BML CHAPTER 1

ML INTRODUCTION

1. Introduction to Machine Learning

Machine Learning (ML) is a branch of Artificial Intelligence (AI) that enables computers to learn and make predictions or decisions without being explicitly programmed. Instead of following hardcoded rules, ML models learn from **data patterns** and improve their performance over time.

Key Features of Machine Learning:

- **Automates Decision Making**: ML models can analyze vast amounts of data and make predictions (e.g., spam detection, fraud detection).
- **Learns from Experience**: The more data an ML model is exposed to, the better its predictions become.
- **Handles Complex Patterns**: ML can identify complex patterns that humans might miss, making it useful in fields like image recognition, speech processing, and recommendation systems.

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2. What is Machine Learning?

Definition

Machine Learning is the process where a system or algorithm **learns from past data**, **finds patterns**, and **makes intelligent decisions** without human intervention.

Types of Machine Learning

There are **three main types** of ML:

1. **Supervised Learning**
    - Involves training a model on a labeled dataset (input-output pairs).
    - The model learns the relationship between inputs (features) and outputs (labels).
    - **Example:** Predicting house prices based on size, location, and amenities.
    - **Common Algorithms:** Linear Regression, Decision Trees, Random Forests.
2. **Unsupervised Learning**
    - Works with **unlabeled data**, meaning the model finds patterns without

explicit instructions.

- Used for clustering and association tasks.
- **Example:** Customer segmentation (grouping customers based on purchasing behavior).
- **Common Algorithms:** K-Means Clustering, PCA (Principal Component Analysis).

3. **Reinforcement Learning**
   - The model learns by trial and error, receiving rewards for correct actions and penalties for incorrect ones.
   - **Example:** Self-driving cars learning to navigate traffic by taking actions (speeding up, slowing down).
   - **Common Algorithms:** Q-Learning, Deep Q Networks (DQN).

3.Introduction to Data in Machine Learning

Why is Data Crucial in ML?

Data is the foundation of machine learning. Without it, ML models cannot be trained, make predictions, or improve over time. The success of these models depends on the quantity, quality, and relevance of the data used during training.

Key Properties of Data:

- **Volume** – The amount of data available; more data usually improves models.
- **Variety** – Comes in multiple formats (text, images, audio, etc.).
- **Velocity** – The speed at which data is generated and processed.
- **Value** – The usefulness of data in generating insights.
- **Veracity** – The accuracy and reliability of data.
- **Viability** – How well data adapts to ML applications.
- **Security & Privacy** – Protecting sensitive data.
- **Accessibility & Usability** – Ensuring data is easy to retrieve and interpret.

Types of Data in ML

- **Structured Data** – Organized in tables (e.g., sales records, customer data).

- **Unstructured Data** – Lacks a fixed format (e.g., images, videos, social media posts).
- **Semi-Structured Data** – A mix of both (e.g., JSON, XML, emails).

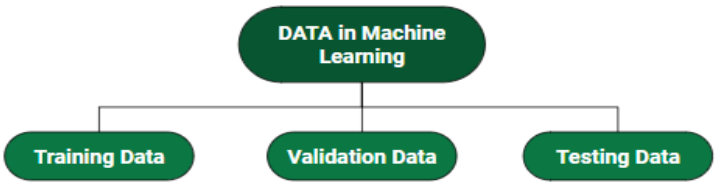
Other classifications:

- **Numerical Data** – Quantitative values (e.g., height, salary).
- **Categorical Data** – Labels or categories (e.g., gender, product types).
- **Ordinal Data** – Ordered categories (e.g., ratings: Poor, Good, Excellent).
- **Labeled Data** – Input-output pairs for supervised learning.
- **Unlabeled Data** – No predefined labels, used in unsupervised learning.

Data → Information → Knowledge

- **Data** – Raw, unprocessed facts (e.g., survey responses).
- **Information** – Organized data that provides meaning.
- **Knowledge** – Insights derived from analyzing information.

Data Splitting in ML



To train and evaluate models effectively, data is divided into:

- **Training Data (70-80%)** – Used for model learning.
- **Validation Data** – Helps fine-tune parameters and prevent overfitting.
- **Testing Data** – Evaluates final model performance.

Challenges & Benefits of Data in ML

Advantages:
✔ Improves accuracy and generalization.

