Northeastern
College of Engineering

Applied Deep Learning and Generative Models in Healthcare
Fall 2025

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

Instructor Information
Full Name: Mahmoud Ebrahimkhani (Matt Ebrahim)
Email Address: m.ebrahimkhani@northeastern.edu
Office Hours: Saturdays from 11:00 AM to 12:00 PM ET

Instructor Biography
Dr. Ebrahim is a Senior Data Scientist at Formation Bio, where he builds large-language-model and knowledge-graph systems that accelerate drug development with transparent, explainable insights. He earned a B.S. in Electrical Engineering and an M.S. and Ph.D. in Biomedical Engineering from Stony Brook University. His doctoral work pioneered machine-learning approaches for terahertz time-domain spectroscopy and imaging, demonstrating deep-learning–based detection of histological markers in burn injuries. After completing his Ph.D., Matt joined the Department of Radiology at Northwestern University as a postdoctoral research associate, advancing the use of generative adversarial networks and diffusion models to synthesize rare-disease MRI data. He then moved to industry as a Machine Learning Scientist at 1910 Genetics, where he designed end-to-end generative-AI pipelines for drug-discovery chemistry.

Teaching Assistant Information
Full Name: Click or tap here to enter text.
Email Address: Click or tap here to enter text.
Office Hours: Click or tap here to enter text.

Course Prerequisites

Solid grasp of core deep-learning concepts (e.g., gradient descent, back-propagation, multilayer perceptrons)

Proficiency in Python for data science and model development
Prior coursework in statistics and machine learning (recommended)

Course Description

This course gives you hands-on practice with deep learning in healthcare. You start with basic convolutional networks for 2-D and 3-D image segmentation, move on to recurrent networks for time-series patient data, and then use graph neural networks to study molecules and proteins. You will also see how transformers and large language models work, why attention helps on clinical text, and how diffusion models and GANs can create realistic medical images or suggest new drug molecules. Every exercise uses real, often messy, datasets, so you will clean data, build simple preprocessing pipelines, align images, and judge results under noisy or sparse conditions. Each week features a small notebook lab, and the term ends with a project where you pick either an imaging task or a drug-discovery task and build a full generative-AI solution that meets basic clinical standards. By the end you will know how to pick a suitable neural network for a medical problem, fine-tune modern models with limited labels, create new biomedical data safely, and share clear, evidence-based reports. You should already be comfortable with Python, basic linear algebra, and introductory machine-learning ideas.

Course Learning Outcomes

By the end of the course you will be able to build and train convolutional and graph neural networks on real medical datasets; apply transformers, large language models, and attention for imaging tasks and drug-design problems; create synthetic medical images and molecular data with diffusion models, GANs, and recurrent networks; clean and prepare noisy, high-dimensional data through feature engineering, segmentation, and registration; and design, test, and clearly report state-of-the-art deep-learning solutions to practical clinical challenges.

Required Tools and Course Textbooks.

Bishop, C. M. Deep Learning: Foundations and Concepts. Springer.
Chollet, F. Deep Learning with Python (2nd ed.). Manning Publications, 2021.
Tunstall, L., von Werra, L., & Wolf, T. Natural Language Processing with Transformers. O'Reilly Media, 2022.

Course Schedule/Topics Covered.

Week	Sept 06	Introduction to Deep Learning in Healthcare	
1	Sept 13	Large Language Models (LLMs) and Transformers in Medicine	
2	Sept 20	Retrieval-Augmented Generation & Clinical NLP	Assignment 1 assigned
3	Sept 27	Medical Image Segmentation	
4	Oct 04	Medical Image Classification	
5	Oct 11	Generative Adversarial Networks (GANs)	Assignment 2 assigned

