Course: Advanced Algorithm and Problem Solving

WEEK 13 Machine Learning Algorithms

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WEEK 13 : Machine learning algorithms

Content

- An Overview of Machine Learning
- Types of Machine Learning Algorithms
- Overview of Neural Network

Lecture Learning Outcome

- Understand what machine learning is
- Understand types of Machine learning algorithms
- Understand why, how and where machine learning can be used
- Understand how different machine learning algorithms works
- Differentiate types of Machine Learning Algorithms
- Understand Applications of Machine learning algorithms

An Overview of Machine Learning

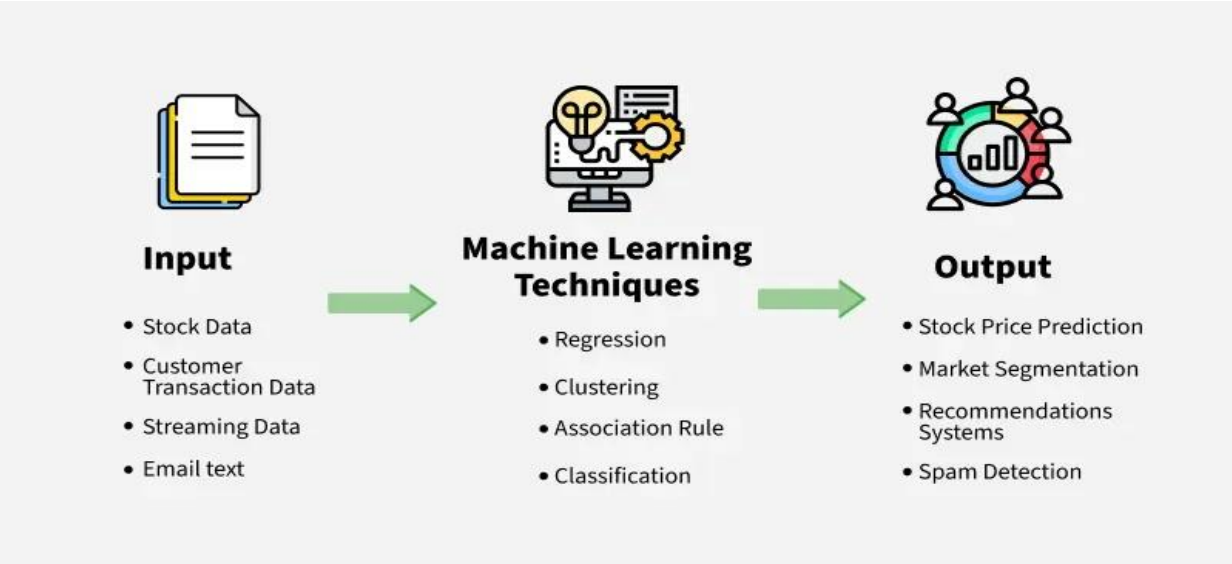
- Machine learning algorithms are essentially sets of instructions that allow computers to learn from data, make predictions, and improve their performance over time without being explicitly programmed.
- Machine learning algorithms are broadly categorized into three types:

  - **Supervised Learning**: Algorithms learn from labeled data, where the input-output relationship is known.
  - **Unsupervised Learning**: Algorithms work with unlabeled data to identify patterns or groupings.
  - **Reinforcement Learning:** Algorithms learn by interacting with an environment and receiving feedback in the form of rewards or penalties.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

An Overview of Machine Learning …cont'd

Need for Machine Learning



- Machine learning is important because it allows computers to learn from data and improve their performance on specific tasks without being explicitly programmed.
- The ability to learn from data and adapt to new situations makes machine learning particularly useful for tasks that involve large amounts of data, complex decision-making, and dynamic environments.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

An Overview of Machine Learning …cont'd

Areas where machine learning is being used

Predictive modeling:

- Machine learning can be used to build predictive models that can help businesses make better decisions.
- For example, machine learning can be used to predict which customers are most likely to buy a particular product, or which patients are most likely to develop a certain disease.

Natural language processing:

- Machine learning is used to build systems that can understand and interpret human language.
- This is important for applications such as voice recognition, chatbots, and language translation.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

An Overview of Machine Learning ....cont'd

Areas where machine learning is being used ...cont'd

Computer vision:

- Used to build systems that can recognize and interpret images and videos.
- This is important for applications such as self-driving cars, surveillance systems, and medical imaging.

