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**Machine Learning and Neural Networks**

**COMP-5011-FA**

**Instructor Information:**

Instructor: Dr. Saad Bin Ahmed

Office Location: AT5020

E-mail: sbinahm@lakeheadu.ca

Office Hours: Wednesday 11:00am - 1:00pm

**Teaching Assistant:** To be defined

**TA Email:** To be defined

**Course Identification:**

Course Number: COMP-5011- FA

Course Name: Machine Learning - 5011-FA

Course Delivery: Lectures, MyCourseLink/D2L

Room and Time: RB3024 , Tuesday and Thursday at 1:00PM - 2:30PM

Final Date to Withdraw (Drop): Friday, November 3, 2023

Final Day of Classes: Monday, December 4, 2023

Fall Study Week: Monday, October 09, 2023 - Friday, October 13, 2023

**Attendance and participation lectures are highly recommended!**

**Prerequisite:** Probability, Discrete Mathematics and Python programming

**Tools:** Students will work extensively with Python and/or OpenCV, numpy, pandas and matplotlib.

**Description:**

The Machine Learning and Neural Networks course provides a comprehensive introduction to the fundamental concepts, techniques, and applications of machine learning and neural networks. This course is designed to equip students with the knowledge and skills necessary to understand, implement, and leverage these powerful technologies in various domains. Students will cover different techniques for features manipulation, classification models including supervised, unsupervised learning, regression and classification tasks, evaluation methods and related knowledge.

**Course Learning Objectives:**

By the end of this course, the student should:

* Understand the foundational principles of machine learning and neural networks.
* Explore various machine learning algorithms and their applications.
* Gain hands-on experience in designing, training, and evaluating neural networks.
* Develop the ability to select appropriate machine learning models for different tasks.
* Learn about common challenges and best practices in machine learning and neural network implementation.
* Apply machine learning techniques to real-world problems and datasets.
* Explore cutting-edge developments and trends in the field of machine learning and neural networks.

**Suggested Text and Online Resource:**

* Pattern Recognition and Machine Learning, Christopher M. Bishop – CB
* Machine Learning: a Probabilistic Perspective, Kevin Murphy – KM
* Machine Learning, Tom Mitchell – TM
* The Elements of Statistical Learning: Data mining, Inference, and Prediction, by Hastie, Tibshirani, Friedman – HTF
* Information Theory, Inference, and Learning Algorithms, David Mackay – DM
* And the Internet (for instant help)

| **Week** | **Topics to cover** |
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| Week 1 | Introduction to Machine Learning, Supervised Learning and its types, Unsupervised Learning, Semi-supervised Learning and Reinforcement Learning |
| Week 2 | Batch Learning Vs Online Learning, Learning Rate, Out of core Learning, Instance Based Learning Vs Model Based Learning, Challenges in Machine Learning, Overfitting, Underfitting, ML Development Lifecycle , Linear Regression |
| Week 3 | Linear Regression mathematical formulation and implementation, Gradient Descent intuition, mathematical formulation and implementation, Detailed understanding of Gradient Descent with visualizations, Understanding Learning curves. |
| Week 4 | Batch Gradient Descent its formulation and mathematical proof, Stochastic Gradient Descent, Mini-Batch Gradient Descent, Tensors in Machine Learning, Exploratory Data Analysis, Univariant, Bivariate and multivariate Analysis |
| Week 5 | Principal Component Analysis, KNN Algorithm |
| Week 6 | Break (Fall Reading Week) |
| Week 7 | Naive Bayes Classifier, Decision Trees, Ensemble Learning, Random Forest, Bagging, Boosting |
| Week 8 | k-Nearest Neighbor (kNN) Algorithm, Algorithm Formulation  Distance Metrics, Choice of k, Algorithm Convergence, Storage, Time Complexity Analysis, Fast kNN |
| Week 9 | Support Vector Machines, Unsupervised Learning, K-means Clustering |
| Week 10 | Artificial Neural Network, Perceptron, feedforward, Backpropagation |
| Week 11 | Recurrent Neural Networks, Long-Short Term Memory Network |
| Week 12 | Transition from Machine Learning to Deep Learning, Convolutional Neural Networks |
| Week 13 | Applications of Machine Learning and Concept of Explainable AI |

**Assignments and Evaluations:**

Students taking this course must understand and agree that:

(1) Unless otherwise allowed by the course instructor, students must complete the assignments in this course without the assistance of anyone else.

(2) Unless otherwise allowed by the course instructor, students must not access any sources or materials (in print, online, or in any other way) to complete any course exam.

**Academic Integrity:**

Students must further understand and agree that, if they violate either of these two rules, or if

they provide any false or misleading information about their completion of course assignments

or exams, they may be prosecuted under the Lakehead University Student Code of Conduct –

Academic Integrity, which requires students to act ethically and with integrity in academic

matters and to demonstrate behaviors that support the University’s academic values.