6	Oct 18	Diffusion Models for Medical Image Generation (1)	
7	Oct 25	Diffusion Models for Medical Image Generation (2)	
8	Nov 01	Automated Diagnosis with Deep Learning	Assignment 3 assigned
9	Nov 08	Graph Neural Networks (GNNs) for Drug Discovery	
10	Nov 15	Protein LMs & Structure Prediction (AlphaFold, ESM-2)	Final-project proposal due
11	Nov 22	Generative AI for Drug Discovery (GFlowNet, diffusion)	
12	Dec 06	Applied Gen-AI Workshops & Case Studies	Assignment 4 assigned
13	Dec 13	Final Project Presentations	Assignment 4 due Fri 12 • 12

Assignment Grading

Attendance: 10 %

Assignments (4 × 15 %): 60 %

Final Project: 30%

Assignment Deadlines

All assignments are due Friday at 11:59 pm ET, the night before the next class, when the following assignment will be released.

Example: If Assignment 1 is assigned in class on Saturday, 20 Sept, it is due Friday, 10 Oct at 11:59 pm ET.

A 10-percentage-point deduction is applied for each 24-hour period (or portion thereof) past the deadline, up to 72 hours. Work submitted more than three days late receives a grade of zero.

Grading Scale

Please note: This is the department's standardized grading scale. While we understand that some classes may apply a curve, faculty must establish and include a clear grading scale within the syllabus, regardless of the chosen grading method.

Percentage Range	Letter Grade	Grade Point Equivalent
95.0–100.0%	A	4.000
90.0–94.9%	A-	3.667
87.0–89.9%	B+	3.333
84.0–86.9%	B	3.000

80.0–83.9%	B-	2.667
77.0–79.9%	C+	2.333
74.0–76.9%	C	2.000
70.0–73.9%	C-	1.667
69.9% and Below	F	0.000

Incomplete Grades

An incomplete grade may be reported by the instructor when a student has failed to complete a major component of a required course, such as homework, a quiz or final examination, a term paper, or a laboratory project. Students may make up an incomplete grade by satisfying the requirements of the instructor. Be aware that instructors' policies on the granting of incomplete grades may vary and that the final decision on an incomplete grade is up to the instructor. **Instructors may deny requests for an incomplete grade.** If the missing assignment(s) have not been submitted to the instructor within 30 days from the end of the term in which the course was offered, or the agreed upon due date, the grade entered will reflect the student's grade in the course for the work completed and the missing assignments receiving no credit toward the final grade.

Attendance/Late Work Policy
Attendance Policy

In each term, students enrolled in on-ground sections are expected to be on campus and attending class beginning with the first day of classes. Students in online sections are expected to log in and participate in class beginning with the first day of classes.

Students who join a class after the first day of class during the university add period, or who are approved for late registration by the instructor and the Graduate School of Engineering, are responsible for all coursework missed prior to enrolling. In the interest of students' success, the college does not support the arrival of students to class after the university add deadline. **Enrolled students who do not attend class during the first week of a semester risk being dropped from the course.**

In cases where an enrolled student cannot arrive to campus by the first day of class due to circumstances beyond their control, it is the student's responsibility to contact the instructor for approval and notify the Graduate School of Engineering.

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 'F' for that course. Course instructors are not expected to make accommodations and students are expected to inform their instructors of any absences in advance of the class. 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 and accommodations in accordance with the University's academic and global entry expectations. Students may be asked to share communications about class absences with their Academic Advisor. 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-gradadvising@northeastern.edu) to learn more about the Medical Leave of Absence. 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.

Course Evaluations
Student feedback on their learning experience is valuable and helps improve future courses. We encourage all students to complete the course evaluation surveys when they become available.

Surveys are distributed at both the midterm mark and the end of the term via email and are completely anonymous and confidential. Any questions about the surveys can be directed to mgen-programs@coe.northeastern.edu

MGEN Student Feedback
Students who would like to provide the MGEN unit with anonymous 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

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.

The following is a broad overview, but not an all-encompassing definition, of what constitutes a violation of academic integrity:

Cheating: The University defines cheating as using or attempting to use unauthorized materials, information, or study aids in any academic exercise. When completing any academic assignment, a student shall rely on their own mastery of the subject.

