Introduction to Course

AI-4009 Generative AI

Presented By: Dr. Muhammad Nouman Noor
Department of AI & DS

Developed By: Dr. Akhtar Jamil

Instructor Information

Instructor	Dr. Muhammad Nouman Noor	**E-mail**	nouman.noor@isb.nu.edu.pk
Research Interest: Computer Vision, Medical Imaging & Deep Learning			
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Meeting Hours

Days	8:30 09:50	10:00 11:20	11:30 12:50	01:00 02:20	02:20 03:50	05:20 06:40
Monday			Office Hours			Adv. Topics in Gen AI
Tuesday		Gen AI	Gen AI		Office Hours	
Wednesday			Office Hours			Adv. Topics in Gen AI
Thursday		Gen AI	Gen AI		Office Hours	Office Hours
Friday						

Course Information

- Generative Artificial Intelligence
- Course Credits: 3 + 0
- Theoretical + Practical

Python, TensorFlow, PyTorch, Keras, FastAI, PyTorch GAN Zoo, TensorFlow GAN (TF-GAN), and GANs in Keras, OpenAI's GPT, T5 (Text-To-Text Transfer Transformer), Microsoft's DeepSpeed

Data Sets:
UCI Machine Learning Repository, Kaggle, Google Dataset Search

GPT4All	Llama	T5	
Claude	BERT	Transformer architecture	
PaLM 2	LaMDA	Bard	Roberta

Course Materials

- Will be shared via Google Classroom

Class Code

irsvg3h3

Text Book

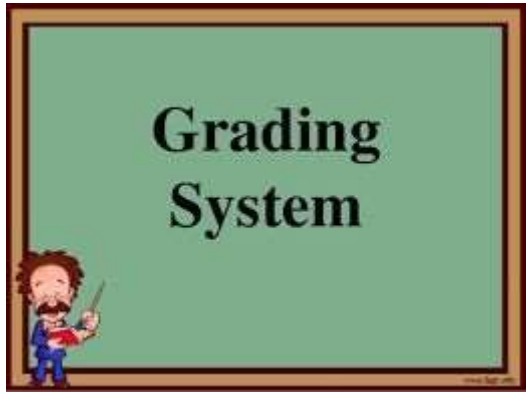
- Generative AI Navigating the course to the Artificial General Intelligence Future by Martin Musiol
- *Generative Deep Learning by David Foster*

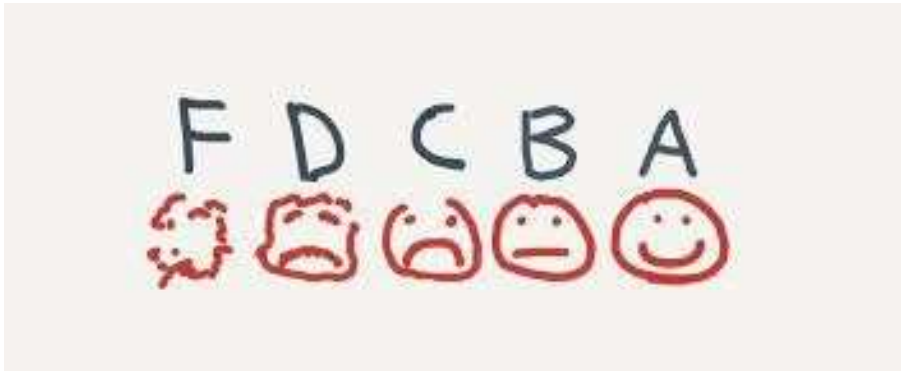
Reference Materials

- *Recent Research Papers*
- *Deep Learning, by Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press.*
- Neural Networks and Deep Learning : A Textbook, Charu C. Aggarwal
- Deep Learning with Python, François Cholle
- Machine Learning and Deep Learning with Python, scikit-learn and TensorFlow, Sebastian Raschka and Vahid Mirjalili

Grading Policy

- Absolute Grading





Grading Policy

Assessment Item	Number	Weight (%)
Assignments	>=3	8
Quizzes	>=4	8
Project	1	14
Sessional-I	1	15
Sessional-II	1	15
Final Exam	1	40

Explanation of Assessment

- All assignments and Quizzes carry equal weightage
- Enough Time will be given for Assignments for their implementation.
- Quizzes can be announced or unannounced.
- Project will be done individually.
  - Project include writing a research paper for publication.