Fraud detection:

- Detect fraudulent behavior in financial transactions, online advertising, and other areas.

Recommendation systems:.

- Machine learning can be used to build recommendation systems that suggest products, services, or content to users based on their past behavior and preferences.

An Overview of Machine Learning ....cont'd

How machine learning algorithms work?

- A machine learning algorithm works by learning patterns and relationships from data to make predictions or decisions without being explicitly programmed for each task.

1. Data Collection

- First, relevant data is collected or curated. This data could include examples, features, or attributes that are important for the task at hand, such as images, text, numerical data, etc.

2. Data Pre-processing

- Before feeding the data into the algorithm, it often needs to be pre-processed. This step may involve cleaning the data (handling missing values, outliers), transforming the data (normalization, scaling), and splitting it into training and test sets.

3. Choosing a Model

- Depending on the task (e.g., classification, regression, clustering), a suitable machine learning model is chosen.
- **Examples:-** include decision trees, neural networks, support vector machines, and more advanced models like deep learning architectures.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

Cont'd …..How machine learning algorithms work?

4. Training the Model

- The selected model is trained using the training data.
- During training, the algorithm learns patterns and relationships in the data.
- This involves adjusting model parameters iteratively to minimize the difference between predicted outputs and actual outputs (labels or targets) in the training data.

5. Evaluating the Model

- Once trained, the model is evaluated using the test data to assess its performance.
- Metrics such as accuracy, precision, recall, or mean squared error are used to evaluate how well the model generalizes to new, unseen data.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

An Overview of Machine Learning ....cont'd

Cont'd .....How machine learning algorithms work?

6. Fine-tuning

- Models may be fine-tuned by adjusting hyperparameters (parameters that are not directly learned during training, like learning rate or number of hidden layers in a neural network) to improve performance.

7. Prediction or Inference

- Finally, the trained model is used to make predictions or decisions on new data.
- This process involves applying the learned patterns to new inputs to generate outputs, such as class labels in classification tasks or numerical values in regression tasks.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

