MODELS , TYPES AND THEIR USE CASES

What is a Model?

A Model is a mathematical or computational representation of real-world data , used to make predictions, classifications and decisions.

They mostly:

* Learn from data
* Encode patterns that are hidden
* Generalize to unseen cases

Types of Models

1. ***Statistical Model :-***

A statistical model is a set of assumptions about the probability distribution that generated some observed data. It is used to identify relationships between variables & make predictions based on probability distribution.

This includes:

* **Linear Regression -** Linear regression is a type of supervised machine learning algorithm that learns from the labelled datasets and maps the data points with most optimized linear functions which can be used for prediction on new datasets.

It assumes that there is a linear relationship between the input and output, meaning the output changes at a constant rate as the input changes. This relationship is represented by a straight line.

For one factor it predicts the other factor.

Use case/example-

We want to predict a student's exam score based on how many hours they studied. We observe that as students study more hours, their scores go up. In the example of predicting exam scores based on hours studied. Here

* **Independent variable (input):** Hours studied because it's the factor we control or observe.
* **Dependent variable (output):**Exam score because it depends on how many hours were studied.

We use the independent variable to predict the dependent variable.

For simple linear regression (with one independent variable), the best-fit line is represented by the equation

*y=mx+b*

**Where:**

* **y** is the predicted value (dependent variable)
* **x** is the input (independent variable)
* **m** is the slope of the line (how much y changes when x changes)
* **b** is the intercept (the value of y when x = 0
* **Logistic Regression-** Logistic Regression is a supervised machine learning algorithm used for classification problems. Unlike linear regression which predicts continuous values it predicts the probability that an input belongs to a specific class. It is used for binary classification where the output can be one of two possible categories such as Yes/No, True/False or 0/1. It uses sigmoid function to convert inputs into a probability value between 0 and 1.

Use case/example-

A hospital uses logistic regression to predict whether a patient has **diabetes** based on features like:  
• Age  
• Blood sugar level  
• BMI  
• Family history  
  
The model outputs a **probability** (e.g., 0.87), and if it’s above 0.5, it predicts the patient **has diabetes**.

we use the [sigmoid function](https://www.geeksforgeeks.org/machine-learning/derivative-of-the-sigmoid-function/) where the input will be z and we find the probability between 0 and 1. i.e. predicted y.

*σ*(*z*)=1/1+*e*−*z*1​

1. ***Machine Learning Models –***

A **machine learning model** is a computational program designed to identify patterns or make predictions based on data. It is created by training a machine learning algorithm on a dataset, enabling it to learn and generalize from the data. These models are widely used across industries like healthcare, finance, and retail to automate tasks, improve decision-making, and provide insights.

These include:-

* **Decision trees :-** **Decision Trees (DTs)** are a non-parametric supervised learning method used for classification and regression.

The goal is to create a model that predicts the value of a target variable by learning simple decision rules inferred from the data features. A tree can be seen as a piecewise constant approximation.

It basically resembles a tree having root node, parent node and a child node. Upon answering the questions, we traverse the tree and get the desired output.

Decision trees learn from data to approximate a sine curve with a set of if-then-else decision rules. The deeper the tree, the more complex the decision rules and the fitter the model.

Use case/example-

Healthcare professionals use sophisticated decision trees to prioritize patient care:

**Chest Pain Assessment:**

* Is the patient experiencing severe chest pain? → Yes: Immediate cardiac evaluation
* Are vital signs stable? → No: Priority treatment required
* Is there shortness of breath? → Yes: Respiratory assessment needed
* Patient history of heart problems? → Yes: Cardiology consultation

These decision trees literally save lives by ensuring critical cases receive immediate attention.

**Exercise Planning:**

Many fitness enthusiasts unconsciously use decision trees to plan their workouts:

* Do I have more than 60 minutes? → Yes: Full gym workout with cardio
* Do I have 30-60 minutes? → Yes: Strength training or yoga session
* Do I have less than 30 minutes? → Yes: Quick HIIT workout or walk
* Am I feeling tired or sore? → Yes: Light stretching or rest day

This decision-making framework ensures consistent exercise habits while respecting your body’s needs and time constraints.

* **Random Forest-** Random Forest Regression is a machine learning technique used for predicting continuous numerical values. It is an ensemble learning method that combines the predictions of multiple decision trees to improve accuracy and reduce errors.

Each decision tree in the forest is trained on a random subset of the data and features, ensuring diversity among the trees.

In Random Forest Regression, the final prediction is obtained by averaging the predictions of all the individual trees. This averaging process helps to minimize overfitting and provides a more robust and reliable prediction.

Random forest is just a collection of decision trees who provide output based on the majority voting.

Use case/example-

**Credit Card Fraud Detection**  
  
A bank uses **Random Forest** to detect **fraudulent transactions** by analyzing:  
• Transaction amount  
• Location  
• Time of day  
• Customer behavior patterns  
  
Each tree in the forest gives a vote (fraud or not fraud), and the final decision is based on the **majority vote**. This helps catch **fraud** with high accuracy and low false alarms.

* **Support Vector Machine-** Support Vector Machine (SVM) is a supervised machine learning algorithm used for both classification and regression tasks. It is particularly effective for classification problems. The primary goal of SVM is to find the optimal hyperplane that separates data points of different classes in an N-dimensional space.

Use case/example-

Face Detection

It classifies the parts of the image as face and non-face. It contains training data of n x n pixels with a two-class face (+1) and non-face (-1). Then it extracts features from each pixel as face or non-face. Creates a square boundary around faces on the basis of pixel brightness and classifies each image by using the same process.

Handwriting Recognition

We can also use SVMs to recognize hand-written characters that use for data entry and validating signatures on documents.