Submission for Assignment / Project

- No assignment and project deliverable will **late submission allowed.**
- It’s the responsibility of the class to submit assessments well before time.
- You are graduate students so manage your time accordingly.

Course Plagiarism Policy

- Plagiarism in any kind of assessment including project or sessional/ final exam, assignments quizzes, will result in F grade in the course.

- So what is it?

Plagiarism is **presenting someone else's work or ideas as your own, with or without their consent**, by incorporating it into your work without full acknowledgement. All published and unpublished material, whether in manuscript, printed or electronic form, is covered under this definition.

Course Plagiarism Policy

- Project Paper
  - Plagiarism for paper will be checked via Turnitin software
  - Any paper with score greater than 20% will be considered plagiarized and ZERO marks will be awarded.
  - Content will be also checked for AI Generated plagiarism, it must not exceed 20% too.

Missed Assessment

- Retake of missed assessment items is NOT allowed.
- Missed assessment item will earn zero marks
- Late submission will NOT be accepted (Even by one second).
- For missed sessional/ final exam due procedure will be followed.
- No change is any deadline

Attendance policy

- Students are supposed to have 100% attendance.
- The minimum attendance requirement at all levels and in all courses is 80%.
- The relaxation of 20% attendance has been given only to cover any planned events or unforeseen situations.
- I will take attendance at the start of lecture, within 10 minutes.
- Beyond 15 minutes, you will be marked ABSENT.

Student Responsibility

- Mobile Usage
  - Use of mobile phones should be avoided.
  - You can leave the class in case of an emergency
- Discussion
  - Class participation is highly appreciated
  - You can ask questions in the class(Highly Appreciated)
  - Discussion among students is not allowed.

Goals of this Course

- This course is designed to gain theoretical and practical knowledge of Generative Models.
- Course will cover some of the advanced level algorithms.
- This course is about the **algorithmic foundations** of generative models.
- Explain **principles** why and how each generative modeling algorithm works.
- You will be focusing on implementation techniques

Paper Writing

- A typical paper must consists of following main section
  - Abstract
    - Should be one paragraph explaining what is being presented in the paper
  - Introduction
    - A short explanation of the problem and reviews of the existing research.
    - You must download and review at least 10-15 papers (Journal Papers are highly encouraged)
  - Data Set
    - Which data has been used for this study
  - Methodology
    - What method(s) has been implemented
  - Experimental Results
    - Explanation of the results obtained. Should include figures, tables etc.
  - Conclusion
    - Summarize what you did overall
  - References
    - Bibliography of which papers were reviewed or used in the paper

Reading Papers

- Every week students must read a research paper related to their topic and write a short report.
  - Your weekly work will directly contribute to your assessment items.
- Particularly following items are required for discussion
  - Methodology of the paper
  - Main Contributions
  - Experimental Results
  - Strong points and weak points

Prerequisite(s)

- There is no prerequisite for this course.
- However, having good programming skills in Python / C++ etc, is beneficial
- Advanced Level of Deep Learning, we assume knowledge of DL models
- Machine Learning Frameworks
  - Scikit-Learn (Conventional ML)
  - **Tensorflow / Keras ,** PyTorch, DEEPLEARNING4J, Microsoft Cognitive Toolkit, Caffe

Prerequisites

- Basic knowledge of Optimization and Probabilities:
  - Gradients, gradient-descent optimization, backpropagation
  - Random variables, independence, conditional independence
  - Bayes rule, chain rule
- Basic knowledge of deep neural networks (ANNs, CNNs, RNNs, Autoencoders).

Projects

- Course projects will be done by individually and can fall into one or more of the following categories:
  - Application of deep generative models on a novel task/dataset
  - Algorithmic improvements into the evaluation, learning and/or inference of deep generative models
  - Theoretical analysis of any aspect of existing deep generative models
- I encourage students to do research to find suitable topics
  - We can also suggest few possible projects

Presentation

- Each student will be given 8-10 minutes for their presentation
- Students will explain every step they have performed for preparing their paper and the results obtained.
- Implementation must be shown to the instructor

Programming resources

- https://www.tensorflow.org/
- https://pytorch.org/
- https://www.nltk.org/
- https://scikit-learn.org/stable/
- https://docs.microsoft.com/en-us/cognitive-toolkit/