Types of Machine Learning Algorithms

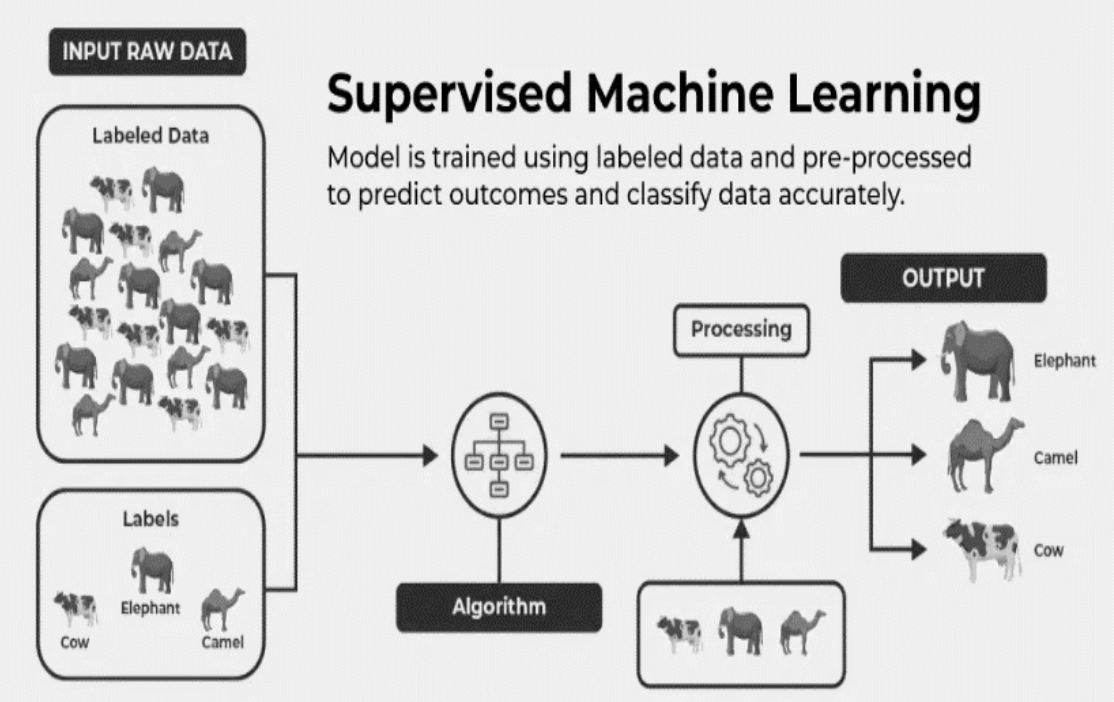
a) Supervised Learning Algorithms

- Supervised learning algorithms are trained on datasets where each example is paired with a target or response variable, known as the label.
- The goal is to learn a mapping function from input data to the corresponding output labels, enabling the model to make accurate predictions on unseen data.
- Supervised learning problems are generally categorized into two main types: Classification and Regression.

[2]. Supervised Machine Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/supervised-machine-learning/

Types of Machine Learning Algorithms ..cont'd

How Supervised Machine Learning Works?



Supervised learning algorithm consists of input features and corresponding output labels. The process works through:

- **Training Data:** The model is provided with a training dataset that includes input data (features) and corresponding output data (labels or target variables).
- **Learning Process:** The algorithm processes the training data, learning the relationships between the input features and the output labels.
- This is achieved by adjusting the model's parameters to minimize the difference between its predictions and the actual labels.

[2]. Supervised Machine Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/supervised-machine-learning/

Cont'd ….How Supervised Machine Learning Works?

To ensure the model generalizes well to new, unseen data

- After training, the model is evaluated using a test dataset to measure its accuracy and performance.
- Then the model's performance is optimized by adjusting parameters and using techniques like *cross-validation to balance bias* and variance.
- **Cross-validation** is a commonly used technique if we want to make sure our machine learning model is not just memorizing the training data but is capable of adapting to real-world data. The main purpose of cross validation is to prevent overfitting.

[3]. Cross Validation in Machine Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/cross-validation-machine-learning/

Types of Machine Learning Algorithms ..cont'd

Types of Cross-Validation

1. **Holdout Validation :** perform training on the 50% of the given dataset and rest 50% is used for the testing purpose
2. **K-Fold Cross Validation :**we split the dataset into k number of subsets known as folds then we perform training on the all the subsets but leave one (k-1) subset for the evaluation of the trained model

3. Stratified Cross-Validation: a technique used in machine learning to ensure that each fold of the cross-validation process maintains the same class distribution as the entire dataset. T

[3]. Cross Validation in Machine Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/cross-validation-machine-learning/

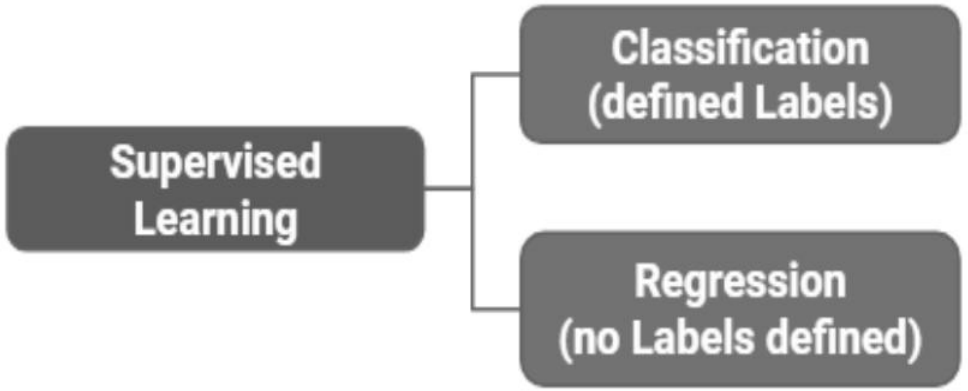
Types of Machine Learning Algorithms ..cont'd

Types of Supervised Learning in Machine Learning

- Supervised learning can be applied to two main types of problems:

  a) Classification: Where the output is a categorical variable (e.g., spam vs. non-spam emails, yes vs. no).

  b) Regression: Where the output is a continuous variable (e.g., predicting house prices, stock prices).



