Basics of Deep Learning

What is Deep Learning?

- Deep Learning (DL) is a **subset of Machine Learning (ML)** that uses **artificial neural networks (ANNs)** with multiple layers to learn from large amounts of data.
- It **automates feature extraction**, meaning it can learn patterns and insights without manual intervention.
- Deep Learning is inspired by how the human brain processes information.

> 💡 **Deep learning models can automatically extract features from data without the need for manual feature engineering.**

Key Characteristics of Deep Learning

- Uses **multiple layers (deep neural networks)** to process data
- Automatically extracts **features** from raw data
- Requires **large datasets** and high computing power
- Can handle **unstructured data** (images, text, audio, etc.)
- Uses techniques like **CNNs (for images), RNNs (for sequences), and Transformers (for NLP)**

Machine Learning vs Deep Learning

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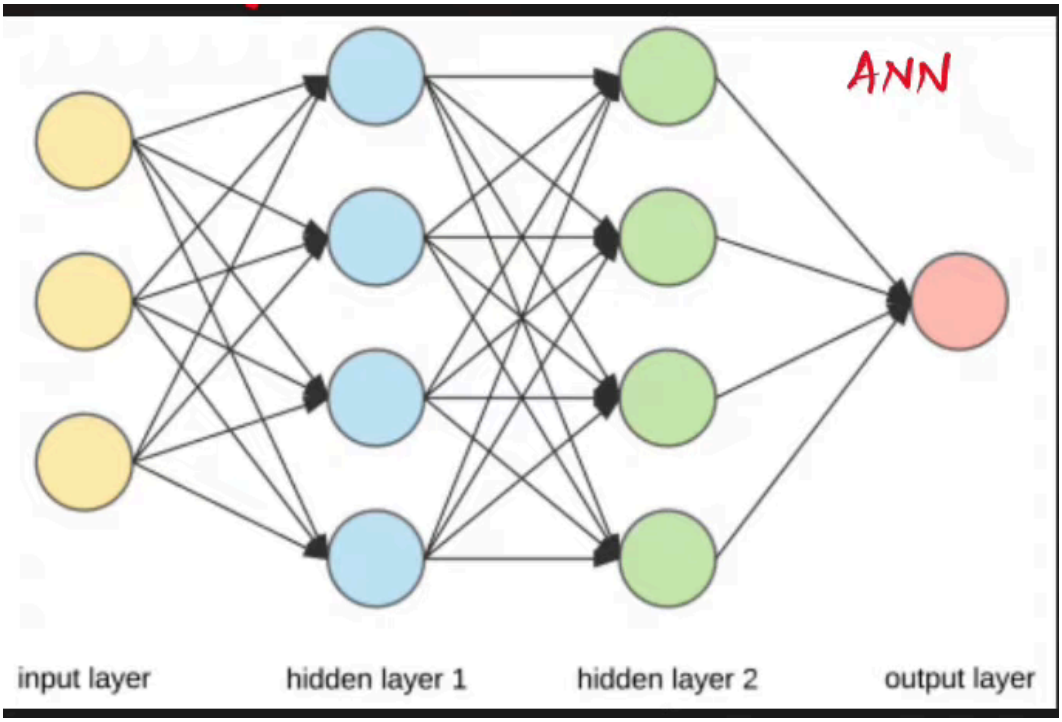
Feature	Deep Learning	Machine Learning
Definition	Algorithms that learn from data with the help of statistical techniques.	A subset of ML using deep neural networks

Approach	Learns features automatically from raw data	Requires manual feature engineering
Data Needs	Requires **large amounts of data**	Works well with smaller datasets
Hardware	Needs **GPUs/TPUs** for training	Can run on CPUs
Interpretability	Hard to interpret ("black box")	More interpretable (e.g., decision trees)
Performance	Excels in **complex tasks** (e.g., image recognition)	Better for **structured data & simpler tasks**
Examples	CNNs (for images), RNNs (for text/speech)	SVM, Random Forest, Linear Regression

Neural Network example:



- Fundamental unit → Perceptrons
- Arrows → Weights
- Perceptrons aligned in a line → Layers

- **Lower Layers** identify edges
- **Deeper layers i**dentify digits, letters or faces.