High Impact Journals/Conferences

- High Impact Conferences
  - https://www.scimagojr.com/journalrank.php?area=1700&type=p&category=1702
- High Impact Journals
  - https://www.scimagojr.com/journalrank.php?category=1702&area=1700&type=j

Outline

Week	List of Topics
.	-Courses Overview - Introduction to Deep Learning - Generative Models - Bayesian Learning
2	Introduction to ANNs and CNNs
3	Introduction to Probabilistic Graphical Models
4	Restricted Boltzmann Machines (RBMs)
5	Autoregressive Models in Image Generation
6	Sessional -I

Outline

7	Latent Variable Models
8	Flow-based Models (Normalizing Flows)
9	Introduction to Variational Autoencoders (VAEs)
10	Generative Adversarial Networks (GANs) - Wasserstein GAN - GAN in NLP, CV - e.g Deep Fakes, BigGAN, StyleGAN2, Pix2Pix and CycleGAN
11	Transformer Models in Data Generation
12	Sessional - II

Outline

13	Large Language Models (e.g., GPT-3, BERT, BART, DistillBert, DALL-E)
14	Introduction to Diffusion Models
15	Audio and Speech Generation Models: (e.g. WaveNet and SampleRN, Tacotron)
16	Project Presentations/ Evaluations
17	Final

It’s Your Turn

- To Introduce Yourself
  - Your Name
  - Educational Background

netiquette – Brown Car Guy

Lecture #1

Goals

This lecture will cover:

- Development Environment Setup/ Mendeley/Overleaf
- Research Stages
- Why Machine Learning?
- Why Generative Models

Development Environment Setup

- Download and Install Anaconda
  - https://www.anaconda.com/
  - Individual Edition is Free
- Visual Studio Code
- Conda Installation of Tensorflow:
  - https://docs.anaconda.com/free/anaconda/applications/tensorflow/
- PIP Installation
  - https://www.tensorflow.org/install/pip#linux

Overleaf - Preferable

- Use **LaTeX for writing**
- The easy to use, online, collaborative LaTeX editor.
- Overleaf is used by over nine million students and academics at 6,800 institutions worldwide
- Work from anywhere
- https://www.overleaf.com

Getting Started with Research

- Step 1. Select a Topic
  - Your interests and Skills
  - Supervisor / Project
  - Availability of resources
- Step 2. Search for Relevant Information
  - IEEE Explore
  - arXiv
  - Springer
  - Scopus
  - Web of Science
  - Google Scholar

Getting Started with Research..

- Step 3. Organize Resources
  - Zotero
  - EndNote
  - Mendeley
  - JabRef
  - License
  - MarginNote
- Step 4. Write Paper
  - Outline the Paper
  - Take Notes
  - Avoid Plagiarism

Inside Davos: Future of AI

- **Sam Altman**
- profound impact of artificial intelligence (AI) on society during the World Economic Forum in Davos
- We’re going to have digital doctors, digital people, and these digital people are going to merge, and there’s going to have to be a level of trust.

Inside Davos: Future of AI

- There will be jobs: Microsoft CEO Satya Nadella on how AI will change workplace
  - There will be a reduction in jobs as we know but different jobs will be created need different skills
- **Microsoft became major force in the proliferation of AI through its investment in OpenAI.**
- AI's commercial impact could translate far more broadly.