[2]. Supervised Machine Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/supervised-machine-learning/

Types of Machine Learning Algorithms ..cont'd

a) Classification

- Classification teaches a machine to sort things into categories. It learns by looking at examples with labels (like emails marked "spam" or "not spam").
- After learning, it can decide which category new items belong to, like identifying if a new email is spam or not.

Example:-

- A classification model might be trained on dataset of images labeled as either dogs or cats and it can be used to predict the class of new and unseen images as dogs or cats based on their features such as color, texture and shape.

Types of Machine Learning Algorithms ..cont'd

b) Regression

- Regression in machine learning refers to a supervised learning technique where the goal is to predict a continuous numerical value based on one or more independent features.
- It finds relationships between variables so that predictions can be made. we have two types of variables present in regression:
  - **Dependent Variable (Target):** The variable we are trying to predict e.g house price.
  - **Independent Variables (Features)**: The input variables that influence the prediction e.g locality, number of rooms.

[2]. Supervised Machine Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/supervised-machine-learning/

Types of Machine Learning Algorithms ..cont'd

……b) Regression

- This is different from classification tasks, where the goal is to pick the right category for new data.
- With regression, the algorithm needs to figure out the complex connections between different factors and the outcome we want to guess.
- These algorithms help in predicting continuous values based on the provided data.
  - Linear Regression
  - Decision Tree Regressor
  - K Nearest Neighbor Regressor
  - Random Forest Regressor
  - Neural Networks

Types of Machine Learning Algorithms ..cont'd

Common Algorithms in Supervised Learning

- **Decision trees** and **random forests** are powerful for classification and regression tasks and are capable of handling complex decision-making processes.
- **Support Vector Machines (SVM)** excel in classification problems, especially in high-dimensional spaces.
- **Linear Regression** is used for predicting continuous values, employing a linear approach to model the relationship between input features and the target variable.
- **K-Nearest Neighbors (KNN)** is a simple, yet effective method for both classification and regression, based on finding the closest data points in the training dataset.

Types of Machine Learning Algorithms ..cont'd

Unsupervised learning

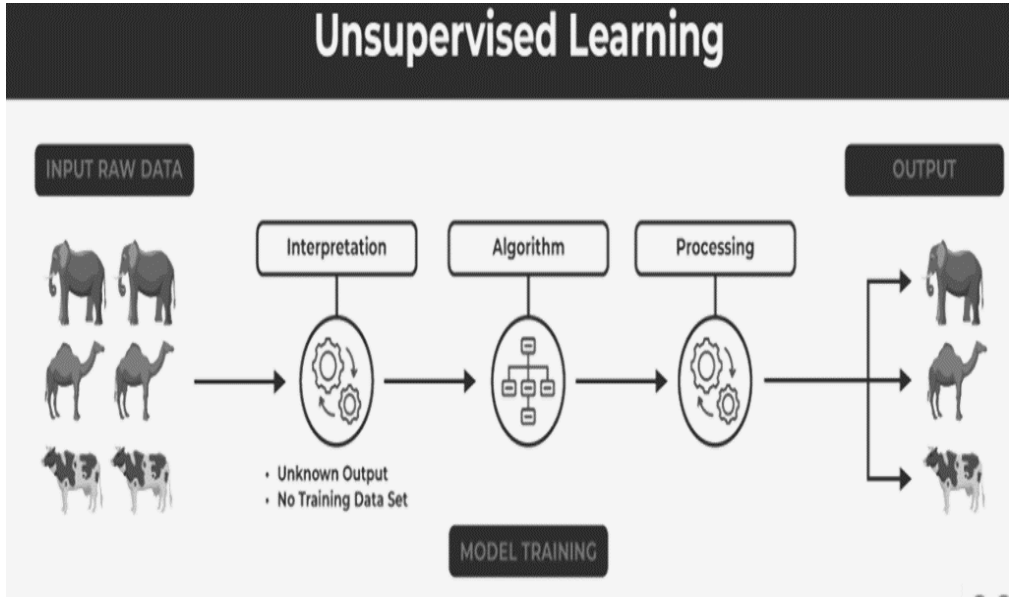
- Unlike supervised learning, where the data is labeled with a specific category or outcome, unsupervised learning algorithms are tasked with finding patterns and relationships within the data without any prior knowledge of the data's meaning.
- Unsupervised machine learning algorithms find hidden patterns and data without any human intervention, i.e., we don't give output to our model.
- The training model has only input parameter values and discovers the groups or patterns on its own.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

