Applied Deep Learning and Generative Models in Healthcare
Spring 2025

Course Information
Course Title: **Applied Deep Learning and Generative Models in Healthcare**
Course Number: CSYE 7374
Term and Year: Spring 2025
Credit Hour: 4
CRN: 41498
Course Format: Online (Virtual)

Instructor Information
Full Name: Mahmoud Ebrahimkhani
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Office Hours: Saturdays from 11:00 AM to 12:00 PM ET

Instructor Biography
Dr. Ebrahimkhani earned his Bachelor's degree in Electrical Engineering and his Master's and Ph.D. in Biomedical Engineering from Stony Brook University. His doctoral research focused on developing machine learning and deep learning models for terahertz spectroscopy and spectral imaging to improve the prediction of histological markers in burn injuries, aiding wound healing treatment planning. He then joined Northwestern University as a postdoctoral research associate, where he applied deep learning to medical imaging. He specialized in using Generative Adversarial Networks (GANs) to estimate three-dimensional aortic hemodynamics from CT angiography data. Currently, Dr. Ebrahimkhani is a Machine Learning Scientist at a biotech startup. He designs, trains, and deploys deep learning models for chemoinformatics and bioinformatics applications, including de novo small molecule design, ADMET property prediction, protein engineering, and protein-ligand docking. His expertise includes generative AI models like diffusion models and architectures such as transformers, graph neural networks, recurrent neural networks, and convolutional neural networks.

Teaching Assistant Information
Full Name: TBD
Email Address:TBD
Office Hours:TBD

Course Prerequisites
▪ Basic knowledge of machine learning and neural networks
▪ Proficiency in programming languages such as Python
▪ Prior coursework in data science or related fields is recommended

Course Description

This course provides students with hands-on experience in applying deep neural networks, including Convolutional Neural Networks (CNNs) and Graph Neural Networks (GNNs), to real-world medical data. The curriculum encompasses essential concepts of Large Language Models (LLMs), transformers, and attention mechanisms, highlighting their applications in medical imaging and drug discovery, such as image segmentation and molecular property prediction.

Students will explore generative AI models, including Denoising Diffusion Probabilistic Models, Generative Adversarial Networks (GANs), and Recurrent Neural Networks (RNNs), to generate new data relevant to healthcare applications. The course emphasizes practical experience with state-of-the-art models to address complex problems in medical settings. Throughout the course, students will work with datasets that are noisy, sparse, and high-dimensional, developing expertise in techniques such as feature engineering, segmentation, and registration to achieve successful outcomes.

Course Learning Outcomes

By the end of this course, students will be able to:

- *Implement Deep Neural Networks:* Apply CNNs and GNNs to real-world medical datasets.
- *Leverage Advanced Models:* Utilize LLMs, transformers, and attention mechanisms in medical imaging and drug discovery.
- *Generate Healthcare Data:* Employ generative AI models (Denoising Diffusion Probabilistic Models, GANs, RNNs) to create new healthcare-related data.
- *Handle Complex Datasets:* Manage and preprocess complex datasets using feature engineering, segmentation, and registration techniques.
- *Develop State-of-the-Art Solutions:* Design, develop, and evaluate advanced models to solve practical challenges in medical applications

Required Tools and Course Textbooks.

Textbooks:1.Deep Learning: Foundations and Concepts by Christopher Bishop, Springer, 2. Deep Learning with Python, Second Edition by François Chollet, Manning
Tools:1. Python programming environment, 2. Deep learning frameworks (e.g., TensorFlow, PyTorch), 3. Access to relevant medical datasets (provided during the course)

Course Schedule/Topics Covered.

- *Deep Neural Networks:* Fundamentals of CNNs and GNNs
- *Large Language Models and Transformers:* Applications in medicine
- *Attention Mechanisms:* Theory and practical use cases
- *Medical Imaging Techniques:* Image segmentation and registration
- *Drug Discovery Applications:* Molecular property prediction
- *Generative AI Models:* Denoising Diffusion Probabilistic Models, GANs, and RNNs
- *Data Handling Techniques:* Data curation, feature engineering, and preprocessing
- *Practical Projects:* Solving real-world medical problems with AI

Week	Date	In Class Topic	Assignment Due
1	01/11	Introduction to Deep Learning in Healthcare	
2	01/18	Convolutional Neural Networks (CNNs) in Medical Imaging	
3	01/25	Graph Neural Networks (GNNs) for Drug Discovery	Assignment 1 Assigned
4	02/01	Large Language Models (LLMs) and Transformers in Medicine	
5	02/08	Attention Mechanisms and Applications in Healthcare	
6	02/15	Medical Image Segmentation	Assignment 2 Assigned
7	02/22	Medical Image Classification	
8	03/01	Generative Adversarial Networks (GANs)	
9	03/08	BREAK – NO CLASSES	
10	03/15	Diffusion Models for Medical Image Generation	Assignment 3 Assigned
11	03/22	Automated Diagnosis with Deep Learning	
12	03/29	Protein Language Models (PLMs) and Protein Structure Prediction (AlphaFold)	Final Project Proposal Due
13	04/05	Molecular Property Prediction and Drug Discovery	Assignment 4 Assigned
14	04/12	Applications of Generative AI in Drug Discovery	
15	04/19	Final Project Presentations	

Assignment Grading
- Attendence: 10%
- Assignments (4 total): 60% (15% each)
- Final Project: 30% (Up to 50% - *20% bonus for exceptional final project submissions*)

Assignment Deadlines:
All assignments are due by 11:59 PM (EST) on Fridays before the next class when a new assignment will be assigned.
- *Example:* Assignment 1 is due on Friday, February 14, 11:59 PM. Assignment 2 will be assigned during class on Saturday, February 15.

