Generative AI

MET CS 788
Course Format (On Campus)

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Office hours: by appointment

Course Description

This course focuses on technical details and the mathematical foundations behind generative AI models. In this course, first, we learn statistical concepts required for generative artificial intelligence. Next, we review regressions and optimization methods. Afterward, we review traditional neural network architectures, including perceptron and multilayer perceptron. Next, we move to Convolutional Neural Networks and Recurrent Neural Networks and close this part with Attention and Transformers.

The second part of the course focus on generative neural networks. We start with traditional self-supervised learning algorithms (Self Organized Map and Restricted Boltzmann Machine). Then, we explore Auto Encoder architectures and Generative Adversarial Networks. Afterward, we moved toward architectures that construct generative models, including recent advances in NLP e.g., BERT, InstructGPT (ChatGPT architecture). Finally, we describe Neural Radiance Field, 3D Gaussian Splatting, and text-2-image models.

Books
- Machine Learning and Artificial Intelligence: Algorithms, Concepts and Models. By Rawassizadeh. ISBN: 979-8992162103

Course Requirements
- Students should be familiar with Python programming language and some mathematics required for machine learning.
- Students must CS 677 and it is highly recommended to be familiar with neural networks.
- This course includes lots of theories, and except for assignments, we do not go into implementation details. Students should be able to learn Keras, Tensor Flow, or Pytorch on their own. Besides, they need to be able to use cloud services such as Google Colab environment to build and train their neural network model.

Class Policies

Boston University Metropolitan College

1) **Attendance & Absences** – Class attendance is not mandatory but highly recommended. All quizzes and the final exam will be done inside the class, and taking online exams are impossible.
2) **Assignment Completion & Late Work** – 40% - 50% of the final grade comes from assignment and project delivery. Late submission of homework is associated with a penalty of 10% grade reduction for any single day.
3) **Quiz and Final exam –** 30%- 40% of the final grade comes from quizzes and the final exam. Quiz and final exams focused on concepts and not coding.
4) **Final Project –** 10% -20% of the final grade comes from final project
5) **Academic Conduct Code** – "Cheating and plagiarism will not be tolerated in any Metropolitan College course. They will result in no credit for the assignment or examination and may lead to disciplinary actions. Please take the time to review the Student Academic Conduct Code: http://www.bu.edu/met/metropolitan_college_people/student/resources/conduct/code.html.

Grading Criteria
Student grades are the sum of their assignments, final exam, and quizzes. The resulting grade will be calculated as follows.

A	95-100
A-	90-94.99
B+	85-89.99
B	80-84.99
B-	75-79.99
C+	70-74.99
C	65-69.99
F	<65

Class Meetings, Lectures & Assignments
Lectures, Readings, and Assignments are subject to change and will be announced in class as applicable within a reasonable time frame.

Date	Topic	Assignments Due
Session 1	Introduction and Statistics I (Statistical Distribution Concepts and Requirements for Generative AI)	NA

Session 2	Statistics II (Statistical Distribution Comparison Methods and Challenges	14 days after Session 2
Session 3	Characteristics of Linear versus Non-linear Models.	NA
Session 4	Mathematical Concepts for Optimization (Gradient, Jacobian, Hessian, and Taylor Series).	14 days after Session 4
Session 5	Review the basics of Neural Networks (MLP, Activation Functions, Backpropagation, Cost Functions)	NA
Session 6	Review of Convolutional Neural Networks and Recurrent Neural Networks	NA
Session 7	Review of Seq2Seq, Attention Mechanisms, Positional Encoding, Transformer Architecture.	7 days after Session 7
Session 8	Representation Learning Concepts, Self-Organized Maps, Boltzmann Machine, Restricted Boltzmann Machine	14 days after Session 8
Session 9	Autoencoders, Generative Adversarial Networks, GAN challenges, GAN Models	NA
Session 10	Large Language Models I (BERT models, GPT models, Post ChatGPT models)	NA
Session 11	Large Language Models II (Prompt engineering methods, NLP evaluations, LLM, RAG) and Agentic AI	14 days after Session 10
Session 12	Text-to-Image Models	NA
Session 13	Neural Radiance Field, 3D Gaussian Splatting	NA
Session 14	Neural Network Regularization and Compression Approaches (Quantization, Compression, Pruning, Low-Rank Adaptation)	NA