needs special accommodations because of any disabilities, please contact the instructor during the first week of classes.
  - Such students are encouraged to work with The Office of Services for Students with Disabilities to help coordinate accessibility arrangements.

- **COVID-19 Policy**
  - Please follow the instructions posted at the University and public health guidelines for the latest COVID-19 Policy.
Course Team

◦ **Instructor**
  ◦ Debswapna Bhattacharya (Office Hours: Monday and Wednesday 4:00 pm - 5:00 pm at Torgersen 2160N)

◦ **TAs**
  ◦ Subhodip Biswas (Office Hours: Friday 12:00 pm - 2:00 pm via https://virginiatech.zoom.us/j/87976013476)
  ◦ Hongjie Chen (Office Hours: Tuesday 4:00 pm - 6:00 pm via https://virginiatech.zoom.us/j/2023032020)
  ◦ Chongyu He (Office Hours: Wednesday 12:00 pm - 2:00 pm via https://virginiatech.zoom.us/j/4805592215)
How to stay in touch?

- **Primary means of communication — Piazza**
  - No direct email to instructor unless private information
  - Instructor/TAs can provide answers to everyone on forum
  - Class participation credit for answering questions on forum!
  - No posting answers on forum. We will monitor.

- **Staff Mailing List**
  - cs-4824-ece-4424-s22-staff-g@vt.edu

- **Class Mailing List**
  - class-cs-4824-20573-202201-g@vt.edu (CS 4824)
  - class-ece-4424-20574-202201-g@vt.edu (ECE 4424)
Todo: before next class

Go through the course webpage at:
https://people.cs.vt.edu/dbhattacharya/courses/cs4824/

...and ask any questions in the next class.

Get into Piazza:
https://piazza.com/vt/spring2022/cs4824ece4424/home