Course Outline

School:	Eng. Tech. & Applied Science
Department:	Information and Communication Engineering Technology (ICET)
Course Title:	Neural Networks
Course Code:	COMP 258
Course Hours/Credits:	56
Prerequisites:	COMP 247, COMP 254
Co-requisites:	N/A
Eligible for Prior Learning, Assessment and Recognition:	Yes
Originated by:	ILIA NIKA
Creation Date:	Winter 2021
Current Semester:	Fall 2021
Approved by:	ppesikan c/o

Chairperson/Dean

Students are expected to review and understand all areas of the course outline.

Retain this course outline for future transfer credit applications. A fee may be charged for additional copies.

This course outline is available in alternative formats upon request.

Acknowledgement of Traditional Lands

Centennial is proud to be a part of a rich history of education in this province and in this city. We acknowledge that we are on the treaty lands and territory of the Mississaugas of the Credit First Nation and pay tribute to their legacy and the legacy of all First Peoples of Canada, as we strengthen ties with the communities we serve and build the future through learning and through our graduates. Today the traditional meeting place of Toronto is still home to many Indigenous People from across Turtle Island and we are grateful to have the opportunity to work in the communities that have grown in the treaty lands of the Mississaugas. We acknowledge that we are all treaty people and accept our responsibility to honor all our relations.

Course Description

This course covers artificial neural networks and their practical applications. Coursework emphasizes fundamental models and algorithms starting with McCulloch-Pitts and Perceptron models, Multi-Layer Perceptron (MLP) networks, backpropagation algorithm, activation functions, convolutional neural networks, and recurrent neural networks. Students will gain hands-on experience by using Keras and TensorFlow to build and train models for solving various classification/prediction problems.

Program Outcomes

Successful completion of this and other courses in the program culminates in the achievement of the Vocational Learning Outcomes (program outcomes) set by the Ministry of Colleges and Universities in the Program Standard. The VLOs express the learning a student must reliably demonstrate before graduation. To ensure a meaningful learning experience and to better understand how this course and program prepare graduates for success, students are encouraged to review the Program Standard by visiting http://www.tcu.gov.on.ca/pepg/audiences/colleges/progstan/. For apprenticeship-based programs, visit http://www.collegeoftrades.ca/training-standards.

Course Learning Outcomes

The student will reliably demonstrate the ability to:

1. Analyze and compare the first artificial neuron models.
2. Explain the mathematical foundations of artificial neural networks.
3. Select a neural network architecture appropriate to a supervised or unsupervised learning problem.
4. Build artificial neural network models to develop intelligent systems for various business problems.
5. Implement the neural network design using Keras and TensorFlow frameworks
6. Apply convolutional neural networks to object recognition problems.
7. Apply Recurrent Neural Networks to NLP and speech recognition problems

Essential Employability Skills (EES)

The student will reliably demonstrate the ability to*:

2. Respond to written, spoken, or visual messages in a manner that ensures effective communication.
3. Execute mathematical operations accurately.
5. Use a variety of thinking skills to anticipate and solve problems.
6. Locate, select, organize, and document information using appropriate technology and information systems.

8. Show respect for diverse opinions, values belief systems, and contributions of others.

**There are 11 Essential Employability Skills outcomes as per the Ministry Program Standard. Of these 11 outcomes, the following will be assessed in this course.*

Global Citizenship and Equity (GC&E) Outcomes

N/A

Methods of Instruction

Pre-recorded lectures, Interactive lab sessions, Demonstrations, Hands-On Exercises, assignments, and projects.

Text and other Instructional/Learning Materials

Text Book(s):

Text Book:

Géron, Aurélien. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, SecondEdition, 2019, Published by O'Reilly Media, Inc

Reference Books

Nielsen, Michael. Neural Networks and Deep Learning, 2019, http://neuralnetworksanddeeplearning.com/

Loy, James. Neural Network Projects with Python, Copyright © 2019 Packt Publishing.

Bonnin, Rodolfo, Machine Learning for Developers, Copyright © 2017, Packt Publishing.

Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016, Online at deeplearningbook.org.

Domingos, Pedro. The Master Algorithm, How the Quest for the Ultimate Learning Machine Will Remake Our World, published by Basic Books, 2015.

Fausett, Laurene. Fundamentals of Neural Networks, Architectures, Algorithms, and Applications, Pearson, 1994.

Rojas, Raul. Neural Networks, A Systematic Introduction, Springer, 1996, http://page.mi.fu-berlin.de/rojas/neural/neuron.pdf.

Evaluation Scheme

- Lab Assignment 1: Design and implement Shallow Neural networks to predict/classify
- Lab Assignment 2: Train and Use MLPs to solve various prediction problems
- Lab Assignment 3: Use CNNs to solve object recognition problems
- Lab Assignment 4: Use RNNs/LSTMs to solve NLP tasks
- Group Project: Develop an intelligent Application that applies artificial neural networks to solve /prediction/classification tasks.

