ARTIFICIAL INTELLIGENCE

Introduction to AI

1. What is AI?
   - Definitions, history, and evolution.
   - Types of AI: Narrow AI, General AI, Superintelligent AI.

2. Applications of AI
   - Healthcare: Diagnostic AI, Personalized Medicine.
   - Finance: Algorithmic Trading, Fraud Detection.
   - Retail: Recommendation Systems, Demand Forecasting.
   - Autonomous Vehicles: Self-Driving Cars, Traffic Management.

3. Foundations of AI
   - AI vs. Human Intelligence (Cognitive Simulation vs. Biological Process).
   - Turing Test and its Limitations.
   - Overview of AI Subfields: Machine Learning, Deep Learning, Reinforcement Learning.

MACHINE LEARNING

Module 1: Introduction to Machine Learning

1. Definition of Machine Learning
2. Traditional Programming vs. Machine Learning
3. Importance of Machine Learning in Real-World Applications
4. AI, Machine Learning, and Deep Learning - Differences
5. Role of Data in Machine Learning
6. Categories of Machine Learning
   - Supervised Learning
   - Unsupervised Learning
   - Semi-Supervised Learning
   - Reinforcement Learning

Data Preprocessing and Feature Engineering

1. Data Collection and Cleaning
2. Handling Missing Values (Mean, Median, Mode, Imputation)
3. Handling Outliers (Z-score, IQR Method)
4. Feature Encoding (One-Hot Encoding, Label Encoding)
5. Feature Scaling (Standardization, Normalization, Min-Max Scaling)
6. Feature Selection Techniques
7. Feature Engineering (Polynomial Features, Binning)
8. Handling Imbalanced Data (SMOTE, Undersampling, Oversampling)

Supervised Learning - Regression Models

Basic Regression

1. Linear Regression (Simple & Multiple)
2. Assumptions of Linear Regression
3. Polynomial Regression
4. Ridge Regression (L2 Regularization)
5. Lasso Regression (L1 Regularization)
6. Elastic Net Regression

Evaluation Metrics for Regression

1. Mean Squared Error (MSE)
2. Mean Absolute Error (MAE)
3. R^2 Score

Supervised Learning - Classification Models

Basic Classification Algorithms

1. Logistic Regression
2. Decision Trees for Classification
3. Random Forest Classifier
4. K-Nearest Neighbors (KNN)
5. Support Vector Machines (SVM)
6. Naïve Bayes Classifier

Evaluation Metrics for Classification

1. Confusion Matrix
2. Accuracy, Precision, Recall, F1-Score
3. ROC and AUC Curve

Unsupervised Learning

Clustering

1. K-Means Clustering
2. Hierarchical Clustering
3. DBSCAN Clustering

Dimensionality Reduction

1. Principal Component Analysis (PCA)
2. Linear Discriminant Analysis (LDA)
3. t-Distributed Stochastic Neighbor Embedding (t-SNE)
4. Uniform Manifold Approximation and Projection (UMAP)

Association Rule Mining

1. Market Basket Analysis
2. Apriori Algorithm
3. Eclat Algorithm
4. FP-Growth Algorithm
5. Support, Confidence, and Lift

Reinforcement Learning

1. Concepts of Agents, Actions, and Rewards
2. Markov Decision Process (MDP)
3. Q-Learning
4. Deep Q-Networks (DQN)

DEEP LEARNING

Introduction to Deep Learning

1. What is Deep Learning?
2. Evolution of Deep Learning (Perceptron to Transformers)
3. Applications of Deep Learning (Healthcare, Finance, NLP, Autonomous Systems, etc.)
4. Hardware Acceleration (GPUs, TPUs)
5. Deep Learning Frameworks (TensorFlow, PyTorch, Keras)

Neural Networks - Basics

1. Biological vs. Artificial Neurons
2. Perceptron Model and Its Limitations
3. Multi-Layer Perceptron (MLP) and Deep Networks
4. Forward and Backpropagation Algorithm
5. Activation Functions (ReLU, Sigmoid, Tanh, Softmax)
6. Weight Initialization Techniques (Xavier, He, Random)
7. Loss Functions for Classification and Regression

Implementing Neural Networks with Keras & TensorFlow

1. Introduction to Keras and TensorFlow
2. Sequential API vs. Functional API

3. Creating and Compiling Models
4. Training, Evaluating, and Predicting with Deep Learning Models
5. Handling Overfitting (Dropout, Batch Normalization, L1/L2 Regularization)
6. Hyperparameter Tuning (Grid Search, Random Search, Bayesian Optimization)