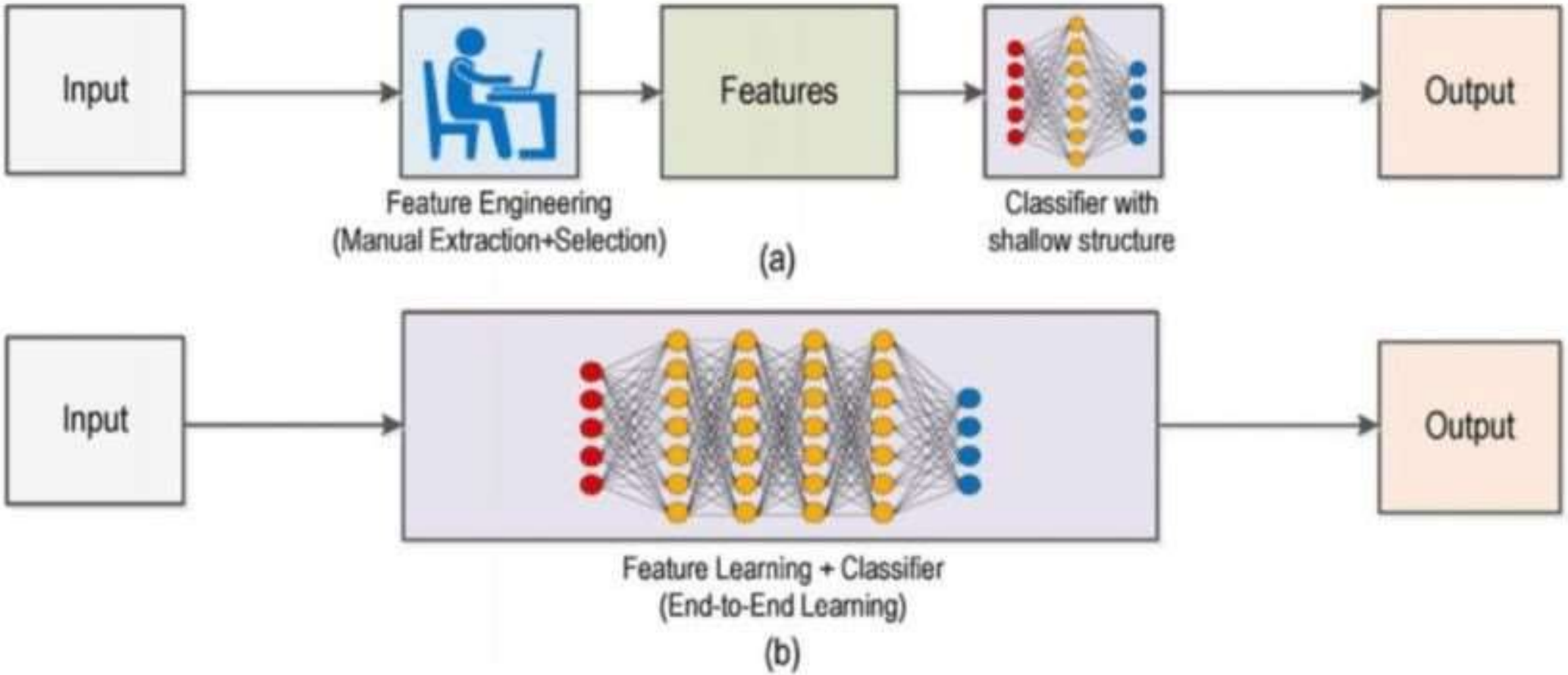
What is Machine Learning?

- A branch of artificial intelligence that enables systems to learn and improve from experience without being explicitly programmed.
- Key Components:
  - Data: Essential for training models.
  - Algorithms: Learn from data to make predictions or decisions.
- Types of Machine Learning:
  - **Supervised Learning**: Learning with labeled data.
  - **Unsupervised Learning:** Learning from unlabeled data to find patterns.
  - **Reinforcement Learning:** Learning by trial and error to achieve a goal.

Deep Learning

- Uses **complex neural networks** with many layers (deep neural networks).
- These networks are capable of automatically discovering and learning patterns in data
  - Superior performance on tasks like image and speech recognition.
- Deep learning models can automatically extract and learn features from raw data, reducing the need for manual feature extraction.

