Multidisciplinary Graduate Engineering
Course Syllabus

Course Information
Course Title: Generative AI
Course Number: INFO7375
Credit Hour: 4.0

Instructor Information
Full Name: Yizhen Zhao
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Technical/Course Materials Requirements

- No textbook is required.
- Students are expected to bring their own laptops with Python installed to attend the class.

Course Description/Prerequisite
The course will serve as an extension to the INFO7374 Machine Learning in Finance & Python and cover algorithms pertaining to generative AI. The course focuses on both the theory and the application. Students will learn the quantitative models and metrics that drive the success of popular Generative AI applications such as Large Language Models, Diffusion Models, Transformer Models, BERT, etc. Students will also develop hands-on Generative AI projects using popular deep learning cloud computing tools that include Vertex AI, TensorFlow, PyTorch, etc. Lectures and coding lab sessions are enriched with case studies and examples ranging from image synthesis to text generation to showcase the application of generative AI in various fields such as art, healthcare, entertainment, finance, etc.

The course includes eight chapters:
- **Lecture 1** introduces how generative AI differs from traditional machine learning methods. The lecture will review fundamentals of probability theory, statistics and optimization methods used in generative models, including concepts like maximum likelihood estimation, Bayesian inference and gradient descent, etc. The lecture will also cover deep learning basics that includes introduction to neural networks and backpropagation, used in training generative AI models.

- **Lecture 2** introduces large language models (LLM) and their use cases. Students will learn algorithms behind ChatGPT and explore prompt tuning to enhance LLM performance.
- **Lecture 3** introduces diffusion models, a family of machine learning models that recently showed promise in the image generation space. Students will learn both the theory and how to train and deploy diffusion models using Google Vertex AI.
- **Lecture 4** gives students a synopsis of the encoder-decoder architecture, which is a powerful and prevalent machine learning architecture for sequence-to-sequence tasks such as machine translation, text summarization, and question answering. Students will learn about the main components of the encoder-decoder architecture and how to train and serve these models. In the corresponding lab walkthrough, students will code in TensorFlow a simple implementation of the encoder-decoder architecture for content generation from scratch.
- **Lecture 5** will introduce students to the attention mechanism, a powerful technique that allows neural networks to focus on specific parts of an input sequence. Students will learn how attention mechanism works, and how it can be used to improve the performance of a variety of machine learning tasks, including machine translation, text summarization, and question answering.
- **Lecture 6** introduces students to the transformer model and the bidirectional encoder representations from transformers (BERT) model. Students learn about the main components of the Transformer architecture, such as the self-attention mechanism, and how it is used to build the BERT model. Students also learn about the different tasks that BERT can be used for, such as text classification, question answering, and natural language inference.
- **Lecture 7** teaches students how to create an image captioning model by using deep learning. Students learn about the different components of an image captioning model, such as the encoder and decoder, and how to train and evaluate their own model. By the end of this lecture, students will be able to create their own image captioning models and use them to generate captions for images.
- **Lecture 8** is a supplementary lecture aimed at explaining what responsible AI is, why it's important, and how to implement responsible AI in app products.

Algorithms covered in the class include but are not confined with Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), Reinforcement Learning Algorithms, Autoregressive/Non-autoregressive Generation Models, Recurrent Neural Networks (RNNs), Convolutional Neural Networks (CNN) and recent advances of self-supervised learning for speech and images, etc.

Student Learning/Course Outcomes (SLOs)

Specialized Knowledge	Broad and Integrative Knowledge	Applied and Collaborative Learning	Civic and Global Learning	Experiential Learning
Generative AI in Finance will study major Generative AI algorithms in the context of finance using Python. The course will also introduce leading Generative AI models used by finance professionals.	*Master the mainstream Generative AI algorithms.*	*Obtain a hands-on experience in working with Generative AI modeling using Python via teamwork.*	*The focus of the course will be on implementation rather than on theories. The methods can be extensively applied in public health, education and other civic learning areas.*	*Understand the implications of algorithm building blocks spanning across matrix analysis, statistics, optimization and stochastic calculus.*

Attendance Policy

Students are expected to complete course readings, participate in class discussions or other learning activities during the unit, and complete written assignments for each unit during the time of that unit.

It is understood that there might be one week when active participation in ongoing class conversations and learning activities might be delayed.

Beyond one-week time, if there is an absence or lateness in participation (1) faculty must be notified in advance; (2) grades will be adjusted accordingly.

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.

Grading/Evaluation Standards
Grade Scale

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

Grade Breakdown:

Category # 1 - 10%

Category # 2 - 80%

Category # 3 – 10%

Course Schedule

Week	Content
Week 1	Lecture 1 Introduction to Generative AI Coding Lab: Gradient Descent, Backpropagation, Text & Image Vectorization
Week 2–3	Lecture 2 Introduction to Large Language Models Coding Lab: ChatGPT, Fine Tuning vs Prompting
Week 4–5	Lecture 3 Diffusion Model: Introduction to Image Generation Coding Lab: Denoising Diffusion Probabilistic Models, Generative Adversarial Network (GAN)
Week 6–7	Lecture 4 Encoder–Decoder Architecture Coding Lab: Variational Auto-encoder (VAE), Flow-based Generative Model
Week 8–9	Lecture 5 Attention Mechanism Coding Lab: Recurrent Neural Networks (RNNs) and Reinforcement Learning
Week 10–11	Lecture 6 Transformer Models and BERT Coding Lab: Speech Recognition, Speaker Verification, BERT and its family, Controllable Chatbot
Week 12	Lecture 7 Create Image Captioning Models Coding Lab: Vertex AI Workbench vs Midjourney

Week 13	Lecture 8 Introduction to Responsible AI + Review Session
Week 14	Final Exam

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.

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 http://www.northeastern.edu/drc/getting-started-with-the-drc/.

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 http://subjectguides.lib.neu.edu/edresearch.

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, member 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

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In case of an emergency, please call 911.

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