- Hands-On Test 1: Build, Train, and Apply a Neural Network model for prediction/classification.

Evaluation Name	CLO(s)	EES Outcome(s)	GCE Outcome(s)	Weight/100
Lab Assignment 1	1, 2, 3, 4	2, 3, 5, 6		10
Lab Assignment 2	2, 3, 4, 5	2, 3, 5, 6		10
Lab Assignment 3	3, 4, 5, 6	2, 3, 5, 6		15
Lab Assignment 4	3, 4, 5, 7	2, 3, 5, 6		15
Group Project	3, 4, 5, 6, 7	2, 3, 5, 6, 8		25
Hands-On Test 1	2, 3, 4, 5	2, 5, 6		25
Total				100%

If students are unable to write a test they should immediately contact their professor or program Chair for advice. In exceptional and well documented circumstances (e.g. unforeseen family problems, serious illness, or death of a close family member), students may be able to write a make-up test.

All submitted work may be reviewed for authenticity and originality utilizing Turnitin®. Students who do not wish to have their work submitted to Turnitin® must, by the end of the second week of class, communicate this in writing to the instructor and make mutually agreeable alternate arrangements.

When writing tests, students must be able to produce official Centennial College photo identification or they may be refused the right to take the test or test results will be void.

Tests or assignments conducted remotely may require the use of online proctoring technology where the student's identification is verified and their activity is monitored and/or recorded, both audibly and visually through remote access to the student's computer and web camera. Students must communicate in writing to the instructor as soon as possible and prior to the test or assignment due date if the they require an alternate assessment format to explore mutually agreeable alternatives.

Student Accommodation

The Centre for Accessible Learning and Counselling Services (CALCS) (http://centennialcollege.ca/calcs) provides programs and services which empower students in meeting their wellness goals, accommodation and disability-related needs. Our team of professional psychotherapists, social workers, educators, and staff offer brief, solution-focused psychotherapy, accommodation planning, health and wellness education, group counselling, pscyho-educational workshops, adaptive technology, and peer support. Walk in for your first intake session at one of our service locations (Ashtonbee Room L1-04, Morningside Room 190, Progress Room C1-03, The Story Arts Centre Room 285, Downsview Room 105) or contact us at calcs@centennialcollege.ca, 416-289-5000 ext. 3850 to learn more about accessing CALCS services.

Use of Dictionaries

- Any dictionary (hard copy or electronic) may be used in regular class work.

Program or School Policies

N/A

Course Policies

N/A

College Policies

Students should familiarize themselves with all College Policies that cover academic matters and student conduct.

All students and employees have the right to study and work in an environment that is free from discrimination and harassment and promotes respect and equity. Centennial policies ensure all incidents of harassment, discrimination, bullying and violence will be addressed and responded to accordingly.

Academic honesty is integral to the learning process and a necessary ingredient of academic integrity. Academic dishonesty includes cheating, plagiarism, and impersonation. All of these occur when the work of others is presented by a student as their own and/or without citing sources of information. Breaches of academic honesty may result in a failing grade on the assignment/course, suspension or expulsion from the college.

For more information on these and other policies, please visit www.centennialcollege.ca/about-centennial/college-overview/college-policies.

Students enrolled in a joint or collaborative program are subject to the partner institution's academic policies.

PLAR Process

This course is eligible for Prior Learning Assessment and Recognition (PLAR). PLAR is a process by which course credit may be granted for past learning acquired through work or other life experiences. The PLAR process involves completing an assessment (portfolio, test, assignment, etc.) that reliably demonstrates achievement of the course learning outcomes. Contact the academic school to obtain information on the PLAR process and the required assessment.

Topical Outline (subject to change):

Week	Topics	Readings/Materials	Weekly Learning Outcome(s)	Instructional Strategies	Evaluation Name and Weight	Evaluation Date
1	Course Overview Introduction to Artificial Neural Networks	Textbook, Chapter 10 Fausett book Rojas book PPT slides	Explain the history of artificial neural networks (ANNs). Differentiate between connectionism and symbolism. Discuss the first artificial neural network architecture from McCulloch and Pitts. Describe the biological neurons and logical computations with neurons proposed by McCulloch and Pitts. Apply McCulloch-Pitts net to model simple patterns.	Lecture Demonstration Lab Session Class Discussion		
2	Perceptron Learning Algorithm (PLA)	Textbook, Chapter 10 Neural networks and deep learning book Chapter 1 Fausett book Rojas book PPT slides	Review basic differential calculus elements: - Functions - Derivatives - Main rules - Partial Derivatives Derive the Perceptron algorithm. Implement the Perceptron algorithm. Explain Perceptron Learning Rule Convergence Theorem. Use perceptron algorithm for simple classification problems. Explain Adaptive Linear Neuron (ADALINE) algorithm and delta rule. Implement and use ADALINE algorithm for simple classification problems. Discuss the limitation of the PLA and Minsky's book.	Lecture Demonstration Lab Session Class discussion		