Convolutional Neural Networks (CNNs)

1. Introduction to Image Processing in Deep Learning
2. Architecture of CNNs
3. Convolutional Layers (Conv2D)
4. Pooling Layers (MaxPooling, AveragePooling)
5. Fully Connected Layers and Flattening
6. CNN-based Architectures (AlexNet, VGG, ResNet, Inception, MobileNet)
7. Transfer Learning with Pretrained CNN Models
8. Image Augmentation Techniques
9. Object Detection (YOLO, Faster R-CNN, SSD)
10. Image Segmentation (U-Net, Mask R-CNN)

Recurrent Neural Networks (RNNs) and Sequence Modeling

1. Introduction to Sequential Data Processing
2. Understanding Recurrent Neural Networks (RNNs)
3. Vanishing and Exploding Gradient Problem in RNNs
4. Long Short-Term Memory (LSTM) Networks
5. Gated Recurrent Units (GRU)
6. Bidirectional RNNs and Attention Mechanisms
7. Applications of RNNs (Text Generation, Sentiment Analysis, Speech Recognition)

Transformers and Attention Mechanisms

1. Introduction to Transformer Architecture
2. Self-Attention and Multi-Head Attention Mechanism
3. Positional Encoding in Transformers
4. Implementing BERT, GPT, and T5
5. Applications of Transformers in NLP and Vision (Chatbots, Image Captioning)

Autoencoders and Dimensionality Reduction

1. Basics of Autoencoders (AE)
2. Undercomplete vs. Overcomplete Autoencoders
3. Variational Autoencoders (VAE)
4. Denoising Autoencoders
5. Applications of Autoencoders (Anomaly Detection, Feature Learning)

Natural Language Processing (NLP)

1. Introduction to NLP

- Definition and importance of NLP
- Real-world applications (chatbots, translation, sentiment analysis)
- Challenges in NLP (ambiguity, context understanding, sarcasm detection)

2. Text Preprocessing and Representation

- Tokenization, Stemming, Lemmatization
- Stopword removal, POS tagging, Named Entity Recognition (NER)
- Vectorization techniques (Bag of Words, TF-IDF, Word Embeddings)

3. Traditional NLP Models

- Rule-based and Statistical NLP approaches
- N-grams, Hidden Markov Models (HMMs)
- Basic text classification (Naïve Bayes, Logistic Regression)

4. Deep Learning for NLP

- Word Embeddings (Word2Vec, GloVe, FastText)
- Recurrent Neural Networks (RNNs) for NLP
- Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU)

5. Transformer-Based Models

- Introduction to the Transformer architecture
- Attention mechanism in NLP
- BERT (Bidirectional Encoder Representations from Transformers)
- GPT (Generative Pre-trained Transformer) and its applications
- Fine-tuning transformers for NLP tasks

6. NLP Applications and Case Studies

- Sentiment Analysis
- Named Entity Recognition (NER)
- Text Summarization
- Question Answering Systems
- Machine Translation

Computer Vision

Introduction to Computer Vision

- Definition and real-world applications (facial recognition, object detection)
- Overview of image processing techniques

Image Processing Fundamentals

- Convolution, Filters, Edge Detection
- Image Segmentation, Thresholding, Morphological Transformations

Deep Learning for Computer Vision

- Convolutional Neural Networks (CNNs)
- Key architectures: AlexNet, VGG, ResNet, EfficientNet
- Transfer Learning in Computer Vision

Object Detection and Segmentation

- Introduction to Object Detection
- Region-Based CNNs (R-CNN, Fast R-CNN, Faster R-CNN)
- Mask R-CNN for object segmentation

Face Recognition and GANs in Computer Vision

- Face recognition techniques (Haar cascades, deep learning models)
- Generative Adversarial Networks (GANs) for image synthesis

Generative AI & Large Language Models (LLMs)

Introduction to Generative AI

- Definition and importance
- Categories: Text, Image, Video, Audio generation

Text Generation Models

- GPT-3, GPT-4, Claude, Mistral
- Applications: Chatbots, content creation, AI coding assistants

Diffusion Models for Image Generation

- DALL-E, MidJourney, Stable Diffusion
- AI-generated art and its implications

Multimodal AI Models

- CLIP (Contrastive Language-Image Pretraining)
- Vision-Language Models (e.g., Flamingo, Gemini)
- Applications in robotics and AI assistants