Fabrication: The University defines fabrication as falsification, misrepresentation, or invention of any information, data, or citation in an academic exercise.

Plagiarism: The University defines plagiarism as using as one's own the words, ideas, data, code, or other original academic material of another without providing proper citation or attribution. Plagiarism can apply to any assignment, either final or drafted copies, and it can occur either accidentally or deliberately. Claiming that one has "forgotten" to document ideas or material taken from another source does not exempt one from plagiarizing.

Unauthorized Collaboration: The University defines unauthorized collaboration as instances when students submit individual academic works that are substantially similar to one another. While several students may have the same source material, any analysis, interpretation, or reporting of data required by an assignment must be each individual's independent work unless the instructor has explicitly granted permission for group work.

Participation in Academically Dishonest Activities: The University defines participation in academically dishonest activities as any action taken by a student with the intention of gaining an unfair advantage over other students.

Facilitating Academic Dishonesty: The University defines facilitating academic dishonesty as intentionally or knowingly helping or contributing to the violation of any provision of this policy.

Please visit https://osccr.sites.northeastern.edu/academic-integrity-policy/ to access the full academic integrity policy.

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/Disability Access Services (DAS)

Northeastern University and Disability Access Services (DAS) 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 DAS, students must provide documentation of a disability that demonstrates a current substantial limitation. Accommodations are approved based on a review of the information that is submitted and reviews are done on a case-by-case basis.

If the course is conducted in an on-ground (in-person) format, students are expected to attend class physically as scheduled. Professors are **not required to provide virtual attendance links** unless a student has documented accommodation approved by the **Disability Access Services (DAS) office** and their **Academic Advisor**. If a student requires accommodation for remote participation, they must

submit a formal request through the **Disability Office** and coordinate with their **Academic Advisor** prior to the course start date.

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

Office of Global Services
As an F-1, J-1, or Study Permit student, you must meet certain obligations in order to maintain lawful nonimmigrant status. Maintaining status is necessary in order to retain eligibility for the benefits of F-1 or J-1 status, such as employment authorization and program extension, and can be crucial to a successful application for a change or adjustment of nonimmigrant status in the future. Failure to maintain your nonimmigrant status can result in serious problems with immigration and *could lead to deportation from the U.S. or Canada.*

Students must maintain on-ground presence throughout the academic term. At Northeastern, there are four different defined instructional methods: Traditional, Hybrid, Live Cast, and Online. Traditional, Hybrid, and Live Cast courses meet the Visas' on-ground presence requirements. **Online courses do not meet the Visas' on-ground presence requirements.**

Students enrolled in Summer courses should adhere to OGS guidelines on maintaining status during the Summer term.

For more information please visit, https://international.northeastern.edu/ogs/current-students/understanding-visa-requirements/guidelines-on-maintaining-status/

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

Outreach, Engagement, Belonging

Northeastern University is committed to fostering a community of belonging, which is essential to the advancement of Northeastern University's mission of teaching and research. Our university is stronger as a result of the varied backgrounds, experiences, and perspectives that all members of our global community bring to the pursuit of knowledge. Embracing this pluralism is not the work of one office, department, or academic unit. It is a shared responsibility that spans disciplines and boundaries. By harnessing the power of our differences, we will continue to light the path to bold new ideas and life-changing discoveries.

It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diverse experiences that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic background, family education level, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and belonging environment for every other member of the class. Your suggestions are encouraged and appreciated.

Please visit Belonging at Northeastern – Northeastern Provost for complete information.

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.

The Office for University Equity and Compliance (OUEC) leads Northeastern University's efforts in maintaining compliance with all federal, state, and provincial civil rights laws and prohibits discrimination within any of its programs, activities, and services. Please visit https://ouec.northeastern.edu/ for more information and for the link to file a report.