DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

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CSXX1907 ***Generative Deep Model*** **L-T-P-Cr: 2-0-2-3**

Pre-requisites: The students are expected to be fluent in computational and mathematical models and should have a basic knowledge of probabilities and calculus. Students are also expected basic knowledge about machine learning from courses in artificial intelligence, probabilistic graphical models: principles and techniques, machine learning or deep learning.

Objectives/Overview:

- The student have a general understanding of the current state-of-the art in generative models.
- The student will be able to distill large amounts of research into coherent summaries.
- The student with be able to think critically about work in the field.
- Provide hands-on experience on one of the most exciting areas of research in deep learning, i.e., generative models.

Course Outcomes – After completing this course, students should be able to:

CO-1. *Developing* an advanced understanding of deep learning and generative models, which represent state-of-the-art approaches for predictive modeling in today's data-driven world.

CO-2. *Identifying* scenarios where it makes sense to deep learning for real-world problem-solving.

CO-3. *Building* a collection of different algorithms and approaches to deep learning and understanding their various strengths and weaknesses.

CO-4. *Implement* a range of generative models, such as autoregressive models, normalizing flow models, energy-based models, and score-based models.

CO-5. *Design* and *develop* problem-solving skills by tackling challenges and complexities in the practical implementation of generative models.

Course Outcomes–Cognitive Levels–Program Outcomes Matrix –

[H: High relation (3); M: Moderate relation (2); L: Low relation (1)]

Course Outcomes	Program Outcomes											
	PO-1 (Engineering knowledge)	PO-2 (Problem analysis)	PO-3 Design/development of solutions)	PO-4 (Conduct investigations of complex problems)	PO-5 (Modern tool usage)	PO-6 (The engineer and society)	PO-7 (Environment and sustainability)	PO-8 (Ethics)	PO-9 Individual and team work)	PO-10 (Communication)	PO-11 (Project management and finance)	PO-12 (Life-long learning)
CO-1	3	3	3	3	2	3			3	3	1	3
CO-2	3	3	3	3	2	3		1	3	3	1	3
CO-3	3	3	3	3	3	3	1	1	3	3	1	3
CO-4	3	3	3	3	2	3	1		3	3	1	3
CO-5	3	3	3	3	3	3	2	1	3	3	1	3
CO-6	3	3	2	1	3	1	1	1	3	3	2	2

UNIT 1 Introduction to Generative Deep Learning: **Lecture 3**

Generative Modeling, Generative Model Taxonomy

Deep Learning:

Deep Neural Networks, Multilayer Perceptron (MLP), Convolutional Neural Network (CNN)

UNIT 2 Variational Autoencoders: **Lecture 3**

Introduction, Autoencoders, Variational Autoencoders, Exploring the Latent Space

UNIT 3 Generative Adversarial Networks: **Lecture 4**

Introduction, Deep Convolutional GAN (DCGAN), Wasserstein GAN with Gradient Penalty (WGAN-GP), Conditional GAN (CGAN)

UNIT 4 Autoregressive Models **Lecture 5**

Introduction, Long Short-Term Memory Network (LSTM), Recurrent Neural Network (RNN) Extensions, PixelCNN

Normalizing Flow Models:

Introduction, Normalizing Flows, RealNVP, Other Normalizing Flow Models, GLOW, FFJORD

Energy-Based Models:

Introduction, Energy-Based Models,

UNIT 5 Diffusion Models **Lecture 5**

Introduction, Denoising Diffusion Models (DDM), the Forward Diffusion Process, the Reparameterization Trick, Diffusion Schedules, the Reverse Diffusion Process, the U-Net Denoising Model, Training the Diffusion Model, Sampling from the Denoising Diffusion Model, Analysis of the Diffusion Model

UNIT 6 Transformers **Lecture 5**

Introduction, GPT, Attention, Queries, Keys, and Values, Multihead Attention, Causal Masking, the Transformer Block, Positional Encoding, Training GPT, Analysis of GPT, Other Transformers: T5, GPT-3 and GPT-4, ChatGPT

UNIT 7 Advanced GANs **Lecture 3**

Introduction, ProGAN, StyleGAN, StyleGAN2, Other Important GANs: Self-Attention GAN (SAGAN), BigGAN, VQ-GAN, ViT VQ-GAN

Text/Reference Book:

1) *David Foster,* Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play, O'Reilly Media, Inc., 2019.
2) *Jakub M. Tomczak,* Deep Generative Modeling, Springer Nature Switzerland, 2022.
3) *Josh Kalin*, Generative Adversarial Networks Cookbook, Packt publishing 2018.