***Assignments:*** There is **Zero-Tolerance** for plagiarism cases. All such cases will be dealt with according to University prescribed rules. All assignments are individual. Students should understand that their assignments must go through a similarity check and if there is similarity detected then **ZERO** mark will be awarded to those students involved in copying.

***Late Assignments:*** Late assignments will automatically receive a **ZERO** however they will be

reviewed to provide formative evaluation feedback and must be submitted for course

completion.

**Evaluation Map**

Following are the evaluation strategies and their percentage in their final Grades will be based on:

* 2 assignments worth (5%) each
* Course Project worth 30%.
* a midterm exam, worth 20% of the final mark
* a final exam, worth 40% of the final mark

**Schedule**(tentative, some of the dates might change) All assignments are due on D2L course link at 23:59pm on the date indicated.

* Assignment 1 due on October 17.
* Assignment 2 due on November 7.

**Condition to Pass this course!!!!!**

**• To be eligible to receive an overall passing grade of 60%,** a student must receive a weighted average of at least 55% on the midterm and final exams, and a weighted average of at least 55% on the assignments.

**Course Policies:**

* Behavioral standards to follow: Student Code of Conduct - Academic Integrity
* Attendance and participation in class discussions is highly recommended.
* Students can communicate with the instructor through email using the **COMP-5011** - as a

prefix in the subject line of their message.

* The course outline and schedule are not fixed and subject to change based on class flow.
* You will be taught theoretical and practical machine learning during lecture sessions. You are required to perform hands-on experience on the taught concepts.
* A passing mark is normally 60% of the total weight of all components.
* University’s attendance policy is followed.
* There will be 2 assignments. The late penalty for assignments is [2.5^i] (2.5 to the i-th power, rounded to the nearest integer), where i>0 is the number of days you are late. So, if you hand-in your assignment 1 day late, you will be penalized 3%, a delay of 2 days will decrease your grade by 6%, 3 days is penalized 16% and 4 days takes 39% off your grade. You cannot be more than 4 days late, Extensions will be granted only by the course instructor. If you have serious medical or compassionate grounds for an extension, you should take supporting documentation to the office of the Dean of your faculty, who will contact the instructor.
* Assignments and time will be posted on MyCourseLink/D2L and announced via emails to all registered students.
* There is a course project which needs to be submitted as part of the course evaluation. A set of expected deliverables and their due dates will be provided on the D2L course link.

**Copyright:**

Students should be aware that all instructional, reference, and administrative materials prepared for this course are protected in their entirety by copyright. Students are expected to comply with this copyright by only accessing and using the course materials for personal educational use related to the course, and that the materials cannot be shared in any way, without the written authorization of the course instructor. If this copyright is infringed in any way, students may be prosecuted under the Lakehead University Student Code of Conduct – Academic Integrity, which requires students to act ethically and with integrity in academic matters and to demonstrate behaviors that support the University’s academic values.

**Regulations:**

It is the responsibility of each student registered at Lakehead University to be familiar with, and comply with all the terms, requirements, regulations, policies and conditions in the Lakehead University Academic Calendar. This includes, but is not limited to, Academic Program Requirements, Academic Schedule of Dates, University and Faculty/School Policies and Regulations and the Fees and Refund Policies and Schedules (Lakehead University Regulations webpage, 2023-24).

**Academic Integrity:**

A breach of Academic Integrity is a serious offense. The principle of Academic Integrity, particularly of doing one’s own work, documenting properly (including use of quotation marks, appropriate paraphrasing and referencing/citation), collaborating appropriately, and avoiding misrepresentation, is a core principle in university study. Students should view the Student Code of Conduct - Academic Integrity for a full description of academic offenses, procedures when Academic Integrity breaches are suspected and sanctions for breaches of Academic Integrity.

**Support for Students:**

There are many resources available to support students. These include but are not limited to:

● [Health and Wellness](https://www.lakeheadu.ca/students)

● [Student Success Centre](https://www.lakeheadu.ca/students/academic-success/student-success-centre)

● [Student Accessibility Centre](https://www.lakeheadu.ca/students/student-life/student-services/accessibility/)

● [Library](https://library.lakeheadu.ca/)

● [Lakehead International](https://www.lakeheadu.ca/international)

● [Indigenous Initiatives](https://www.lakeheadu.ca/indigenous)

Lakehead University is committed to achieving full accessibility for persons with disabilities. Part of this commitment includes arranging academic accommodations for students with disabilities and/or medical conditions to ensure they have an equitable opportunity to participate in all of their academic activities. If you are a student with a disability and think you may need accommodations, you are strongly encouraged to contact Student Accessibility Services (SAS)

and register as early as possible. For more information, please contact Student Accessibility Services (SC0003, 343-8047 or sas@lakeheadu.ca