Types of Machine Learning Algorithms ..cont'd

Cont'd .....Unsupervised learning

- The image shows set of animals: elephants, camels, and cows that represents raw data that the unsupervised learning algorithm will process.
- **Interpretation** :- signifies that the algorithm doesn't have predefined labels or categories for the data. It needs to figure out how to group or organize the data based on inherent patterns.
- **Algorithm:-** the core of unsupervised learning process using techniques like clustering, dimensionality reduction, or anomaly detection to identify patterns and structures in the data.
- **Processing** stage shows the algorithm working on the data.
- The **output** shows grouped the animals into clusters based on their species (elephants, camels, cows).



[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

Types of Machine Learning Algorithms ..cont'd

Cont'd .....Unsupervised learning

The input to the unsupervised learning models

- **Unstructured data**: May contain noisy(meaningless) data, missing values, or unknown data
- **Unlabeled data**: Data only contains a value for input parameters, there is no targeted value(output).
- It is easy to collect as compared to the labeled one in the Supervised approach.

[1]. What is Machine Learning? GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/ml-machine-learning/

Types of Machine Learning Algorithms ..cont'd

Types of unsupervised learning

- Clustering
- Association Rule Learning
- Dimensionality Reduction

[4]. What is Unsupervised Learning?, GeeksforGeeks, GeeksforGeeks 2025. https://www.geeksforgeeks.org/unsupervised-learning/

Types of Machine Learning Algorithms ..cont'd

1. Clustering Algorithms

- Clustering in unsupervised machine learning is the process of grouping unlabeled data into clusters based on their similarities.
- The goal of clustering is to identify patterns and relationships in the data without any prior knowledge of the data's meaning.
- Broadly this technique is applied to group data based on different patterns, such as similarities or differences, our machine model finds.
- These algorithms are used to process raw, unclassified data objects into groups.

[4]. What is Unsupervised Learning?, GeeksforGeeks, GeeksforGeeks 2025. https://www.geeksforgeeks.org/unsupervised-learning/

Types of Machine Learning Algorithms ..cont'd

Some common clustering algorithms:

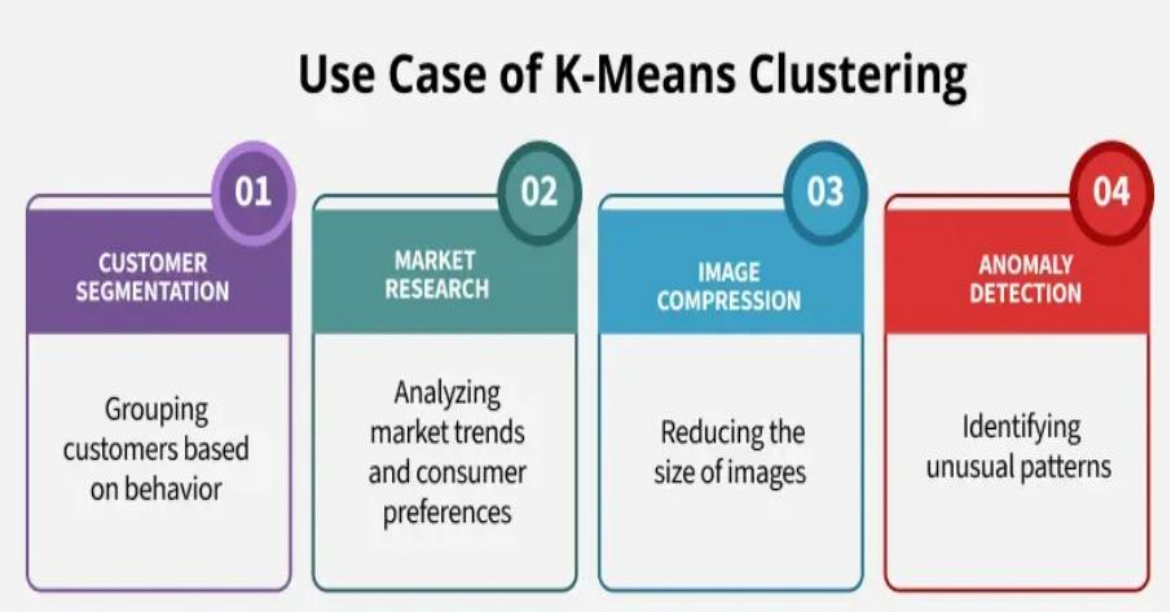
- **K-means Clustering:** Groups data into K clusters based on how close the points are to each other.
- **Hierarchical Clustering**: Creates clusters by building a tree step-by-step, either merging or splitting groups.
- **Density-Based Clustering (DBSCAN):** Finds clusters in dense areas and treats scattered points as noise.
- **Mean-Shift Clustering:** Discovers clusters by moving points toward the most crowded areas.
- **Spectral Clustering:** Groups data by analyzing connections between points using graphs.