✔ Enables automation and personalization.
✔ Reduces manual effort, boosting efficiency.

Challenges:
❌ Poor data quality can harm model performance.
❌ Bias in training data can lead to unfair outcomes.
❌ Privacy and security risks with sensitive data.
❌ Overfitting or underfitting due to improper data selection.

4.Applications of ML

Machine Learning (ML) has revolutionized various industries by enabling systems to learn from data and make decisions with minimal human intervention. Here are some notable applications:

1. Image Recognition: ML algorithms can identify and classify objects within images, facilitating applications like facial recognition and medical imaging analysis.

2. Speech Recognition: ML models convert spoken language into text, powering virtual assistants and transcription services.

3. Recommender Systems: By analysing user behaviour and preferences, ML algorithms suggest products, movies, or music tailored to individual tastes.

4. Fraud Detection: ML models detect anomalies in financial transactions, helping identify fraudulent activities in real-time.

5. Self-Driving Cars: ML enables autonomous vehicles to interpret sensor data, navigate environments, and make driving decisions.

6. Healthcare: ML assists in managing medical data, diagnosing diseases, and predicting health outcomes.

7. Natural Language Processing (NLP): ML models understand and generate human language, enhancing chatbots, translation services, and sentiment analysis.

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5. Best libraries for ML

1. NumPy

- A fundamental library for numerical computing. It provides multi-dimensional arrays and matrices, and efficient mathematical functions.
- **Use case**: Performing matrix operations in ML models.

2. Pandas

- A data manipulation library offering structures like DataFrame for handling structured data.
- **Use case**: Preprocessing and cleaning data for ML.

3. Matplotlib

- A library for creating static, animated, and interactive visualizations.
- **Use case**: Visualizing data distributions, model performance, etc.

4. SciPy

- Built on NumPy, it provides advanced mathematical functions for optimization, integration, and more.
- **Use case**: Solving optimization problems and advanced computations.

5. Scikit-learn

- A library for machine learning with tools for classification, regression, and clustering.
- **Use case**: Implementing classical ML algorithms like decision trees, SVMs, etc.

6. Theano

- A deep learning library that allows efficient computation of mathematical expressions.
- **Use case**: Training deep learning models (legacy use).

7. TensorFlow

- An open-source library for numerical computation and deep learning, developed by Google.
- **Use case**: Building deep learning models for tasks like image classification or NLP.

8. Keras

- A high-level API for building and training deep learning models, built on top of TensorFlow.
- **Use case**: Fast prototyping and deep learning experiments.

These libraries are essential for building, training, and evaluating ML models, helping in data preprocessing, model development, and visualization.

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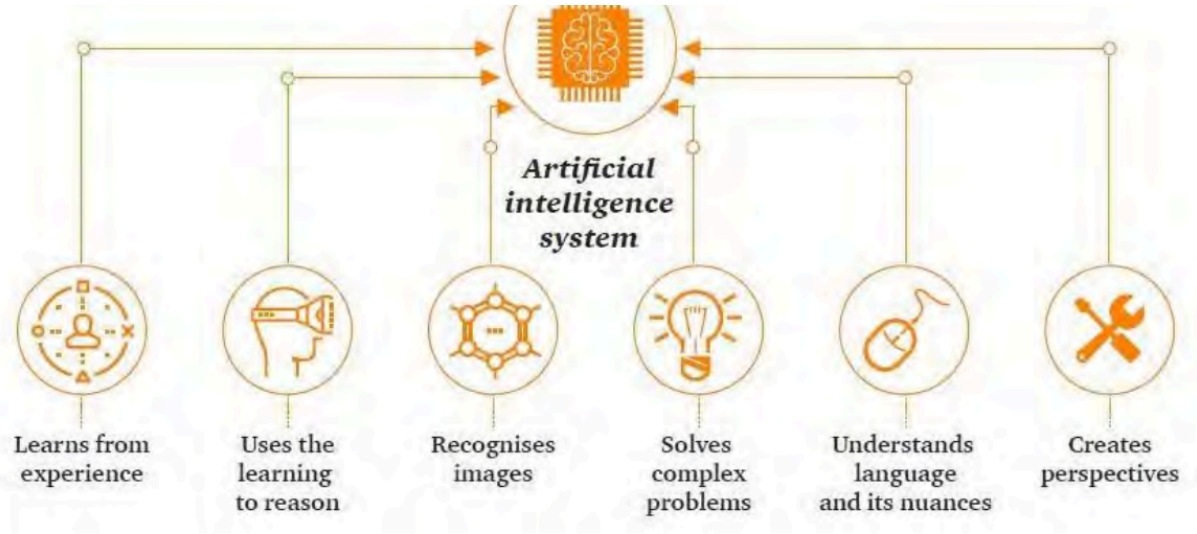
6. What is Artificial Intelligence