Late Submission Policy:
- A grace period of 72 hours will be allowed for late submissions.
- 10% of the total grade will be deducted per day of delay, up to a maximum of three days (72 hours) after the deadline.
- Assignments submitted more than three days late will receive a grade of zero.

Examples:
- If you submit Assignment 1 between Friday, February 14 at 11:59 PM and Saturday, February 15 at 11:59 PM, your grade will be capped at 90%.
- If you submit it by Sunday, February 16 at 11:59 PM, your grade will be capped at 80%.
- After Monday, February 17 at 11:59 PM, the assignment will not be graded.

Grading Scale

	87-89.9% B+	77-79.9% C+	
	84-86.9% B	74-76.9% C	
95-100% A			
90-94.9% A-	80-83.9%B-	70-73.9% C-	
			69.9% or below F

Attendance/Late Work Policy

Attendance Policy

Students registered in MGEN courses (INFO, CSYE, and DAMG) are allowed **a maximum of 2 absences per course, with 3 or more absences resulting in an automatic 'F' for that course.** Students are expected to inform their instructors of any absences in advance of the class; if a student is sick long-term or experiences a medical issue that prevents class attendance, it is strongly encouraged that they speak with their Academic Advisor (coe-mgen-gradadvising@northeastern.edu) to learn more about the Medical Leave of Absence. Should a student anticipate being unable to attend 3 or more classes, they should discuss their situation with their Academic Advisor to explore other types of leave in accordance with the University's academic and global entry expectations. International students should review the Office of Global Services webpage to understand their visa compliance requirements.

Teaching Assistants (TAs) or Instructional Assistants (IAs) will be present at each class to collect student attendance.

Late Work Policy

Students must submit assignments by the deadline in the time zone noted in the syllabus. Students must communicate with the faculty prior to the deadline if they anticipate work will be submitted late. Work submitted late without prior communication with faculty will not be graded.

End-of-Course Evaluation Surveys
Your feedback regarding your educational experience in this class is particularly important to the College of Engineering. Your comments will make a difference in the future planning and presentation of our curriculum.

At the end of this course, please take the time to complete the evaluation survey at **https://neu.evaluationkit.com**. Your survey responses are **completely anonymous and confidential**. For courses 6 weeks in length or shorter, surveys will be open one week prior to the end of the courses; for courses greater than 6 weeks in length, surveys will be open for two weeks. An email will be sent to your Northeastern University Mail account notifying you when surveys are available.

Academic Integrity
A commitment to the principles of academic integrity is essential to the mission of Northeastern University. The promotion of independent and original scholarship ensures that students derive the most from their educational experience and their pursuit of knowledge. Academic dishonesty violates the most fundamental values of an intellectual community and undermines the achievements of the entire University.

As members of the academic community, students must become familiar with their rights and responsibilities. In each course, they are responsible for knowing the requirements and restrictions regarding research and writing, examinations of whatever kind, collaborative work, the use of study aids, the appropriateness of assistance, and other issues. Students are responsible for learning the conventions of documentation and acknowledgment of sources in their fields. Northeastern University expects students to complete all examinations, tests, papers, creative projects, and assignments of any kind

according to the highest ethical standards, as set forth either explicitly or implicitly in this Code or by the direction of instructors.

Go to http://www.northeastern.edu/osccr/academic-integrity-policy/ to access the full academic integrity policy.

MGEN Student Feedback
Students who would like to provide the MGEN unit with <u>anonymous</u> feedback on this particular course, Teaching Assistants, Instructional Assistants, professors, or to provide general feedback regarding their program, may do so using this survey: https://neu.co1.qualtrics.com/jfe/form/SV_cTIAbH7ZRaaw0Ki

University Health and Counseling Services
As a student enrolled in this course, you are fully responsible for assignments, work, and course materials as outlined in this syllabus and in the classroom. Over the course of the semester if you experience any health issues, please contact UHCS.

For more information, visit https://www.northeastern.edu/uhcs.

Student Accommodations
Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations through the DRC, students must provide appropriate documentation that demonstrates a current substantially limiting disability.

For more information, visit https://drc.sites.northeastern.edu.

Library Services
The Northeastern University Library is at the hub of campus intellectual life. Resources include over 900,000 print volumes, 206,500 e-books, and 70,225 electronic journals.

For more information and for education specific resources, visit https://library.northeastern.edu
Network Campus Library Services: Northeastern University Library Global Campus Portals

24/7 Canvas Technical Help
For immediate technical support for Canvas, call 617-373-4357 or email help@northeastern.edu

Canvas Student Resources: https://canvas.northeastern.edu/student-resources/

For assistance with my Northeastern e-mail, and basic technical support:
Visit ITS at https://its.northeastern.edu
Email: help@northeastern.edu
ITS Customer Service Desk: 617-373-4357

Diversity and Inclusion

Northeastern University is committed to equal opportunity, affirmative action, diversity, and social justice while building a climate of inclusion on and beyond campus. In the classroom, members of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration, and an awareness of global perspectives on social justice.

Please visit http://www.northeastern.edu/oidi/ for complete information on Diversity and Inclusion

Title IX

Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance.

Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty, and staff.

In case of an emergency, please call 911.

*Please visit **https://www.northeastern.edu/ouec** for a complete list of reporting options and resources both on- and off-campus.*