



Course Title: Generative AI and Applications

Course Code: CSE-848

**Pre-requisite: Atleast one course on Machine Learning /
Deep Learning**

Course description:

The goal of the course on generative artificial intelligence is to impart advanced knowledge and abilities in the subject. Machine learning algorithms are used in generative AI to create and synthesize new data, including text and images. Students who take this course will be given the skills they need to comprehend cutting-edge generative models and develop their own by covering both the theoretical underpinnings and practical applications of generative AI.

Recommended Books:

1. Foster D. Generative Deep Learning: Teaching Machines to Paint. Write, Compose, and Play O'Reilly Media Incorporated. 2019:139-40.
2. Goodfellow I, Bengio Y, Courville A. Deep learning. MIT press; 2016 Nov 10.
3. Foster D. Generative deep learning. " O'Reilly Media, Inc."; 2022 Jun 28.
4. Tomczak JM. Deep generative modeling. Springer; 2022.
5. Babcock J, Bali R. Generative AI with Python and TensorFlow 2: Create images, text, and music with VAEs, GANs, LSTMs, Transformer models. Packt Publishing Ltd; 2021 Apr 30.
6. Manaswi NK. Generative Adversarial Networks with Industrial Use Cases: Learning How to Build GAN Applications for Retail, Healthcare, Telecom, Media, Education, and HRTech. BPB Publications; 2020 Mar 4.
7. van der Zant T, Kouw M, Schomaker L. Generative artificial intelligence. Springer Berlin Heidelberg; 2013.
8. Ahirwar K. Generative adversarial networks projects: Build next-generation generative models using TensorFlow and Keras. Packt Publishing Ltd; 2019 Jan 31.

Prerequisite: None

Objectives:

The educational objectives of the course "Generative AI and Applications" are as below:

- a. Be familiar with the foundational concepts of generative AI, such as deep learning, probabilistic modelling, and generative models. Learn about various generative modelling approaches, including flow-based models, generative adversarial networks (GANs), variational autoencoders (VAEs), and autoencoders.
- b. Learn advanced techniques for training and evaluating generative models, including optimization methods, loss functions, and evaluation metrics.
- c. Gain insights into the ethical considerations and challenges associated with generative AI, including issues related to bias, fairness, and privacy.

- d. Develop practical skills in implementing and fine-tuning generative models using popular deep learning frameworks, such as TensorFlow and PyTorch.
- e. Apply generative AI techniques to various domains, such as image synthesis, text generation, music composition, and data augmentation.
- f. Explore state-of-the-art research papers and advances in generative AI, and critically analyze their implications and potential applications.
- g. Undertake a hands-on project that involves designing, implementing, and evaluating a generative AI system in a chosen domain.

Course Learning Outcomes:

At the end of the course, the students should be able to:

1. Understand the fundamental ideas of generative AI, such as deep learning, probabilistic modelling, and generative models.
2. Learn about advanced training and assessment methods for generative models, such as optimisation strategies, loss functions, and evaluation metrics.
3. Learn about the ethical dilemmas and difficulties raised by generative AI, such as those with bias, justice, and privacy.
4. Learn how to create and optimise generative models using well-known deep learning frameworks.
5. Apply generative AI methods to a variety of fields, including data augmentation, text generation and image synthesis.

Assessment system:

Quizzes	10-15%
Assignments	5-10%
MSE	30-40%
ESE	40-50%

Week wise Lecture Plan:

Week	Lecture Topic	Assignments	Quizzes
1	Introduction to Generative AI		
2	<ul style="list-style-type: none"> • Introduction to generative models • Scenarios that are challenging and require Generative AI • Probability theory and generative modeling • Deep learning foundations for generative AI 		
3	<ul style="list-style-type: none"> • Normalizing Flow Models 		
4	Autoencoders and Variational Autoencoders (VAEs)	Assignment 1	
5	<ul style="list-style-type: none"> • Autoregressive Models • Variational autoencoders 		
7	Generative Adversarial Networks (GANs)		Quiz 1
8	<ul style="list-style-type: none"> • Introduction to GANs and their components • Training GANs and improving stability • Conditional and progressive GANs 		
9	Transformers and Language Models		Quiz 2
10	<ul style="list-style-type: none"> • Transformers • Text generation and language modeling 		
11	<ul style="list-style-type: none"> • Large Language Models 	Assignment 2	
12	MSE		
13	<ul style="list-style-type: none"> • Optimization methods for generative models • Evaluation Metrics for Generative Models 		
14	<ul style="list-style-type: none"> • Data augmentation using generative models • Prompt programming and neural text decoding 	Assignment 3	
16	Ethical Considerations in Generative AI		
	<ul style="list-style-type: none"> • Bias and fairness in generative models • Privacy implications and considerations • Addressing ethical challenges in generative AI 		Quiz 3
17	Advances in Generative AI		
	<ul style="list-style-type: none"> • Review of recent research papers and breakthroughs • Exploring cutting-edge architectures and techniques • Emerging trends and future directions in generative AI 		
18	ESE		