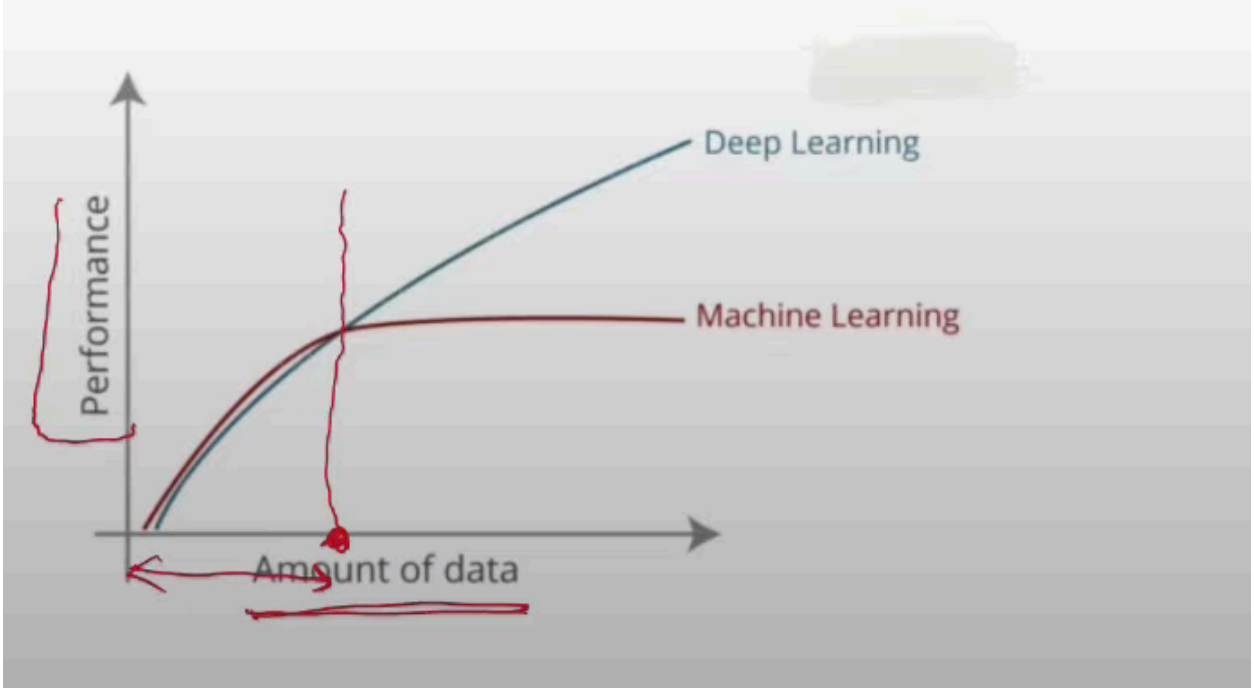
When to Use Deep Learning vs Machine Learning?

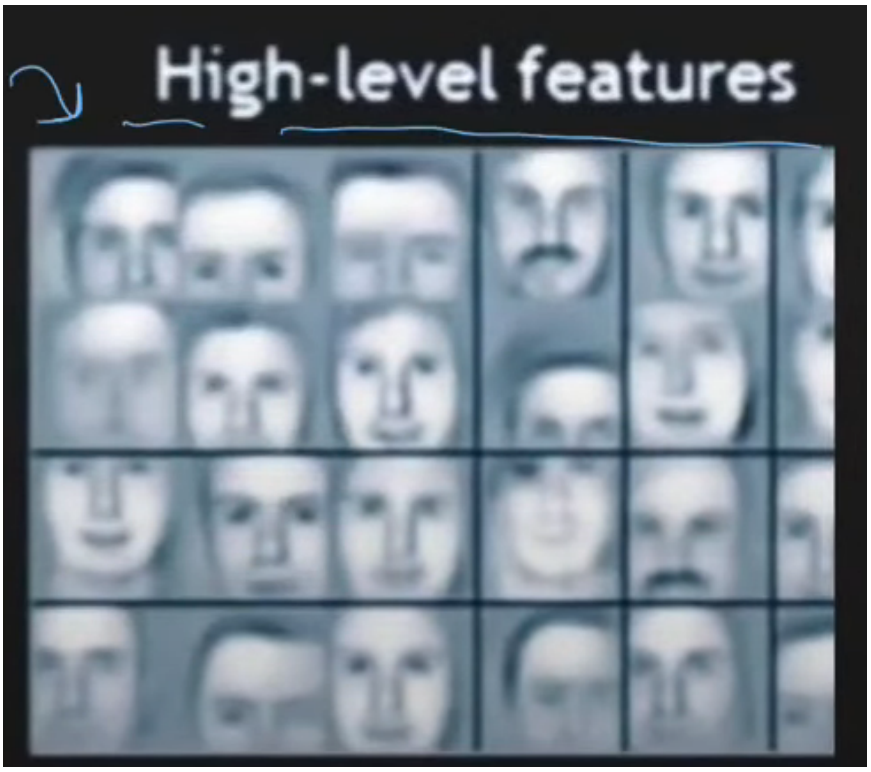
✅ Use Machine Learning if:

