Carleton UNIVERSITY | Department of Systems and Computer Engineering

SYSC 4415
Introduction to Machine Learning

Calendar description

Introduction to supervised and unsupervised machine learning (ML), including deeper knowledge of several algorithms of each type. Evaluation and quantification of predictive performance of ML systems. Use of one or more ML development environments.

Lectures three hours a week, laboratory/problem analysis one hour per week.

http://calendar.carleton.ca/undergrad/courses/SYSC/

Prerequisites

(ECOR 2050 or STAT 3502 or STAT 2605 or SYSC 2510), SYSC 2006 (with a minimum grade of C-), and third-year status in Engineering.

Prior knowledge

Students should have knowledge of:

- Are proficient in software development in at least one language
- Can program in Python or learn to do so on their own time within the first two weeks of class
- Understand basic probability and statistics
- Have strong math skills, including working with differential equations, matrix operations, and gradients

Course objectives

This course will follow “The One Hundred Page Machine Learning Book” from cover-to-cover. Students will gain an introductory-level understanding of both supervised and unsupervised machine learning (ML), including deeper knowledge of a number of algorithms of each type. Students will learn how to evaluate and quantify predictive performance of ML systems. Students will also become familiar with one or more ML development environments with practical assignments and demonstrations.

List of topics

- Math/Notation/Definitions
- ML Algorithms (e.g., Linear and Logistic Regression, Decision Trees, Support Vector Machines, K-Nearest Neighbour)

- Anatomy of a Learning Algorithm (e.g., Gradient descent, building blocks of a learning algorithm, online learning, numerical feature encoding, and weighting classes to address imbalance)
- Best Practices (e.g., Feature Engineering, Learning algorithm selection, Train/Test/Validation sets, Under-fitting, Over-fitting, Regularization, Model performance assessment, Hyperparameter tuning/cross-validation)
- Neural networks (Multi-layer feed-forward networks, Backpropagation)
- Deep Learning (Convolutional neural networks, Recurrent neural networks, LSTM/GRU)
- Advanced Practice (e.g., Training neural networks, Encoding input data, Regularlization, Multiple inputs & outputs, Transfer learning, Class imbalance, Combining classifiers, algorithm efficiency)
- Problems & Solutions (e.g. Kernel regression, Multiclass classification, One-class classification, Multi-label classification, Ensemble learning, Label sequences, Sequence-to-sequence learning, Active Learning, Semi-supervised learning, One-shot learning, Zero-shot learning)
- Unsupervised Learning (e.g., Density estimation, Clustering, Dimensionality reduction, Outlier detection)
- Other Forms of Learning (e.g., Metric learning, Learning to rank, Learning to recommend, Denoising auto-encoders)
- Introduction to Natural Language Processing (NLP)
- Extra Topics (e.g., Topic modeling, Gaussian Processes, Generalized Linear Models, Probabilistic Graphic Models, Markov Chain Monte Carlo, Genetic Algorithms, Reinforcement learning)
- Ethics of Developing & Deploying ML Systems

Learning outcomes

By the end of this course, students should be able to:

- Demonstrate understanding of basic supervised and unsupervised machine learning models.
- Develop models to solve various types of machine learning problems, including regression, classification, natural language processing, and clustering.
- Demonstrate a theoretical and practical understanding of a number of machine learning approaches including decision trees, logistic and linear regression, support vector machines, neural networks, convolutional networks, and recurrent neural networks.
- Apply existing machine learning platforms to develop classification and regression models.
- Understand how to quantify predictive performance of machine learning models (i.e., metrics and basic experiment design)

Graduate Attributes (GAs)

The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes at the time of graduation. There are no GA's related to this course. For more information, please visit: https://engineerscanada.ca/.

Instructor and TA contact

Specific to course offering (tbd)

Textbook (or other resources)

Specific to course offering (tbd)

Evaluation and grading scheme

Specific to course offering (tbd)

Breakdown of course requirements

Specific to course offering (tbd)

Tentative week-by-week breakdown

Specific to course offering (tbd)

Important Information

Specific to course offering (tbd)

General regulations

Attendance: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 2.1.3, Course Selection and Registration and Section 2.1.7, Deregistration.*

Health and Safety: Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: http://sce.carleton.ca/courses/health-and-safety.pdf

Deferred Term Work : Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current *Undergraduate Calendar, Academic Regulations*

of the University, Section 4.4, Deferred Term Work.

Appeal of Grades : The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the *Undergraduate Calendar, Academic Regulations of the University, Section 3.3.4, Informal Appeal of Grade and Section 3.3.5 Formal Appeal of Grade.*

Academic Integrity: Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: https://carleton.ca/registrar/academic-integrity/. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

Plagiarism: Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

Academic Accommodation: You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://www.carleton.ca/equity/ For an accommodation request, the processes are as follows:

- **Pregnancy or Religious obligation**: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf
- **Academic Accommodations for Students with Disabilities**: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your ***Letter of Accommodation*** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).
- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy.

For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/sexual-violence-support/.

- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf