PH 3022
Machine Learning and Neural Computation

Introduction

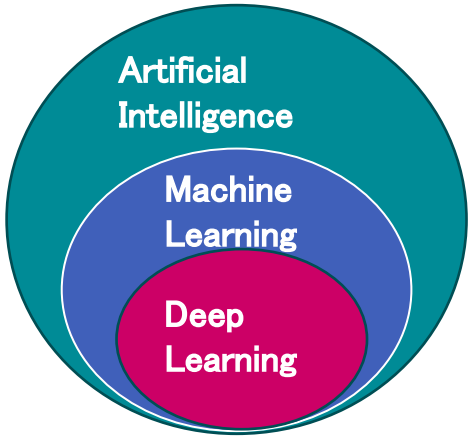
Department of Physics – University of Colombo

Artificial Intelligence Vs Machine Learning Vs Deep Learning

Artificial Intelligence (AI) refers to the broader field of computer science that aims to create machines or software that can perform tasks that typically require human intelligence, such as understanding natural language, recognizing patterns, making decisions, and solving problems.

Machine Learning (ML) is a subset of AI that focuses on the development of algorithms and models that enable computers to learn from and make predictions or decisions based on data without being explicitly programmed for each task.

Deep Learning is a subfield of ML that is particularly concerned with artificial neural networks, which are inspired by the structure and function of the human brain.



Artificial Intelligence

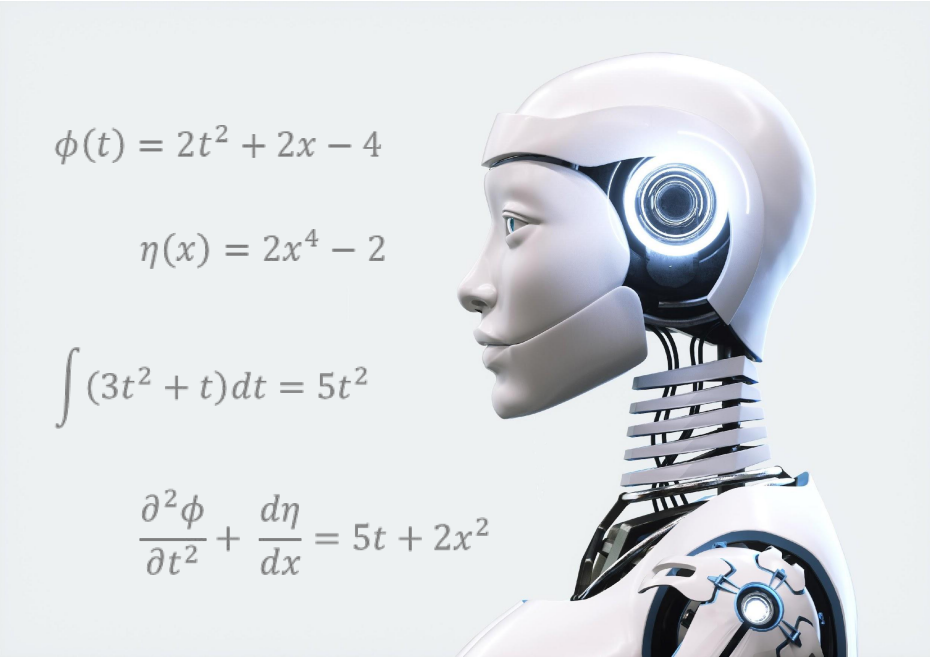


Image Reference: Microsoft Office

AI encompasses various techniques and approaches, including rule-based systems, expert systems, symbolic AI, and statistical methods, among others.

Machine Learning

Machine learning is categorized into three main paradigms: **supervised learning, unsupervised learning, and reinforcement learning** .

These paradigms differ in their problem-solving capabilities and how data is presented to the computer.

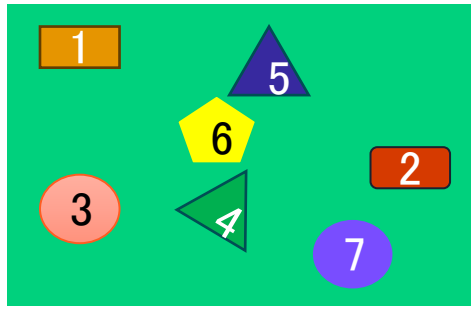
The choice of paradigm is often determined by the nature of the task and the characteristics of the available data.