- You have **small or medium datasets**
- You need a **simple, interpretable model**
- The problem involves **structured data (tables, numerical values)**

✅ Use Deep Learning if:

- You have a **large dataset** (millions of images, text, or speech data)
- The problem involves **unstructured data** (e.g., image recognition, speech processing, NLP)
- You have access to **high computing power (GPUs/TPUs)**





Libraries

- Tensorflow by Google
  - Difficult yo use
- Pytorch by Facebook
- Keras - Front end library that talked to Tensorflow
  - Keras is build-in library in Tensorflow

Types of Neural Networks

Neural networks are the **brain** 🧠 **behind AI**, each designed for **specific tasks** like recognizing images 📸, understanding text 📖, or predicting trends 📈. Below is a **simple breakdown** of the most important types, with **emoji-powered clarity!**

Feedforward Neural Network (FNN)

✔️ **Structure:** Information moves **only forward** from input to output.

✔️ **Use Cases:** Basic classification and regression tasks.

✔️ **Example:** Predicting house prices, simple image recognition.

Diagram:

📥 **Input Layer** → 🟢 **Hidden Layer(s)** → 📤 **Output Layer**

Convolutional Neural Network (CNN) → 🖼️ Image Master

- **What?** Uses **filters (kernels)** to detect edges, shapes, and textures.
- **Best for? Images & videos** (e.g., face recognition 👩‍💻, self-driving cars 🚗).
- **Example:** ResNet, VGG, YOLO (for object detection), Google Photos, Face ID, Self-driving cars.

📷

Input (Image) → 🔲 Convolution + Pooling Layers → 🟢 Fully Connected Layers → 📤 Output (Class label)

Recurrent Neural Network (RNN) → ⏳ Memory Keeper

- **What?** Processes **sequences** (text, time-series) with **memory loops**.
- **Best for? Speech recognition** 🎙️**, stock prediction** 📊**, translation** 🌍.

- **Weakness?** Forgets long-term info → **LSTM/GRU fixes this!**

📝 Input (Text/Speech) → 🔁 Recurrent Layer (Memory) → 📩 Output (Prediction/Next word)

🔷 **Variants:**

- **LSTM (Long Short-Term Memory)**: Handles long-range dependencies better.
- **GRU (Gated Recurrent Unit)**: Similar to LSTM but simpler.

Long Short-Term Memory (LSTM) → 🧠 Smart Memory

- **What?** Advanced RNN with **3 gates** (input, forget, output).
- **Best for? Long sequences** (e.g., predicting next word in a sentence ✍️).

Gated Recurrent Unit (GRU) → ⚡ Faster LSTM

- **What?** Simpler than LSTM (only **2 gates**).
- **Best for?** Faster training on **text/speech tasks** 🗣️

Autoencoder → 🗜️ Data Compressor

- **What? Compresses & reconstructs** data (like a ZIP file 🗃️).
- **Best for? Denoising images** 🖼️, **fraud detection** 🕵️‍♂️.
- ✔️ **Key Feature:** Used for **feature extraction and anomaly detection**.

📩 Input Data → 🔽 Encoder (Compresses) → 🔼 Decoder (Reconstructs) → 📩 Output (Rebuilt Data)

Generative Adversarial Network (GAN) → 🎨 AI Artist

- **What? Two NNs fighting**:

    - **Generator** (creates fake data 🎭).
    - **Discriminator** (spots fakes 🔍).
- ✔️**Structure:** Two networks (Generator & Discriminator) compete with each other.
- ✔️**Key Feature:** Generates **realistic fake images, videos, and text**
- **Best for? Deepfakes, AI art 🖌️, game design 🎮.**

> 💡 **GAN can generate images, stories, etc. that never existed.**

Generator (Creates Fake Data) → 🔍 Discriminator (Detects Fake vs Real) → 🔁 Training Loop

Transformer → 🤖 NLP King

- **What?** Uses **self-attention** (no loops, processes data in parallel ⚡).
- **Best for? Chatbots 💬, translation 🌐, ChatGPT-like models**.
- **Example:** BERT, GPT-4.

Overview:

- **Working with images? → CNN 🖼️**
- **Dealing with text/time data? → LSTM/Transformer ⏳🤖**
- **Need AI to generate data? → GAN 🎨**
- **Want super-fast NLP? → Transformer 🤖**