

Syllabus: EEE 598 Generative AI: Theory and Practice (Spring 2025)

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Office Hours: TBD

Meeting Info: Tue, Thu 1:30pm – 2:45pm, Location: CRTVC (Creative Commons) 205

Syllabus Disclaimer The syllabus is a statement of intent and serves as an implicit agreement between the instructor and the student. Every effort will be made to avoid changing the syllabus but the possibility exists that unforeseen events will make changes necessary.

Course Description: Generative AI is changing the face of modern life in every way possible and was made possible by the wild success of the deep learning revolution. At its core, generative AI involves the idea of implicitly learning the underlying distribution of a training dataset with the goal of sampling from this distribution (generative model) to produce similar yet unseen data. The history of GenAI traces back to the design of variational autoencoders, generative adversarial networks (GANs), and more recently, diffusion models. These concepts are at the core the ultra-large models of known genAI models such as ChatGPT, Gemini, Llama, etc. that are trained on ginormous amounts of data with the goal of learning to synthesize “real data”. Despite its success, there are many concerns of genAI models, primary among them being those of privacy (of the training data) and fairness (of the outcomes across various demographics).

This course will focus on the foundational aspects of generative AI detailing three key types of generative approaches: (i) GANs, (ii) diffusion models, and (iii) variational encoders. The course will also address whether such deep models can be learned in a privacy preserving manner so the released model does not reveal the training data. Furthermore, the course will also address the issue of assuring that the outputs of generative models are not biased towards subpopulations/groups that are dominant in the training data. Finally, the role of transformers in enabling recent generative models will also be covered.

Course Style: This is a discussion and seminar style course with an interactive learning approach. In addition to instructional lectures on the basic concepts, students will work collaboratively on reading state of the art papers and engage in discussions and presentations. The aim of this course is to introduce students to an important topic in modern machine learning in a rigorous and interactive manner. A desired outcome is for students to be able to understand the differences between different generative approaches, identify limitations and challenges of assuring privacy and fairness of such models, and learn to determine which approaches are ideal for a problem setting at hand.

Prerequisites: Working knowledge of probability, linear algebra, and Python programming

Corequisites: EEE554 (probability and random processes) or UG equivalent, EEE549 (statistical ML) or equivalent

Course outcome: students should be able to understand state of the art generative approaches and design such algorithms for specific applications

Course Topics:

- Introduction to generative AI
- Generative Adversarial Networks (GANs)
- Challenges of training with GANs, success of alpha-fold
- Diffusion models: theory

- Training diffusion models: Challenges
- Probabilistic and Implicit diffusion models
- GANs vs. diffusion models
- Why variational autoencoders don't do well
- Fairness and Privacy
- Assuring fairness of generative models
- Is it possible to learn large models with privacy guarantees?
- Guest lectures on privacy, fairness, and generative models for videos

Grading:	Reading+Discussion Assignments	20 %
	Scribing 1 (submitting notes for a lecture)	15 %
	Scribing 2 (submitting notes for a lecture)	15 %
	Slack Participation	5 %
	GenAI-related Seminar Participation & Brief Report	10 %
	Final Project	35 %

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