Supervised vs. Unsupervised Learning

@ Supervised Learning

- Trained on a dataset **labeled** by humans.
- Goal is to learn **mapping function** from input variable to output variable
- Allow the model to make accurate predictions on new and unseen data.

- Common Use Cases:
  - **Classification:** Predicting a discrete, categorical label.
    - *Example:* Is an image a "dog" or "not a dog"?
    - *Algorithms:* Logistic Regression, Decision Trees, Support Vector Machines.
  - **Regression:** Predicting a continuous, numerical value.
    - *Example:* Forecasting future stock prices.
    - *Algorithms:* Linear Regression, Random Forest Regressor.

@ Unsupervised Learning

- Trained on data with **no explicit labels**
- Goal is to discover **underlying structure and feature** inherent in the data

- **Common Use Cases:**
  - **Clustering:** Grouping data points into clusters based on their similarities.
    - *Example:* Segmenting customers into different purchasing behavior groups.
    - *Algorithms:* K-Means Clustering, Hierarchical Clustering.

Summary Table

Feature	**Supervised Learning**	**Unsupervised Learning**
Data	Labeled	Unlabeled
Goal	Predict Outcomes	Discover Patterns
Examples	Classification, Regression	Clustering, Association
Output	Labels / Values	Groupings / Structure

Chain Question:

Are today's state-of-the-art AI models supervised or unsupervised?

- Modern SOTA models are rarely confined to a single learning paradigm.
- Unlike traditional ML models, these foundational models leverage a sophisticated blend of supervised, unsupervised, reinforcement learning, and self-supervised.
    - **reinforcement learning**: learning method that the model interacts with its environment, receiving rewards or penalties based on its action, and improves behavior over time to maximal total reward.
    - **self-supervised**: learning method that the model learn patterns and representation from unlabeled data by creating its "own learning signals"

- **1. Large Language Models (LLMs)**: *Example: GPT-4, Claude 3*
    - **Primarily Self-Supervised (Pre-training):**
        - Core Training phase involve prediction next token in a sentence from disabled text data
    - **Supervised Fine-Tuning:**
        - Next, the model fine tuned to a smaller curated dataset to align response with human preference for specific tasks such as maintaining a chat format.
    - **Reinforcement Learning with Human Feedback (RLHF):**
        - Next, reward based training process where human feedback is used to refine it's model output. make them more helpful, harmless and coherent.

- **2. Diffusion Models:** *Example: DALL-E 3, Sora*
    - **Core Unsupervised/Self-Supervised Training:**
        - These models learn to generate data by reversing its process and gradually adding noise to the image until it becomes unrecognizable. This process is inherently unsupervised.
    - **Guided by Supervised Data:**
        - For practical applications like text-to-image generation, the model is guided by text prompts or class labels, introducing a supervised element to control the output.

- **3. Self-Driving Cars:** *Example: Waymo, Tesla FSD*

  Strongly Multi-Modal: These systems are a complex integration of multiple learning approaches.

  - **Supervised Learning:**
    - Crucial for perception tasks like object detection (identifying pedestrians, vehicles) and lane following, which rely on extensively labeled image and sensor data.
  - **Unsupervised/Self-Supervised Learning:**
    - Used to learn robust features from vast quantities of raw video data without explicit labels.
  - **Imitation Learning:**
    - A semi-supervised approach where the model learns driving policies by observing and mimicking human drivers.

- **4. Humanoid Robots:** *Example: Figure AI, Tesla Optimus*

  Heavily Mixed Paradigm: Robotics requires a seamless fusion of different learning methods to interact with the physical world.

  - **Reinforcement Learning:**
    - Essential for learning complex motor skills like walking, balancing, and manipulating objects through trial and error.
  - **Imitation Learning:**
    - Enables the robot to learn new tasks by observing human demonstrations.
  - **Supervised Learning:**
    - Used for perception tasks, such as recognizing objects and humans in its environment.
  - **Self-Supervised Learning:**
    - Helps the robot understand object affordances (what can be done with an object) through interaction.

AI Model Learning Paradigm Summary

AI Model Type	Supervised	Unsupervised	Self-supervised	Reinforcement	Imitation
LLMs (GPT, Claude)	✅ (Fine-tuning)	❌	✅ (Pre-training)	✅ (RLHF)	❌
GANs	✅ (Conditional)	✅	❌	❌	❌
Diffusion Models	✅ (Text-guided)	✅	✅	❌	❌
Self-Driving Cars	✅	✅	✅	✅ (Limited)	✅
Humanoid Robots	✅	✅	✅	✅	✅

Conclusion: Modern AI is a Hybrid

The classic distinction between "supervised" and "unsupervised" is no longer sufficient to describe modern AI. Today's most powerful systems are characterized by:

- **Hybridization:** They are a sophisticated mixture of multiple learning techniques.
- **Data-Driven:** Their capabilities are driven more by the scale and variety of data they are trained on than by the specific type of labels.
- **Synergy:** This hybridization is the key to their power, allowing them to learn from raw data, human feedback, and real-world interaction simultaneously.