Supervised learning is commonly the default choice, but there are situations where a decision needs to be made among the paradigms.

In some cases, a combination of these paradigms can be employed to achieve improved results.

This chapter provides an overview of the characteristics and potential applications of these learning paradigms.

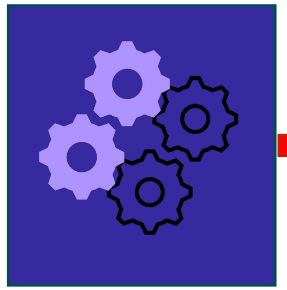
Supervised Learning



Training Data

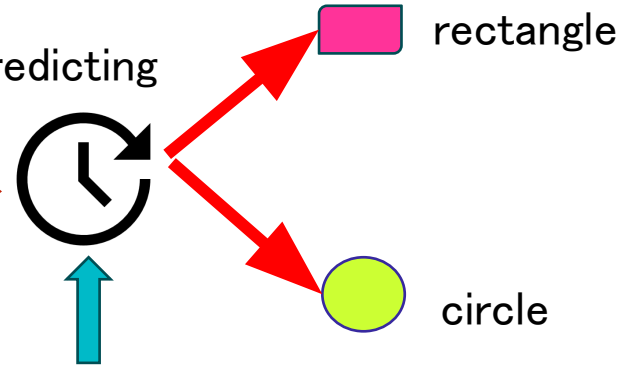
Index	Label
1	rectangle
2	rectangle
3	circle
4	triangle
5	triangle
6	pentagon
7	circle

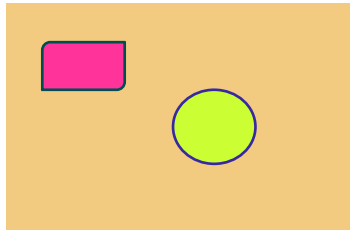
Labels



Model Training

Predicting





Test set

In supervised learning, the algorithm is trained on a labeled dataset, where the input data is paired with the corresponding output labels. The goal is for the algorithm to learn a mapping from inputs to outputs.

Training the Model

During the training phase, the machine learning model is exposed to a labeled dataset, which consists of input data along with corresponding output labels.

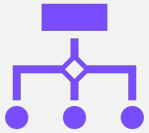
The model learns the underlying patterns and relationships within the data, adjusting its internal parameters through a process called optimization.

The objective is for the model to generalize well to new, unseen data.

The algorithm iteratively processes the training data, making predictions and comparing them to the actual labels.

The model's parameters are updated to minimize the difference between its predictions and the true labels, typically using optimization algorithms like gradient descent.

Predicting for Test Data

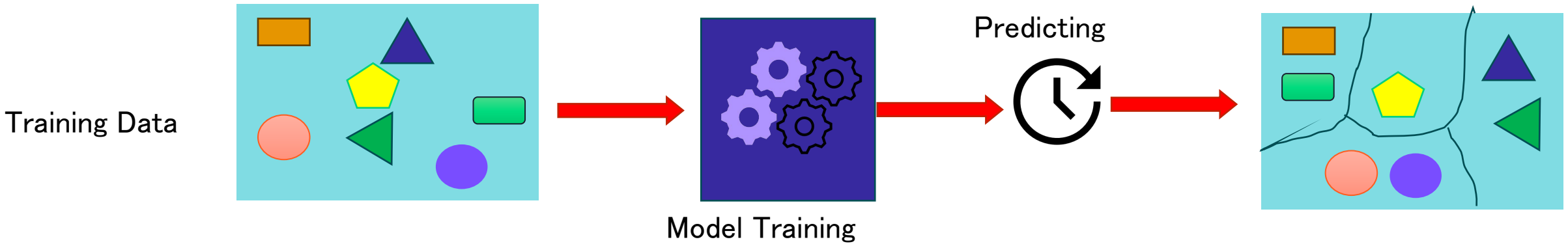


Once the model is trained, its performance is evaluated on a separate set of data called the test set.

This set is not used during the training phase and serves as a proxy for unseen, real-world data.

The model's ability to generalize is assessed by comparing its predictions on the test set to the true labels.

