BMES-725-001. Neural Networks. CRN # 31653. Spring 2022-23

DESCRIPTION
The emergence of big data, machine learning algorithms, and increased computing power has enabled significant breakthrough in neural networks and related applications. This class will discuss recent progress and findings in the exciting field of deep learning. While mathematical aspects will be covered, the primary goal is to provide students with the deep learning tools and technical aspects needed to solve the data science problems in biomedicine. Besides the construction by students of computer simulations of important deep neural networks, the class will also show how to develop deep learning applications in the Cloud. Selected applications in computational neuroscience, computational biology, medical imaging, and electronic medical records will be presented. Advanced topics including autoencoders and generative models (generative adversarial networks or GAN, diffusion models, large language models such as GPT-3/4 and ChatGPT) and their applications in generating images and text will be discussed.

PREREQUISITES: Approved by instructor
MEETING TIMES: Tuesday, 6:00-8:50 pm, Apr 03 – Jun 17
LOCATION: PISB 109

INSTRUCTOR:
Hualou Liang, PhD
Professor
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Email: hualou.liang@drexel.edu
Phone: (215) 571-3706
OFFICE HOURS: Tuesday, 5-6 pm, online via Zoom

RECOMMENDED TEXTBOOKS:
Deep Learning, I. Goodfellow, Y. Bengio and A. Courville.
http://www.deeplearningbook.org/

Neural networks and deep learning, Michael Nielsen, an online book
http://neuralnetworksanddeeplearning.com/

For a vast list of Deep Learning resources including links to online courses, books, lectures, datasets, and tutorials, visit this website
https://github.com/ChristosChristofidis/awesome-deep-learning

TEACHING ASSISTANTS:
N/A

COURSE OBJECTIVES:
1. Learn the fundamental concepts and techniques in neural networks and deep learning.
2. Exposure to deep neural network techniques when dealing with big data sets in a wide range of biomedical applications.

3. Provide hands-on experience in designing and programming deep learning algorithms to solve data science problems in biomedicine.
4. Acquaint students of convolutional neural networks and major deep learning software.

WEB CONTENT: Please log into the Learn system, http://learning.drexel.edu and change your preferences to receive email at your Drexel (or other preferred) address. Many course communications will be entirely through Learn "Messages" (NOT "Send Email"), and you will be able to read email through that. You can only reply through the system, but I will be reading your replies. I may not respond to email outside Learn unless it deals with a non-course related matter. Also, if assignments are submitted electronically, it must be through the course website, otherwise I will delete them immediately from my inbox to avoid running out of space.

GRADING: Class participation (10%), Paper review (20%), Paper presentation (teams of 2-3): 30%, Project (team size maximum of 3): 40%

POLICIES:

Course Specific Policy:

- Assignments and other material will not be accepted late, except as explicitly permitted by the Professor with a discretionary penalty. Excused late assignments can be submitted for credit only, but not for a letter grade (they will be dropped from the average).
- Except for problem sets, students will be expected to work as individuals, with penalties at the discretion of the Professor (usually a failing grade).
- If students do work as a group, the work they hand in should list the names of all group members. A group cannot have more than 3 (THREE) members.
- Anything written for the final exam (if there is a take-home portion) and the projects must be the student's own work. A failing grade will be assigned if anything is included without citation (both words and concepts) or if the students seek help from someone else without crediting "unpublished communications" with those individuals by name.
- Missing a test will generally not be permitted except under extraordinary circumstances as determined by the Professor.
- Regular attendance is required, as the course will include regular class participation. In class, group work will also be a part of the course. Students missing more than two classes must see the instructor to avoid a grade penalty. Any materials or announcements covered in class missed during an absence are the student's responsibility. Students are expected to arrive on time and stay the length of the class. Students who are late more than two times or who leave the class early more than twice will be required to meet with the instructor and may be penalized.

Appropriate Use of Course Materials

It is important to recognize that some or all of the course materials provided to you may be the intellectual property of Drexel University, the course instructor, or others. Use of

this intellectual property is governed by Drexel University policies, including the policy found here: https://drexel.edu/it/about/policies/policies/01-Acceptable-Use/ Briefly, this policy states that course materials, including recordings, provided by the course instructor may not be copied, reproduced, distributed or re-posted. Doing so may be considered a breach of this policy and will be investigated and addressed as possible academic dishonesty, among other potential violations. Improper use of such materials may also constitute a violation of the University's Code of Conduct found here: https://drexel.edu/cpo/policies/cpo-1/ and will be investigated as such.

Academic Integrity Policy:

Drexel University is committed to a learning environment that embraces academic honesty. In order to protect members of our community from results of dishonest conduct, the University has adopted policies to deal with cases of academic dishonesty. Please read, understand, and follow the "Academic Integrity Policy", as written in the Official Student Handbook:

http://drexel.edu/studentaffairs/community_standards/studentHandbook/general_information/code_of_conduct/

Americans with Disabilities Act: Students with documented disabilities who need course accommodations, have emergency medical information or require special arrangements for building evacuation should contact the instructor within the first two weeks of class. Verification of any special arrangements needs to be made through the *Office of Disability Services, 3201 Arch Street, Suite 210.* For further information visit: http://www.drexel.edu/oed/disabilityResources/Overview/.

WEEKLY SCHEDULE (Tentative):

1. Course introduction. Course logistics, overview, history of neural networks, and what is deep learning vs. machine learning?
2. Introduction to Neural Networks (Shallow models). Feedforward neural networks, Backpropagation
3. What are Convolutional Neural Networks (CNN, Deep models)? Convolution, Non-Linearity (ReLU), Pooling and Classification.
4. Deep Learning with Python/Jupyter Notebook. Deep learning software (TensorFlow, Keras, PyTorch etc), CNN architectures.
5. More Code Time: Development of deep learning applications in the Cloud (Google Colab)
6. Deep neural networks in computational neuroscience (EEG/MEG/fMRI analysis: brain mapping and decoding)
7. Deep learning for computational biology: protein structure, gene expression analysis and pharmacogenomics.
8. Deep learning in medical imaging and electronic medical records /clinical data.
9. Advanced topics: autoencoders and generative models (generative adversarial networks (GAN) and diffusion models
10. Large language models (GPT-3/4, ChatGPT) in digital health and predictive medicine
11. Student spotlight talks, conclusions.