ECE 884-730
Neural Networks and Deep Learning
a hands-on computational course on
Architectures, Learning and Applications
Fall 2022

TIME: flexible times, *asynchronous online* (i.e. you access uploaded teaching modules via MSU D2L at your suitable times. (Online office hours will be held synchronously, however, via MSU Zoom.)
Location: online via D2L
CREDITS: 3 units
INSTRUCTOR: Professor Fathi M. Salem
2308D Engineering Building
Email: salem@egr.msu.edu; salemf@msu.edu

OFFICE HRS: Tu & Th 5:00-6:30 pm—synchronously online (via MSU Zoom). I will be available via Zoom during these times; also (email) on other times if necessary using SUBECT: ECE884.

PREREQUISITES:
Graduate standing, and familiarity with basic undergraduate-level multi-variable calculus, difference or differential equations, linear algebra and some probability and statistics. Software requirements include familiarity with programming/coding. Strong preference is for Python. We will use popular Deep Learning Libraries/Frameworks (mostly, Tensorflow (Keras), PyTorch is an alternative for you).

COURSE OBJECTIVES: This course is a student-centered course presented asynchronously using modules and weekly tasks. It has the overall goal of enabling the student to acquire capabilities and a working knowledge in the current and developing domain of computational Neural Networks and Deep Learning or "deep learning." Since 2012, it emerged with *deep* architectural networks and the family of adaptive stochastic gradient descent (SGD) learning mechanisms. The course will coach the student through the main/dominant architectures and learning mechanisms with a view towards basic understanding, software implementation, and hands-on ability to tackle current applications. It emphasizes some code developing but mostly using existing Libraries/Frameworks/Packages to enable the student to incrementally acquire the knowledge of deep learning in current practice.

COMPUTING PLATFORMS/LIBRARIES/FRAMEWORKS:
There are numerous packages or libraries available for "Neural Networks & Deep Learning," eg. Scikit-learn, etc. There are also a host of frameworks/libraries publically available (i.e., free) for "Deep Learning" research and deployment. These include **Keras**, **Tensorflow** (Google), **Caffe** (UC Berkeley), **Nvidia**, PyTorch (Facebook), others libraries from Microsoft , Amazon,….

We may discuss some these libraries in the class lectures & notes, however, we shall focus mostly on using some Python-based codes and **Keras** within**Tensorflow**. Of course, you are welcome to use/explore any framework that is most suitable for you.

COURSE DESCRIPTION:
This course provides an introduction to the current state-of-the-art of deep neural networks and learning with emphasis on implementations and project execution. The buz word is "deep learning." The course will identify the elements of "deep learning". What makes a neural network a deep learning network. The popular architectures are (i) feedforward: deep neural networks (DNN), convolutional neural network (ConvNets), and (ii) Feedback: (simple) recurrent neural networks (RNN), Long Short Term Memory (LSTM) RNNs, Gated RNNs, etc., and also (iii) a combination of the feedforward and feedback architectures. The main learning used is frequently a form of the Stochastic Gradient Descent (SGD) and its various forms.

The course will focus on the advantages and limitations of several neural models and architectures. Common and new applications of neural networks will also be highlighted during the class.

We shall use Gitlab (https://gitlab.msu.edu) for assignment release and submissions. Please read up the handout on

(MSU) Gitlab on the D2L class site if you are not familiar with it. All enrolled students will receive an email invite to your class group: ece884fall2022.

MAJOR TOPICS:

Basics: (part I in Textbook, also part II online**)**

1. Elements of deep neural networks: The building blocks and architectures
2. Adaptive and Learning processes: Gradient, Energy, Entropy -based methods and Systems.

Supervised Learning: (part I and II in Textbook, Part II online**).**

3. Deep Neural Networks (DNN): auto-encoders, sparse representation, local connections, convolutional networks
4. Convolutional Neural Networks (ConvNets): on its own
5. Recurrent Neural Networks (RNN): rnn, irrn, lstm, GRN, and other gated RNNs

Unsupervised Learning: (Notes & modules, Textbook, Online**)**

6. Information-Theoretic Models and learning: Independent Component and entropy-based methods
7. Applications, applications and project

Class Reading Material:

- **Class Textbook:** Fathi M. Salem, **Recurrent Neural Networks: from simple to gated architectures,** Springer 2022.
- **Online book:** http://www.deeplearningbook.org

*We encourage you to pursue all (online) resources which may be suggested in class.

ADDITIONAL REFERENCE MATERIAL: May be shared from the internet.

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.

ATTENDANCE: Classroom attendance is not required. Modules and video-taped class lectures will be available on D2L. Assignments will be issues and submitted via the (MSU) gitlab website (https://gitlab.msu.edu).

GRADING: Grading will be based on 2 assignments (mini-projects), and a final project, where students will be expected to apply the techniques covered and learned in prior projects to current practical scientific and engineering applications. The grade will be distributed as follows:

- Assignments: 2 Mini-project Assignments (A1:20%, A2:25 %) 45%
- Final Project (Zoom) Presentation: 10 %
- Final Project Report: 45%
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Three mini-project assignment #1 will focus on DNN/ConvNet. Mini-project #2 will focus on RNN. Each will be given as a take-home assignment. The Final Project grade will be based on a final project completion with an in-class (Zoom) presentation during a day likely over the Final Exam period (August 12-16, 2022), and submitted final project report by the end of that day.

Note: Assignments must be turned in on the due date. **No make-up of assignments will be allowed without a written medical excuse. However, depending on COVID-19 Health conditions, we shall be flexible.**

IMPORTANT DATES (Please refer to the Registrar's website at http://www.reg.msu.edu/ for a detailed calendar):

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, the instructor adheres to the University regulations, policies, and ordinances on academic honesty and integrity, as specified in General Student Regulation, 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

LIMITS TO CONFIDENTIALITY

Essays, journals, and other materials submitted for this class are generally considered confidential pursuant to the University's student record policies. However, students should be aware that University employees, including instructors, may not be able to maintain confidentiality when it conflicts with their responsibility to report certain issues to protect the health and safety of MSU community members and others. As the instructor, I must report the following information to other University offices (including the Department of Police and Public Safety) if you share it with me:

--Suspected child abuse/neglect, even if this maltreatment happened when you were a child,
--Allegations of sexual assault or sexual harassment when they involve MSU students, faculty, or staff, and
--Credible threats of harm to oneself or to others.

These reports may trigger contact from a campus official who will want to talk with you about the incident that you have shared. In almost all cases, it will be your decision whether you wish to speak with that individual. If you would like to talk about these events in a more confidential setting you are encouraged to make an appointment with the MSU Counseling Center.