Artificial Intelligence (AI) is the field of computer science focused on creating machines and software that can perform tasks typically requiring human intelligence. These tasks include learning from experience, reasoning, problem-solving, understanding natural language, and perceiving the environment, enabling machines to mimic human cognitive functions.



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7. Agents in AI

In artificial intelligence (AI), an **agent** is a system that perceives its environment, processes this information, and takes actions to achieve specific goals. These agents can operate autonomously, making decisions and performing tasks without human intervention. The concept of agents is fundamental in AI, as it encapsulates the idea of intelligent behaviour in machines.

Types of AI Agents:

1. **Simple Reflex Agents:** These agents respond to current perceptions with predefined rules, without considering the history of past actions. They operate on a stimulus-response basis.
2. **Model-Based Reflex Agents:** These agents maintain an internal model of the world to handle partial observability. They use this model to make decisions based on both current and past perceptions.

3. **Goal-Based Agents:** These agents act to achieve specific goals. They evaluate different possible actions based on their goals and select the most appropriate one.
4. **Utility-Based Agents:** These agents aim to maximize their performance measure, known as utility. They consider the desirability of different states and choose actions that lead to the most preferred state.
5. **Learning Agents:** These agents have the capability to learn from their experiences. They improve their performance over time by adapting to new situations and information.

Applications of AI Agents:

AI agents are utilized in various domains, including:

- **Virtual Assistants:** Such as Siri and Alexa, which perform tasks like setting reminders and answering queries.
- **Autonomous Vehicles:** Self-driving cars that navigate and make driving decisions without human input.
- **Recommendation Systems:** Platforms like Netflix and Amazon that suggest products or content based on user preferences.
- **Robotics:** Machines that perform tasks ranging from industrial manufacturing to household chores.

  Example of an AI agent with diagram:-

- A thermostat can be considered an AI agent because it continuously monitors its environment (room temperature) through a sensor, interprets the data, and takes actions (turning heating or cooling on/off) to maintain a desired temperature, essentially acting autonomously to achieve a specific goal - a prime example of a simple, reactive AI agent.
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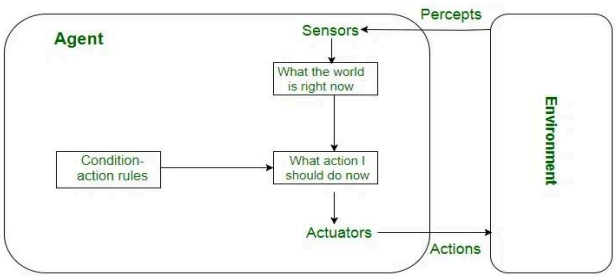

8. Difference between Artificial intelligence and Machine Learning

Aspect	Artificial Intelligence (AI)	Machine Learning (ML)
Definition	AI is the field of study focused on creating systems that perform tasks requiring human-like intelligence.	ML is a subset of AI that focuses on algorithms that allow systems to learn from data.
Scope	Broader, includes reasoning, perception, problem-solving, and language understanding.	Narrower, focuses specifically on learning patterns from data.
Approach	Can include rule-based systems, expert systems, and logic-based approaches.	Relies on statistical models and data-driven approaches.
Goal	To simulate human intelligence and decision-making.	To create models that improve their performance with experience (data).
Examples of Application	Robotics, Natural Language Processing, Expert Systems.	Predictive analytics, recommendation systems, image recognition.
Involvement of Data	Not necessarily dependent on large datasets for decision-making.	Heavily dependent on large datasets to train algorithms.
Technology	Includes rule-based systems, decision trees, etc.	Involves algorithms like regression, classification, clustering, etc.