Unsupervised Learning

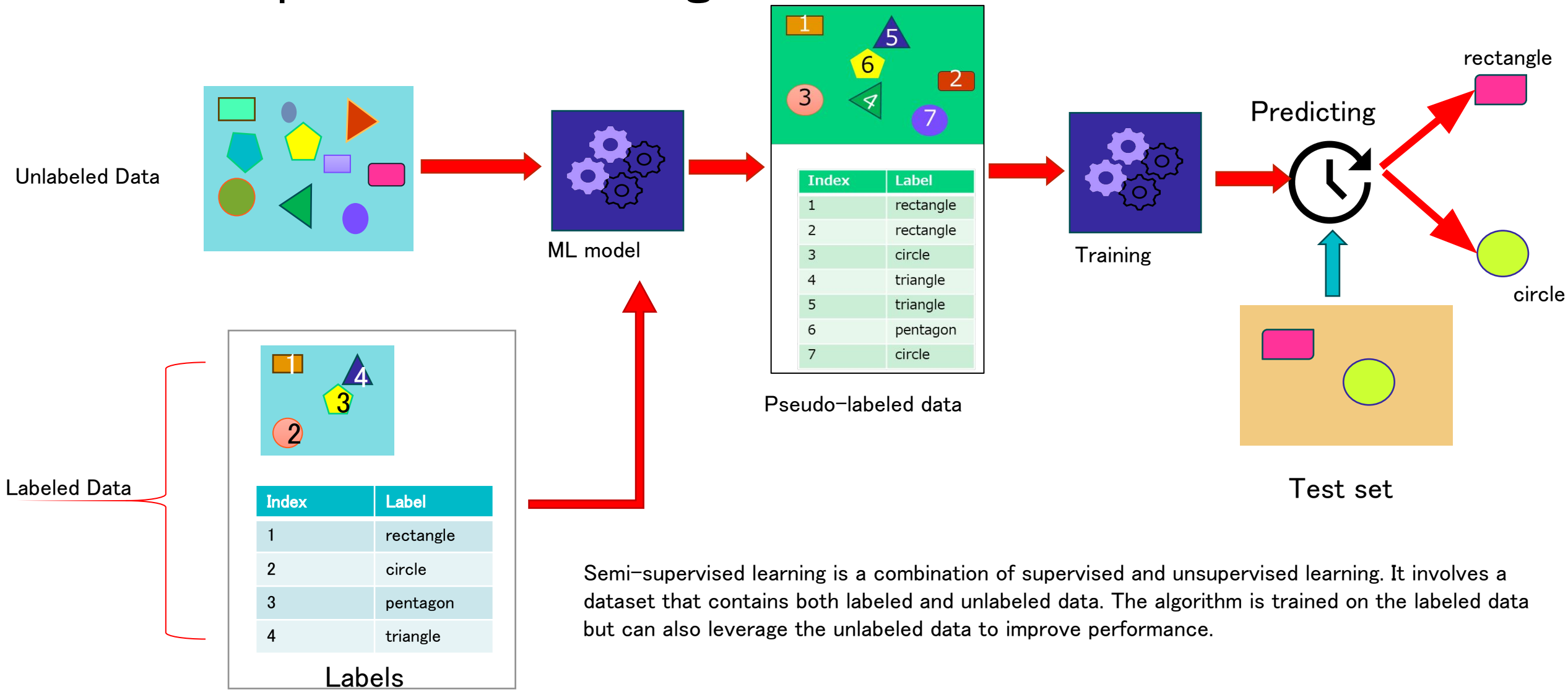


Unsupervised learning involves working with unlabeled data.

The algorithm explores the inherent structure of the data without explicit guidance, finding patterns, relationships, or groupings within the dataset.

Clustering is a common unsupervised learning task where the algorithm groups similar data points together.

Semi-Supervised Learning



Index	Label
1	rectangle
2	rectangle
3	circle
4	triangle
5	triangle
6	pentagon
7	circle

Index	Label
1	rectangle
2	circle
3	pentagon
4	triangle

Semi-supervised learning is a combination of supervised and unsupervised learning. It involves a dataset that contains both labeled and unlabeled data. The algorithm is trained on the labeled data but can also leverage the unlabeled data to improve performance.