[4]. What is Unsupervised Learning?, GeeksforGeeks, GeeksforGeeks 2025. https://www.geeksforgeeks.org/unsupervised-learning/

Types of Machine Learning Algorithms ..cont'd

K-Means Clustering

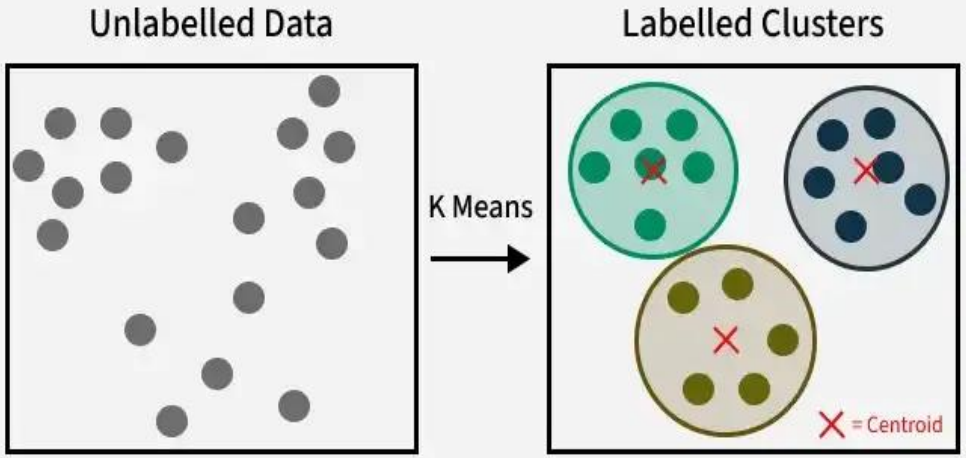
- K-Means Clustering is an Unsupervised Machine Learning algorithm which groups unlabeled dataset into different clusters.
- It is used to organize data into **groups based on their similarity**.



[4]. What is Unsupervised Learning?, GeeksforGeeks, GeeksforGeeks 2025. https://www.geeksforgeeks.org/unsupervised-learning/

Types of Machine Learning Algorithms ..cont'd

Cont'd ....K-Means Clustering



How k-means clustering works?

- We are given a data set of items with certain features and values for these features like a vector.
- The task is to categorize those items into groups.
- 'K' in the name of the algorithm represents the number of groups/clusters we want to classify our items into.

[4]. What is Unsupervised Learning?, GeeksforGeeks, GeeksforGeeks 2025. https://www.geeksforgeeks.org/unsupervised-learning/

Types of Machine Learning Algorithms ..cont'd

Applications of Unsupervised learning

- **Customer Segmentation:** Algorithms cluster customers based on purchasing behavior or demographics, enabling targeted marketing strategies.
- **Anomaly Detection:** Identifies unusual patterns in data, aiding fraud detection, cybersecurity, and equipment failure prevention.
- **Recommendation Systems**: Suggests products, movies, or music by analyzing user behavior and preferences.
- **Image and Text Clustering:** Groups similar images or documents for tasks like organization, classification, or content recommendation.
- **Social Network Analysis:** Detects communities or trends in user interactions on social media platforms.
- **Astronomy and Climate Science**: Classifies galaxies or groups weather patterns to support scientific research

[4]. What is Unsupervised Learning?, GeeksforGeeks, GeeksforGeeks 2025. https://www.geeksforgeeks.org/unsupervised-learning/

