CPEN 355 : Machine Learning with Engineering Applications Fall 2023

Lecture Syllabus

Instructor: Prof. Xiaoxiao Li *Scribe: Xiaoxiao Li*

1 Course Description

- Credits: 4
- Pre-reqs: One of MATH 152, MATH 221 and one of MATH 318, MATH 302, STAT 302, STAT 321, ELEC 321 and one of CPEN 221, CPEN 223, CPSC 259.
- This course is restricted to students in year: ≥ 3 with one of these specializations: IN CPEN
  -OR-
  in year: ≥ 3 with one of these specializations: IN ELEC -OR-
  in year: ≥ 4 with one of these specializations: ****ENPH,****IGEN.

2 Contact Information

- Instructor: Xiaoxiao Li
- Email: xiaoxiao.li@ece.ubc.ca

3 Time and Location

- Class Meets:
  Mon & Weds || 11:00 – 12:00 || MacLeod 2018
  Fri || 11:00 – 12:00 || Hugh Dempster Pavilion 310
- Tutorials: Mon || 14:00 – 15:00|| West Mall Swing Space 121
  - Wenlong Deng dwenlong@student.ubc.ca
  - Sadegh Mahdavi smahdavi@ece.ubc.ca
- Instructor Office Hours: Mon 12:00 - 1:00 pm (by appointment only)

4 Prerequisites

- Proficiency in Python
  All class assignments will be in Python.

- College Calculus, Linear Algebra
  You should be comfortable taking derivatives and understanding matrix vector operations and notation.
- Basic Probability and Statistics
  You should know basics of probabilities, Gaussian distributions, mean, standard deviation, etc.

5 Course Goals

The course aims to provide an introductory level exposure to machine learning concepts with a balance between practical and theoretical aspects and hands-on experience suitable for engineering students. At the end of the course, students will be able to: apply the concept of learning and machine learning to real-world problems; identify the machine learning tasks and select suitable machine learning models; execute training and validation of models; apply techniques to control overfitting and assess the success of learning; use and modify available software for machine learning models and apply to new problems; realize the ongoing challenges and problems in machine learning; continue with specialized and advance machine learning courses.

6 Computational Resources

GPU computing is required for this class. I strongly recommend to Google Colab or use your own/lab's GPU since that is the most convenient way of writing and testing code with GUI. Click here to try out the Colab tutorial.

7 Course Content

This course will cover the following topics:

1. Course Policy (Sep 6)
2. Introduction to Machine Learning (Sep 8)
3. Machine Learning Basics
   - Concepts and Basic Math (Sep 11)
   - Linear Regression (Sep 13)
   - Penalized Regression: Lasso and Bridge (Sep 15)
   - Logistic Regression (Sep 18)
   - Newton's Method (Sep 20)
   - Intro to Machine Learning Practice (Python, Pytorch, Co-lab, etc.) (Sep 22)
   - Model Training and Evaluation (Sep 25)
   - Assignment 1 Announcemnet (Sep 11)

- Assignment 1 Submission (Sep 18)
- Assignment 2 Announcemnet (Sep 22)
- Assignment 2 Submission (Sep 29)

4. Supervised Learning
    - Introduction to Supervised Learning and K-Nearest Neighbors (Sep 27)
    - KNN and Computational Complexity (Sep 29)
    - Support Vector Machines (Oct 2, Oct 4)
    - Decision Tree and Random Forest (Oct 6, Oct 11, Oct 12)[1]
    - In-class Quiz (Oct 13)
    - Practice: Housing Price Prediction (Oct 16)
    - Assignment 3 Announcement (Oct 2)
    - Assignment 3 Submission (Oct 16)
5. Unsupervised Learning
    - Intro to Unsupervised Learning and Clustering (Oct 18)
    - Advanced Clustering (Oct 20)
    - Gaussian Mixture Model (Oct 23)
    - Principal Components Analysis (Oct 25, Oct 27)
    - Independent Component Analysis (Oct 30)
    - Semi-supervised Learning (Nov 1)
    - Practice: Unsupervised Learning (Nov 3)
    - Assignment 4 Announcement (Oct 20)
    - Assignment 4 Submission (Nov 3)
6. Overview of Deep Neural Networks
    - Background and Introduction to Multilayer Perceptrons (Nov 6, Nov 8)
        - Fully Connected Layers
        - Activation Functions
        - Objective Functions
    - Backpropogation and Optimization (Nov 10)
    - Practice: ANN for Image Recognition (Nov 17)
    - Assignment 5 Announcement (Oct 6)
    - Assignment 5 Submission (Nov 20)
7. Introduction to Deep Learning Models
    - Convolutional Neural Networks (Nov 20, Nov 22, Nov 24)
    - Recurrent Neural Networks (Nov 27, Nov 29)

[1] Oct 12 follows Monday's schedule

- AutoEncoder (Dec 1)
- Generative Adversarial Network (Dec 4, Dec 6)
- In-class Quiz (Dec 8)

8. Final Project Report Submission (Dec 18)

8 Grading, Assignments, and Final Project

- 5 Assignments: 60% = 5*12%
  - Conceptual and practical questions
  - Programming questions
- 2 in-class exams: 20% = 2*10%
- Final project: 20% [2]
  - A machine learning project including data collection, data preprocessing, data analysis using machine learning models. You need to submit codes together with a well structured report (at least 2 pages and no more than 10 pages). **No Teamwork allowed**.
  - *Passing the course does on conditional on if you pass the final project*
- Late submission will result in *0.8 decay per day. Extension is only accepted via applying for Academic Concession.

9 Suggested Reading Materials

- Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001.
- Müller, Andreas C., and Sarah Guido. Introduction to machine learning with Python: a guide for data scientists. " O'Reilly Media, Inc.", 2016.
- Goodfellow, Ian, Yoshua Bengio, Aaron Courville, and Yoshua Bengio. Deep learning. Vol. 1, no. 2. Cambridge: MIT press, 2016.
- Torfi, Amirsina. Deep Learning Roadmap. https://www.machinelearningmindset.com/books/

10 Acknowledgment

* Our course materials and design are referred to the the following resources, thanks for the great work done by the smart people!

- https://speech.ee.ntu.edu.tw/ tlkagk/courses.html

[2] You need to pass the final project to pass the course.

- http://cs231n.stanford.edu/
- http://deeplearning.cs.cmu.edu/
- https://www.deeplearningbook.org/lecture_slides.html
- https://www.cs.princeton.edu/courses/archive/spring16/cos495/
- http://ttic.uchicago.edu/ shubhendu/Pages/CMSC35246.html
- https://www.cc.gatech.edu/classes/AY2018/cs7643_fall
- http://introtodeeplearning.com/
- https://hrlblab.github.io/cs3891.html
- Prof. Lutz Lampe's teaching materials
- Prof. Qi Dou's teaching materials