



# DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

## NATIONAL INSTITUTE OF TECHNOLOGY PATNA

Ashok Raj Path, PATNA 800 005 (Bihar), India

Phone No.: 0612 – 2372715, 2370419, 2370843, 2371929, 2371930, 2371715 Fax – 0612- 2670631 Website: [www.nitp.ac.in](http://www.nitp.ac.in)

**MC47XX10**

**Generative Deep Learning**

**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<br>(Engineering knowledge) | PO-2<br>(Problem analysis) | PO-3<br>(Design/development of solutions) | PO-4<br>(Conduct investigations of complex problems) | PO-5<br>(Modern tool usage) | PO-6<br>(The engineer and society) | PO-7<br>(Environment and sustainability) | PO-8<br>(Ethics) | PO-9<br>(Individual and team work) | PO-10<br>(Communication) | PO-11<br>(Project management and finance) | PO-12<br>(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.