Types of Machine Learning Algorithms ..cont'd

Reinforcement Machine Learning

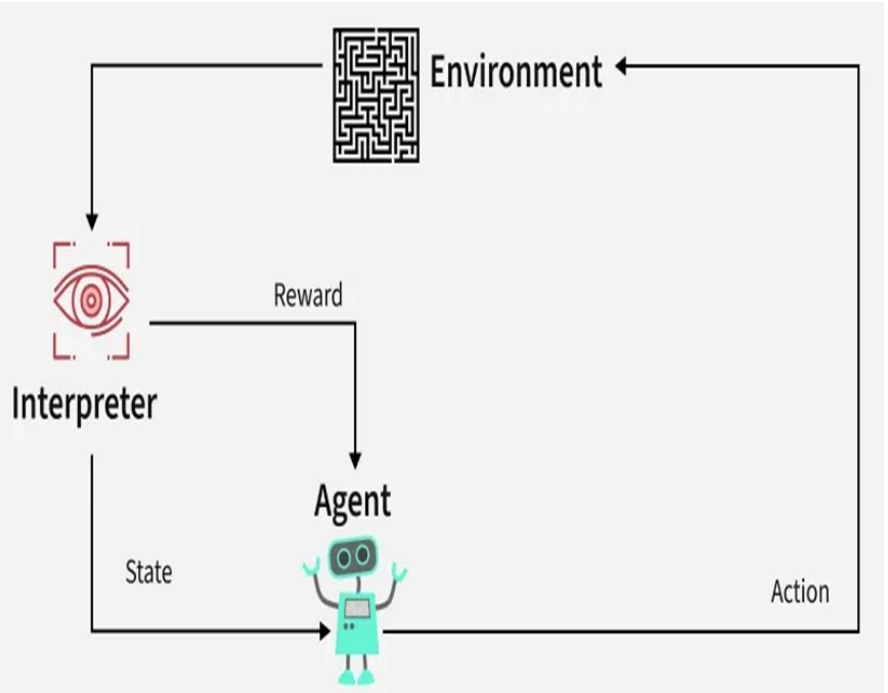
- Reinforcement Learning (RL) is a branch of machine learning that focuses on how agents can learn to make decisions through trial and error to maximize cumulative rewards.
- RL allows machines to learn by interacting with an environment and receiving feedback based on their actions. This feedback comes in the form of rewards or penalties.
- The goal of reinforcement learning is to learn a policy, which is a mapping from states to actions, that maximizes the expected cumulative reward over time.

[5]. Reinforcement Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/model-based-reinforcement-learning-mbrl-in-ai/

Types of Machine Learning Algorithms ..cont'd

Cont'd ...Reinforcement Machine Learning

- Reinforcement Learning revolves around the idea that an agent (the learner or decision-maker) interacts with an environment to achieve a goal.
- The agent performs actions and receives feedback to optimize its decision-making over time.
  - **Agent:** The decision-maker that performs actions.
  - **Environment:** The world or system in which the agent operates.
  - **State:** The situation or condition the agent is currently in.
  - **Action:** The possible moves or decisions the agent can make.
  - **Reward:** The feedback or result from the environment based on the agent's action.



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Types of Machine Learning Algorithms ..cont'd

Two main types of reinforcement learning:

