DAY – 6

5 August 2025

Deep learning is a subset of machine learning using multi-layered Artificial Neural Networks (ANNs) to mimic the human brain, enabling computers to learn complex patterns from vast data (images, text, sound) to make predictions or decisions, requiring no explicit programming for tasks like image recognition or natural language processing, with "deep" referring to the many interconnected layers processing data hierarchically.

Core Concepts

- **Artificial Neural Networks (ANNs):** Inspired by the brain, these are networks of interconnected "neurons" (nodes) organized in layers (input, hidden, output).
- **Layers:** Data passes through multiple hidden layers, with each layer learning increasingly complex features from the previous one (e.g., edges to shapes to objects in images).
- **Learning from Data:** Models learn by example, adjusting connection strengths (weights) based on feedback, improving accuracy over time, similar to human experience.
- **Automatic Feature Extraction:** Unlike traditional ML, deep learning automatically discovers and learns relevant features from raw data, handling unstructured data well.

How it Works (Simplified)

- **Input Layer:** Receives raw data (e.g., pixels of an image).
- **Hidden Layers:** Each layer performs mathematical operations, extracting patterns (e.g., Layer 1 finds edges, Layer 2 finds shapes, Layer 3 recognizes objects).
- **Output Layer:** Produces the final result (e.g., identifying a cat in the image).
- **Training:** The network makes a guess, compares it to the correct answer, calculates the error, and adjusts its internal weights (backpropagation) to reduce future errors.

Key Characteristics & Applications

- **Data-Hungry:** Performs best with massive datasets.
- **Computational Power:** Often requires powerful GPUs/TPUs for training.
- **Applications:** Self-driving cars, voice assistants, medical diagnosis, recommendation systems, generative AI.

Deep Learning vs. Traditional Machine Learning

- **Deep Learning:** Learns features automatically from raw data, uses deep (many) layers, and excels with unstructured data.
- **Traditional ML:** Requires manual feature engineering, often uses simpler models, better for structured data.
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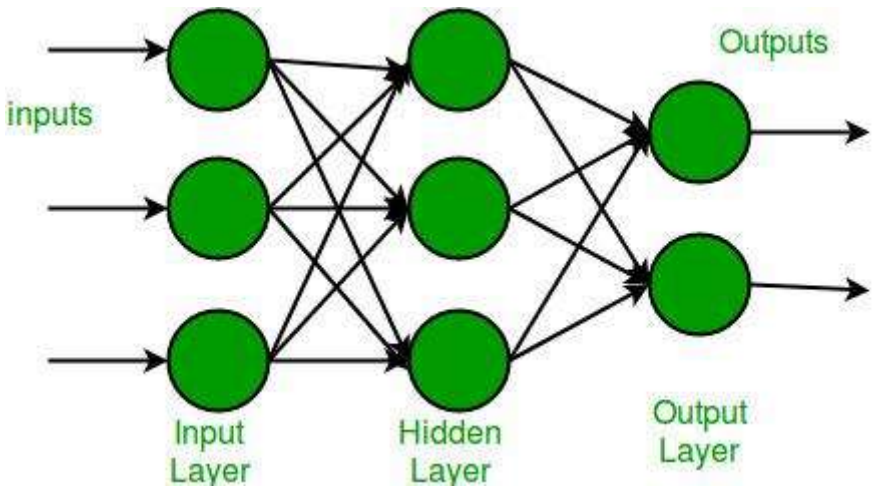

Types of Deep Learning Models

Let's see various types of Deep Learning Models:

1. Convolutional Neural Networks (CNNs)

Convolutional Neural Networks (CNNs) are a class of deep neural networks that are designed for processing grid-like data such as images. They use convolutional layers to automatically detect patterns like edges, textures and shapes in the data.

- Deep Learning Algorithms
- Convolutional Neural Networks (CNNs)
- Basics of Digital Image Processing
- Importance for CNN
- Padding
- Convolutional Layers
- Pooling Layers
- Fully Connected Layers
- Backpropagation in CNNs
- CNN based Image Classification using PyTorch
- CNN based Images Classification using TensorFlow

CNN Based Architectures: There are various architectures in CNNs that have been developed for specific kinds of problems such as:

- Convolutional Neural Network (CNN) Architectures
- LeNet-5
- AlexNet
- VGGnet
- VGG-16 Network
- GoogLeNet/Inception
- ResNet (Residual Network)
- MobileNet

2. Recurrent Neural Networks (RNNs)

Recurrent Neural Networks (RNNs) are a class of neural networks that are used for modeling sequence data such as time series or natural language.

- Recurrent Neural Networks (RNNs)
- How RNN Differs from Feedforward Neural Networks
- Backpropagation Through Time (BPTT)
- Vanishing Gradient and Exploding Gradient Problem
- Training of RNN in TensorFlow

- Sentiment Analysis with RNN
- Types of Recurrent Neural Networks: There are various types of RNN which are as follows:
- Types of Recurrent Neural Networks
- Bidirectional RNNs
- Long Short-Term Memory (LSTM)
- Bidirectional Long Short-Term Memory (Bi-LSTM)
- Gated Recurrent Units (GRU)

3. Generative Models in Deep Learning

- Generative models generate new data that resembles the training data. The key types of generative models include:
- Generative Adversarial Networks (GANs)
- Autoencoders
- GAN vs. Transformer Models

Types of Generative Adversarial Networks (GANs): GANs consist of two neural networks, the generator and the discriminator that compete with each other. Variants of GANs include:

- Deep Convolutional GAN (DCGAN)
- Conditional GAN (cGAN)
- Cycle-Consistent GAN (CycleGAN)
- Super-Resolution GAN (SRGAN)
- StyleGAN

Types of Autoencoders: Autoencoders are neural networks used for unsupervised learning that learns to compress and reconstruct data. Various types of Autoencoders include:

- Types of Autoencoders
- Sparse Autoencoder
- Denoising Autoencoder
- Convolutional Autoencoder
- Variational Autoencoder

4. Deep Reinforcement Learning (DRL)

Deep Reinforcement Learning combines the representation learning power of deep learning with the decision-making ability of reinforcement learning. It helps agents to learn optimal behaviors in complex environments through trial and error using high-dimensional sensory inputs.

- Deep Reinforcement Learning
- Reinforcement Learning
- Markov Decision Processes
- Key Algorithms in Deep Reinforcement Learning
- Deep Q-Networks (DQN)
- REINFORCE
- Actor-Critic Methods
- Proximal Policy Optimization (PPO)

Advantages and Disadvantages of Deep Learning

- **Advantages:**

High accuracy and automation in complex tasks.

Automatic feature extraction from data.

- **Disadvantages:**

Needs large datasets and computational power.

Complex architecture and training process.