Week	Topics	Readings/Materials	Weekly Learning Outcome(s)	Instructional Strategies	Evaluation Name and Weight	Evaluation Date
3	Multilayer Perceptrons (MLPs)	Textbook, Chapter 10 Neural networks and deep learning book Chapter 1 PPT slides	Define MLPs. Differentiate between regression and classification MLPs. Define feedforward neural networks (FFNNs). Explain the architecture of a feedforward network. Define the neural network as a function, define the loss function and activation function. Implement the code to train a neural network from scratch in Python using gradient learning.	Lecture Demonstration Lab Session Class Discussion	Lab Assignment 1	Week 3
4	Backpropagation Algorithm	Neural networks and deep learning book Chapter 2 Rojas book, Chapter 7 Textbook, Chapter 10 PPT slides	Review the chain rule and gradient calculation for MLPs. Define the learning problem and the error function of the neural network. Describe and derive the backpropagation algorithm. Differentiate between gradient descent and stochastic gradient descent. Design, implement and train a neural network (MLP) from scratch in Python using backpropagation algorithm.	Lecture Demonstration Lab Session		
5	Implementing MLPs with Keras and TensorFlow	Textbook, Chapter 10 PPT slides	Install TensorFlow using Anaconda Navigator Use Keras to load the dataset. Build an image classifier using the sequential API. Compile, train, and evaluate the model. Use the model to make predictions.	Lecture Demonstration Lab Session	Lab Assignment 2	Week 5

Week	Topics	Readings/Materials	Weekly Learning Outcome(s)	Instructional Strategies	Evaluation Name and Weight	Evaluation Date
			Build complex models using the functional API. Save and Restore a Model. Fine-Tune Neural Network Hyperparameters (number of hidden layers, number of neurons per hidden layer, learning rate, batch size, etc.)			
6	Training Deep Neural Networks Group project announced	Textbook, Chapter 11 Neural networks and deep learning book Chapter 3, 5 PPT slides	Explain the Vanishing/Exploding Gradients Problem. Use better activation functions. Implement batch normalization with Keras. Reuse pretrained layers. Use faster optimizers. Use regularization to avoid overfitting.	Lecture Demonstration Lab Session		
7	Custom Models and Training with TensorFlow	Textbook, Chapter 12 PPT slides	Use TensorFlow like NumPy. Customize models and training algorithms by using custom loss functions, layers, and models. Compute gradients using Autodiff. Use TensorFlow functions and graphs.	Lecture Demonstration Lab Session	Hands-On Test 1	Week 7
8	Loading and Preprocessing Data with TensorFlow	Textbook, Chapter 13 PPT slides	Explain the Data API. Use the Dataset with tf.keras. Preprocess the input features by encoding categorical fetaures using one-hot vectors or embeddings. Use Keras preprocessing layers.	Lecture Demonstration Lab Session		
9 - 10	Convolutional Neural	Textbook, Chapter 14	Describe the architecture of the visual cortex.	Lecture	Lab	Week 10

Week	Topics	Readings/Materials	Weekly Learning Outcome(s)	Instructional Strategies	Evaluation Name and Weight	Evaluation Date
	Networks	Neural networks and deep learning book Chapter 6 ML For Software Developers, Chapter 6 PPT slides	Define the convolution and the convolution operator. Implement 2D convolution. Explain the architecture convolutional networks (convolutional layers, pooling layers) Discuss popular CNN architectures (Lenet-5, AlexNet, GoogLeNet, ResNet) Design and implement convolutional networks for solving image recognition problems.	Demonstration Lab Session	Assignment 3	
11-12	Recurrent Networks	Textbook, Chapter 15 Neural networks and deep learning book Chapter 6 ML For Software Developers, Chapter 7 PPT slides	Define recurrent networks. Examine the types of sequences to be modeled. Explain the training method. Analyse the main problems with RNNs. Handle long sequences using LSTM Algorithm. Apply RNNs to NLP problems (generate fake Shakespeare text, etc.). Apply RNNs for Neural Machine translation.	Lecture Demonstration Lab Session	Lab Assignment 4	Week 12
13	Practical Applications of MLPs	PPT slides	Discuss practical applications of MLPs in various areas of business	Class discussion		
14	Project presentation	Textbook Neural networks and deep learning book Deep Learning book	Develop an intelligent Application that applies artificial neural networks to solve /prediction/classification tasks	Presentation to class	Project Presentation	Week 14