Semi-Supervised Learning

The model is initially trained on the labeled portion of the dataset using traditional supervised learning techniques.

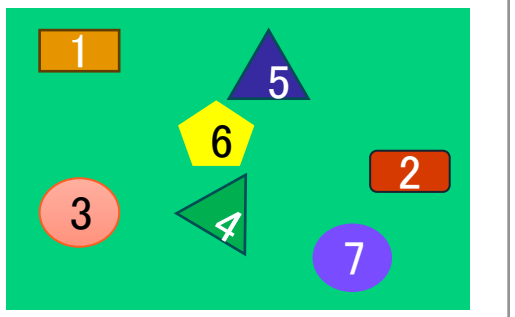
After the initial training, the trained model is used to make predictions on the unlabeled data. These predictions are treated as pseudo-labels for the unlabeled examples.

The pseudo-labeled examples are then combined with the original labeled data to create an augmented dataset. This augmented dataset, which now includes both the labeled and pseudo-labeled examples, is used for further training.

The model is fine-tuned on this augmented dataset, incorporating the information from the pseudo-labeled examples. The objective is to adjust the model's parameters to better fit both the labeled and pseudo-labeled data.

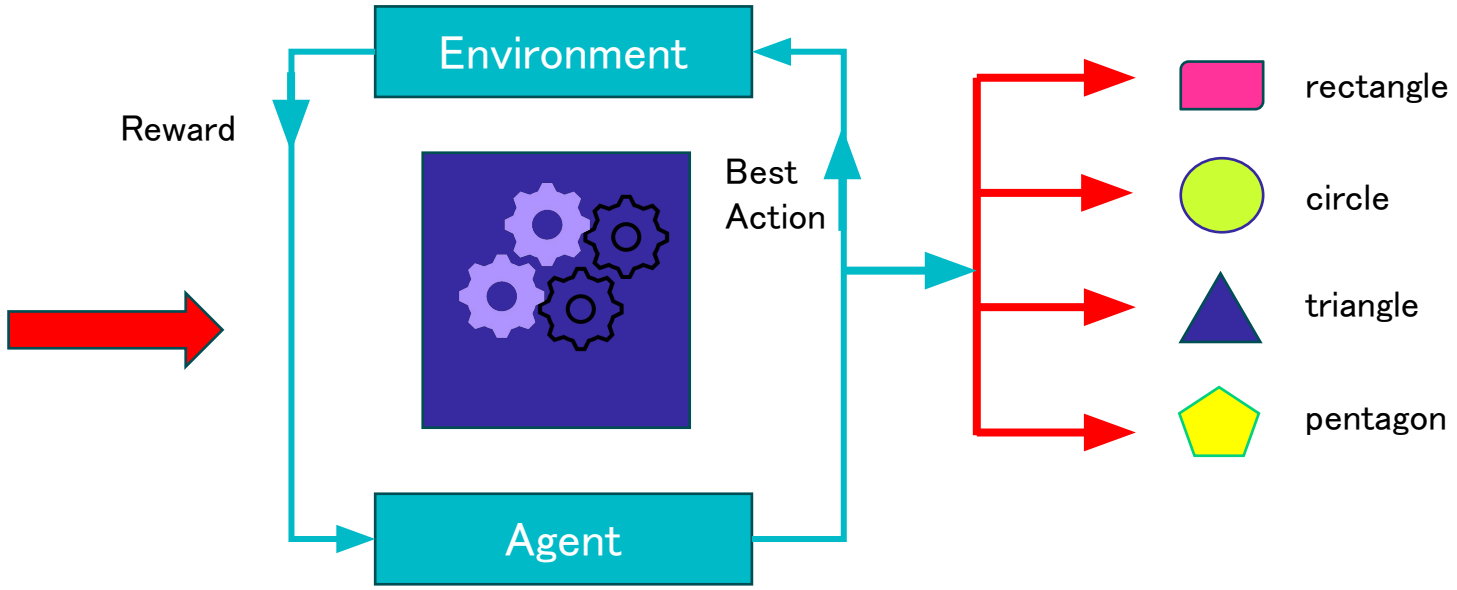
Steps 2-4 can be iterated for several rounds, with the model continually making predictions on unlabeled data, generating pseudo-labels, and incorporating them into the training process.