1. ***Deep Learning Models-***

A deep learning model is a compilation of nodes that connect and layer in neural networks, much like the human brain. These networks pass information through each layer, sending and receiving data to identify patterns. Deep learning models use different types of neural networks to achieve specific solutions.

They apply deep learning algorithms to immense data sets to find patterns and solutions within the information. Typically, the models have three or more layers of neural networks to help process data. These models can process  unstructured or unlabeled data, creating their own methods for identifying and understanding the information without a person telling the computer what to look for or solve.

These include:

* **Convolutional Neural Networks (CNNs)**

Convolutional neural networks represent the gold standard for [computer vision](https://fonzi.ai/blog/what-is-opencv) and image processing tasks. These deep learning networks utilize convolutional layers that detect spatial patterns and hierarchies, from simple edges and textures to complex objects and scenes.

Use case/example-

In healthcare, CNNs assist radiologists by detecting cancer in medical imaging and analysing MRI scans with unprecedented accuracy. Self driving cars rely on these networks for object detection and lane recognition. Manufacturing companies deploy CNN-based systems for automated quality control and defect detection.

**Medical Image Analysis**  
  
A hospital uses a **CNN** to analyse **X-ray images** and detect **pneumonia**.  
• The CNN scans the image in layers, identifying patterns like lung opacity.  
• It learns to classify whether the image shows signs of pneumonia or not.  
• Output: “90% probability of pneumonia.”  
  
 CNNs are great for **image-related tasks**.

* **Recurrent Neural Networks (RNNs)**

Recurrent neural networks excel at processing sequential data through their unique ability to maintain memory of previous inputs. Unlike feedforward networks that process each input independently, RNNs incorporate feedback loops that allow information to persist, making them ideal for natural language processing and time-series analysis.

Use case/example-

These deep learning architectures power numerous applications in speech recognition, automatic speech recognition systems, and language modeling. Voice search functionality, real-time translation services, and predictive typing all rely on RNN variants to understand and generate human speech and natural language.

**Text Prediction / Autocomplete**  
  
Your smartphone keyboard uses an **RNN** to **predict the next word** while typing:  
• Input: *“I am feeling very”*  
• RNN processes the sequence word by word, remembering context.  
• Output: Suggests: *“happy”*, *“tired”*, etc.  
 RNNs have **memory**, so they’re good at handling **sequential data** like text or time series.

* **Transformer Models**

Transformer models have revolutionized natural language processing through their innovative self-attention mechanism, which processes input sequences in parallel rather than sequentially. This architectural breakthrough enables superior modeling of context and long-term dependencies while allowing massive parallelization during the training process.

The transformer architecture consists of encoder and decoder components that work together to understand and generate text. The self-attention mechanism allows each position in the input to attend to all other positions simultaneously, creating rich contextual representations that capture subtle linguistic relationships.

Use case/example-

BERT (Bidirectional Encoder Representations from Transformers) and the GPT family (Generative Pre-trained Transformers) represent landmark achievements in transformer based language model.

**For** **Language Translation (e.g., Google Translate)**  
  
A **Transformer model** takes a sentence in English:  
  
*“How are you?”*  
  
And translates it to French:  
  
*“Comment ça va ?”*  
  
• It understands the **context of the whole sentence**, not just word-by-word.  
• Uses **self-attention** to focus on important words during translation.  
  
Transformers are ideal for **NLP tasks** like translation, summarization, and chatbots.

1. ***Generative Models-***

A generative model is a type of machine learning model that aims to learn underlying patterns or distributions of data to generate new, similar data. This is used in unsupervised machine learning to describe phenomena in data, enabling computers to understand the real world.

They learn data patterns, internalize the structure, and then use that knowledge to generate original content. From AI-written poems to synthetic MRI scans, these models are reshaping creativity, productivity, and problem-solving.

These include:

* **Generative adversarial networks (GANs)**

GANs are used for changing images in various ways (from style to color or content) or synthetic data generation (for training other models).

GANs work based on two neural networks – the **generator** and the **discriminator**. The generator creates fake poor-quality images, while the discriminator distinguishes between real and fake images made by the generator.

Basically, the two networks play a game against each other: the generator tries to produce data that is indistinguishable from real data, while the discriminator tries to get better at telling the difference. This back-and-forth duel continues until the generator creates realistic data that the discriminator can't differentiate from real data.

Use case/example:-

**AI-generated Art / Deepfake Faces**  
  
A company uses a **GAN** to create **realistic human faces** that don’t actually exist.  
• The **Generator** creates fake images.  
• The **Discriminator** tries to detect if they’re fake.  
• Over time, the generator gets so good, the images look real.

* **Diffusion Models-**

Diffusion models generate data by reversing a process that gradually adds noise to it. They learn to remove noise from a random input step by step until a clean, coherent image or audio emerges. These models are highly detailed and controllable.

Use case/example-

**Text-to-Image Generation (e.g., DALL·E, Midjourney)**  
  
You type: “A cat playing guitar in space”  
  
A **diffusion model** starts with random noise and **gradually removes noise** to form a detailed image matching the prompt.  
  
 It creates **high-quality, creative images** from text.

* **Large Language Models (LLMs)-**

LLMs are massive transformer-based models trained on diverse text data to understand and generate human-like text. They predict the next word or phrase based on context. Trained on trillions of parameters, they are capable of reasoning, summarizing, and answering questions across domains.

Use case/example-

**AI Chatbots (like ChatGPT)**  
  
A company integrates an **LLM** into its customer service chatbot:  
• It can **understand** and **respond** to human language.  
• Handles questions like:  
*“How can I reset my password?”*  
• Replies naturally, without predefined scripts.  
  
Trained on massive amounts of text, LLMs understand **context**, **tone**, and **intent** across many topics.