Machine Learning vs Deep Learning



Machine Learning vs Deep Learning

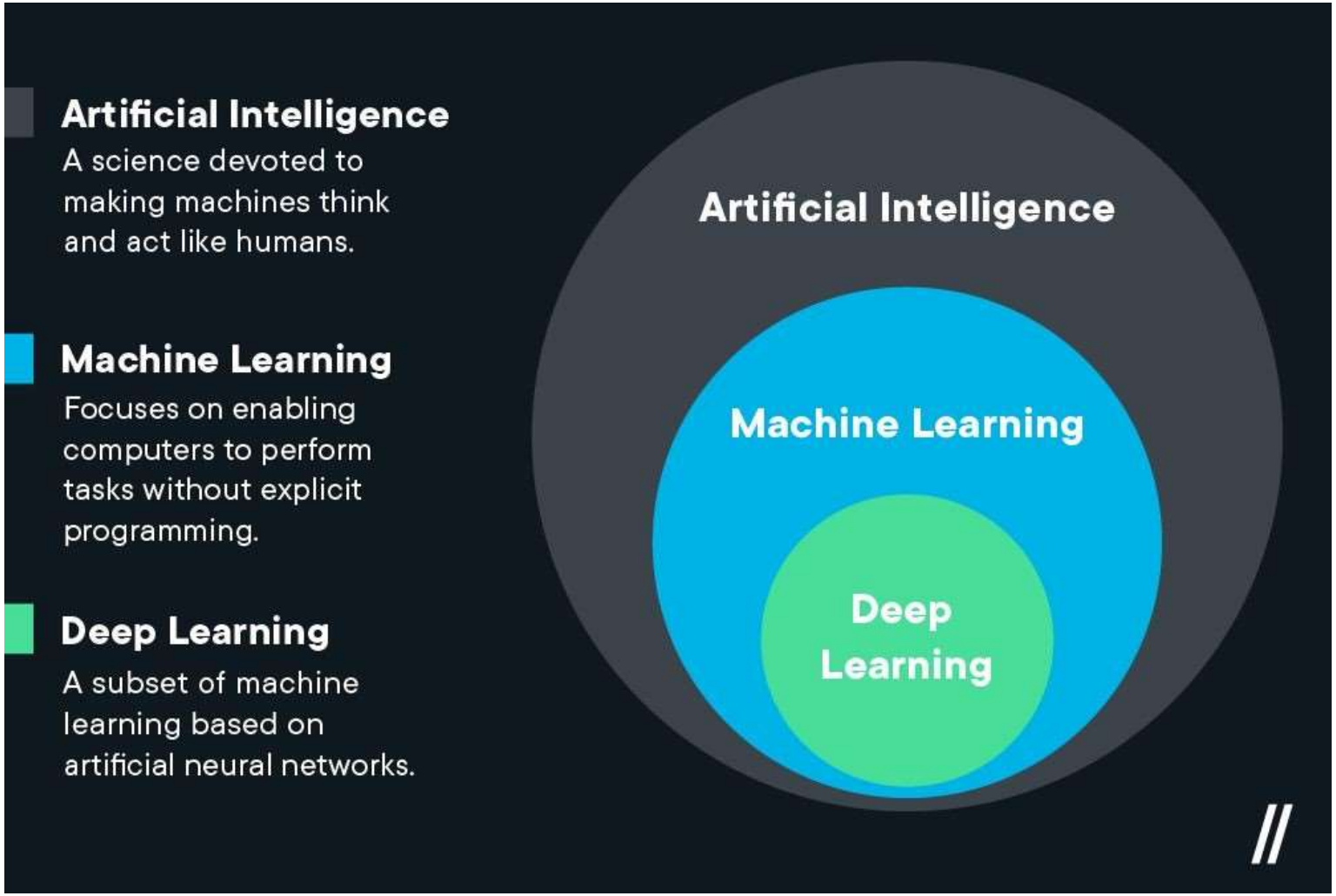
Machine learning

Uses algorithms and learns on its own but may need human intervention to correct errors

Deep learning

Uses advanced computing, its own neural network, to adapt with little to no human intervention

Artificial Intelligence



What are Generative Models?

- Generative models are a class of statistical models used in machine learning that focus on the generation of new data instances.
- Generative models used in **unsupervised machine learning**.
- They try understanding and replicating the complex probability distributions of training data.
- Capture the essence of data - its patterns, variations, and structure - and can produce new data that follows the same statistical properties.
- They contrast with discriminative models, which are designed to distinguish between different kinds of data instances.

Discriminative Vs Generative Model

- **Generative Models**
- Generative learn the joint probability distribution P(X, Y) , where X is the input data and Y is the output label.
- They understand how the data is generated in terms of a probabilistic model.
- These models can generate new data points that is similar to the training data.
- e.g. Gaussian Mixture Models, Hidden Markov Models, Naive Bayes, Variational Autoencoders (VAEs), and Generative Adversarial Networks (GANs).

Discriminative Vs Generative Model

- **Discriminative Models**
- Discriminative models learn the conditional probability $P(Y \mid X)$, which is the probability of the output label Y given the input data X.
- They focus on the boundary between classes.
- These models are used to distinguish between different types of data points.
- They do not inherently generate new data points but classify input data into predefined categories.
- Examples include Logistic Regression, Support Vector Machines, Decision Trees, and most of the Neural Networks used for classification tasks.

References

- Chapter 20, Deep Learning, MIT Press, Ian Goodfellow, Yoshua Bengio, Aaron Courville
- Lecture slides of https://www.cs.cornell.edu/~kuleshov/

Thank You ☺