# ECE/CSE 885
# Introduction to Neural Networks
# Neural Networks: Architectures, Algorithms and Applications
# Spring 2020

**TIME:** Tu Th 10:20-11:40 a.m.
**ROOM:** 3400 Engineering Building
**CREDITS**: 3 units
**INSTRUCTOR:** Professor Fathi Salem
2308D Engineering Building
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Phone: 517-355-7695
**OFFICE HRS:** Tu & Th 1-2 or by appointment.

**PREREQUISITES:**
Graduate standing, and familiarity with multi-variable calculus, difference or differential equations, linear algebra and some probability and statistics. Software requirements include familiarity with Python are very helpful. Simulators of Neural Network include Python-based packages, e.g. Tensorflow, Keras, Pytorch, etc., should be used for class assignments and the project(s).

**COURSE CONTENT:** Overview of Neural Networks approaches; feedforward and recurrent (feedback) neural architectures; learning and adaptive algorithms including supervised and unsupervised approaches; Basic applications to include (speech/image) classification, sequence -to-sequence mappings and prediction.

**COURSE WEB SITE:** The primary web site is on the D2L Course Management System. Please go to the following URL: https://d2l.msu.edu and log-in with your MSUNet ID and password. This site is available to enrolled class members.

**COURSE OBJECTIVES:**
This course provides an introduction to the *fundamentals* of current (Deep) Neural Networks approaches. The course will cover the basic principles, architectures and learning mechanisms, as well as advantages and limitations of several neural models and architectures from deep networks and deep learning. Current and new applications of neural networks will be discussed during the class to "deepen" our understanding. Grading will be based on take-home mini-assignments and a final project, where students will be expected to apply up-to-date techniques to current practical applications.

**TOPICS (from the following list, tentative):**
**Basics:**
1. (Artificial) neural networks (NN) architectures and models: overview of Deep NN, Convolutional NN, Recurrent NN
2. Adaptive and Learning processes: Gradient, Energy, Entropy -based methods and Systems.

**Feedforward Networks and Supervised Learning:**
3. The Perceptron, the LMS algorithm, the Multilayer (Perceptron) networks, and Deep Neural Networks
4. The dominant learning/training approach: Stochastic Gradient Descent (SGD) and its variants
5. Convolutional Neural Networks (ConvNets)

**Unsupervised Learning:**
6. Principal Component Analysis (PCA): Algebraic PCA and Adaptive PCA, extensions.
7. Self Organizing Maps (SOM): non-orthogonal feature spaces
8. Information-Theoretic Models and learning: Independent Component Analysis (ICA) and sparsity of representations

**Recurrent Neural Networks (RNN) and supervised Learning:**
9. Simple RNNs and the learning techniques and limitations
10. Gated RNNs and their learning techniques and limitations
12. Suitable applications

**Select Topics:**
13. Auto-encoders, Generative Adversarial Networks, Reinforcement Learning,

**Reading Material:**

**-Class notes will be available.**

-Class Textbook: I. Goodfellow, Y. Bengio, and A. Courville, **Deep Learning**, MIT Press, 2016. (available from Amazon as a hardcopy & also available free online at http://www.deeplearningbook.org)

**-Other online resources:** Numerous online references/resources are available. Examples include:

- Online Textbook: http://www.neuralnetworksanddeeplearning.com

**-Other books:** Simon Haykin, *Neural Networks and Learning Machines, 3rd* Edition, Prentice Hall, 2009.

**GRADING:**

- Two mini-projects/assignments 20% each: 40% (total)
- Literature/Paper presentation (in lieu of a Midterm) 15%
- Final Project & Presentation: (35+10=) 45%

The project grade will be based on a final report and "in-class" presentation due by the Final Exam time (Friday, May 1, 2020, 7:45-9:45 am).

**Note:** Assignments/Projects may require the use of Library/Framework packages (e.g. Google Tensorflow, Keras). Assignments must be turned in on the due date to receive credit. **No make-up assignments/exams will be allowed without a written medical excuse.**

**ATTENDANCE**: Classroom attendance and participation is expected.

**IMPORTANT DATES (**Please refer to the Registrar's website at http://www.reg.msu.edu/ for a detailed calendar):
Martin Luther King Day; University Open, Classes Cancelled—1/20/2020
End of tuition refund-- no refund after this date
MIDDLE OF SEMESTER -- Last day for withdrawing/dropping courses with no grade reported
Classes end for Spring 2020

**ACADEMIC HONESTY**

Article 2.3.3 of the Academic Freedom Report states: "The student shares with the faculty the responsibility for maintaining the integrity of scholarship, grades, and professional standards." In addition, this instructor adheres to the University regulations, policies, and ordinances on academic honesty and integrity, as specified in General Student Regulation 1.0, Protection of Scholarship and Grades; the all-University Policy on Integrity of Scholarship and Grades; and Ordinance 17.00, Examinations, all of which are available on the MSU Web site (www.msu.edu). Students who violate these rules may receive a penalty grade, including, but not limited to, a failing grade on the assignment or in the course. The following conduct is specifically cited: (1) Supplying or using work or answers that are not one's own; (2) Providing or accepting assistance with completing assignments or examinations; (3) Interfering through any means with another's academic work; (4) Faking data or results