Reinforcement Learning



Index	Label
1	rectangle
2	rectangle
3	circle
4	triangle
5	triangle
6	pentagon
7	circle

Labels



Reinforcement learning involves an agent interacting with an environment and learning to make decisions by receiving feedback in the form of rewards or punishments.

The agent's goal is to maximize the cumulative reward over time.

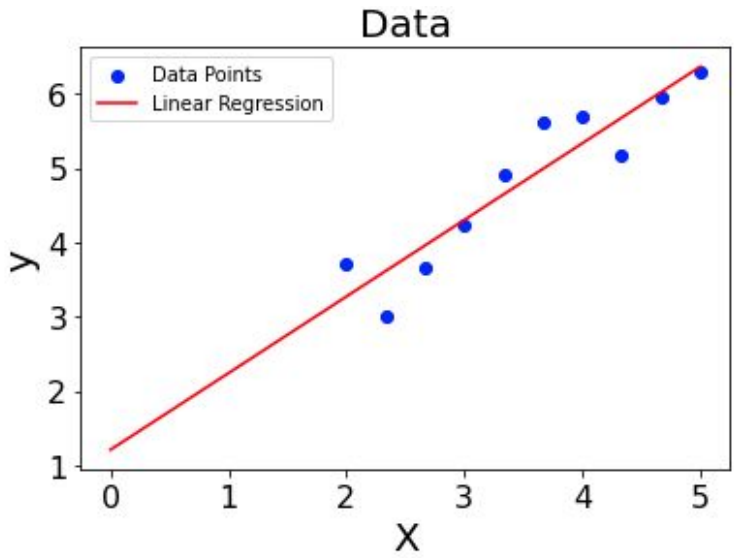
Games like chess is a classic example where reinforcement learning has been applied. The agent takes actions, observes the outcomes, and adjusts its strategy over time to maximize the game score.

Regression – Supervised Learning

In regression, the algorithm predicts a continuous output variable.

The goal is to model the relationship between the input features and the target variable, allowing the algorithm to make predictions within a range of possible values.

Example: Predicting house prices, stock prices, temperature, or any other continuous numeric value.

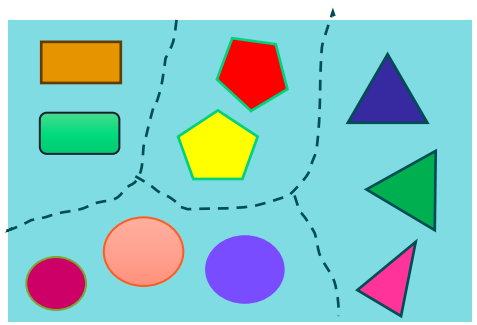


Classification – Supervised Learning

In classification, the algorithm assigns input data to a specific category or class.

The output variable is discrete and represents a predefined set of classes.

Example: Spam detection in emails (binary classification: spam or not spam), image recognition (multi-class classification: identifying objects in an image), or medical diagnosis (classifying patients into different disease categories).



Category/ Class
rectangle
circle
triangle
pentagon

Key Terminology

Features:

Features, also known as input variables or independent variables, are the attributes or characteristics of the data that are used as input for a machine learning model. They are the information the model uses to make predictions.

Labels:

Labels, also known as the target variable or dependent variable, represent the output or the variable the model is trying to predict. In supervised learning, the model learns to map input features to output labels.

Square footage	Number of Bedrooms	Distance to the city center	Crime Rate	Amenities	House price in dollars
1500	2	1.4	0.4	yes	300,000
1200	3	1.5	0.7	No	280,000
1000	4	0.6	0.2	Yes	250,000
800	1	0.5	0.2	Yes	246,000
600	2	1.6	0.1	Yes	200,000

Key Terminology

Training:

Training is the phase where a machine learning model learns from the labeled training data. The model adjusts its internal parameters to minimize the difference between its predictions and the actual labels in the training set.

Testing:

Testing, or evaluation, is the phase where the performance of a trained machine learning model is assessed on new, unseen data (the test set). This helps to gauge how well the model generalizes to data it hasn't seen during training.

Predictions:

Predictions are the model's output for new, unseen data based on the patterns it learned during the training phase. The model uses the input features to make predictions about the corresponding labels or outcomes.