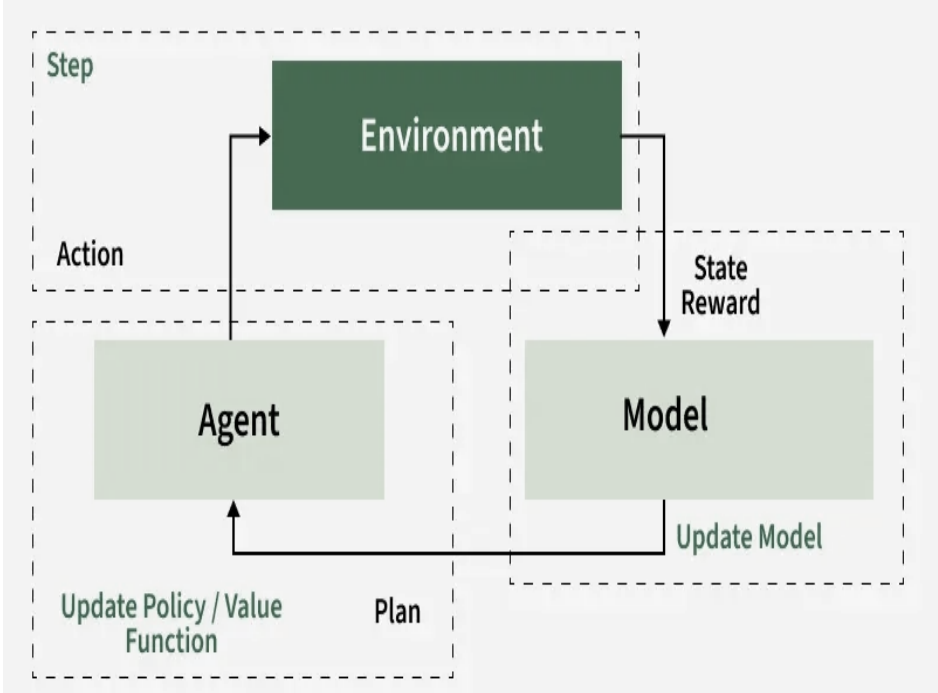
- **Model-based reinforcement learning:** The agent learns a model of the environment, including the transition probabilities between states and the rewards associated with each state-action pair. The agent then uses this model to plan its actions in order to maximize its expected reward.
- **Model-free reinforcement learning:** The agent learns a policy directly from experience without explicitly building a model of the environment. The agent interacts with the environment and updates its policy based on the rewards it receives.

[5]. Reinforcement Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/model-based-reinforcement-learning-mbrl-in-ai/

Types of Machine Learning Algorithms ..cont'd

How model-based reinforcement learning works?

- **Model Learning**: The agent collect experience by interacting with the environment and then use these experiences to learn a model to predict future states and rewards.
- **Model-Based Planning:** After learning how the environment works, the agent uses that model to plan future steps without interacting with the real world. Algorithms like Monte Carlo Tree Search (MCTS) or Dynamic Programming can be used to identify optimal actions.
- **Policy Optimization:** The agent use the results from planning to optimize its policy which is then deployed back into the real environment.
- **Continuous Learning**: The model is updated regularly as the agent gathers new experiences, improving the model's accuracy and the agent's performance over time.



[5]. Reinforcement Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/model-based-reinforcement-learning-mbrl-in-ai/

Types of Machine Learning Algorithms ..cont'd

Application of Reinforcement Learning

- **Robotics:** RL is used to automate tasks in structured environments such as manufacturing, where robots learn to optimize movements and improve efficiency.
- **Game Playing:** Advanced RL algorithms have been used to develop strategies for complex games like chess, Go, and video games, outperforming human players in many instances.
- **Industrial Control:** RL helps in real-time adjustments and optimization of industrial operations, such as refining processes in the oil and gas industry.
- **Personalized Training Systems:** RL enables the customization of instructional content based on an individual's learning patterns, improving engagement and effectiveness.

[5]. Reinforcement Learning, GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/model-based-reinforcement-learning-mbrl-in-ai/

Overview of Neural Network

- Neural networks are machine learning models that mimic the complex functions of the human brain.
- These models consist of interconnected nodes or neurons that process data, learn patterns, and enable tasks such as pattern recognition and decision-making.
- Neural networks are capable of learning and identifying patterns directly from data without pre-defined rules.
- These networks are built from several key components:
  - **Neurons:** The basic units that receive inputs, each neuron is governed by a threshold and an activation function.
  - **Connections:** Links between neurons that carry information, regulated by weights and biases.
  - **Weights and Biases**: These parameters determine the strength and influence of connections.
  - **Propagation Functions**: Mechanisms that help process and transfer data across layers of neurons.
  - **Learning Rule**: The method that adjusts weights and biases over time to improve accuracy.

Overview of Neural Network …cont'd

Importance of Neural Networks

- Neural networks are pivotal in identifying complex patterns, solving intricate challenges, and adapting to dynamic environments.
- Their ability to learn from vast amounts of data is transformative, impacting technologies like natural language processing, self-driving vehicles, and automated decision-making.
- Neural networks streamline processes, increase efficiency, and support decision-making across various industries.
- As a backbone of artificial intelligence, they continue to drive innovation, shaping the future of technology.

[6]. What is a Neural Network?,GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/neural-networks-a-beginners-guide/

Overview of Neural Network …cont'd

Learning in neural networks

It follows a structured, three-stage process:

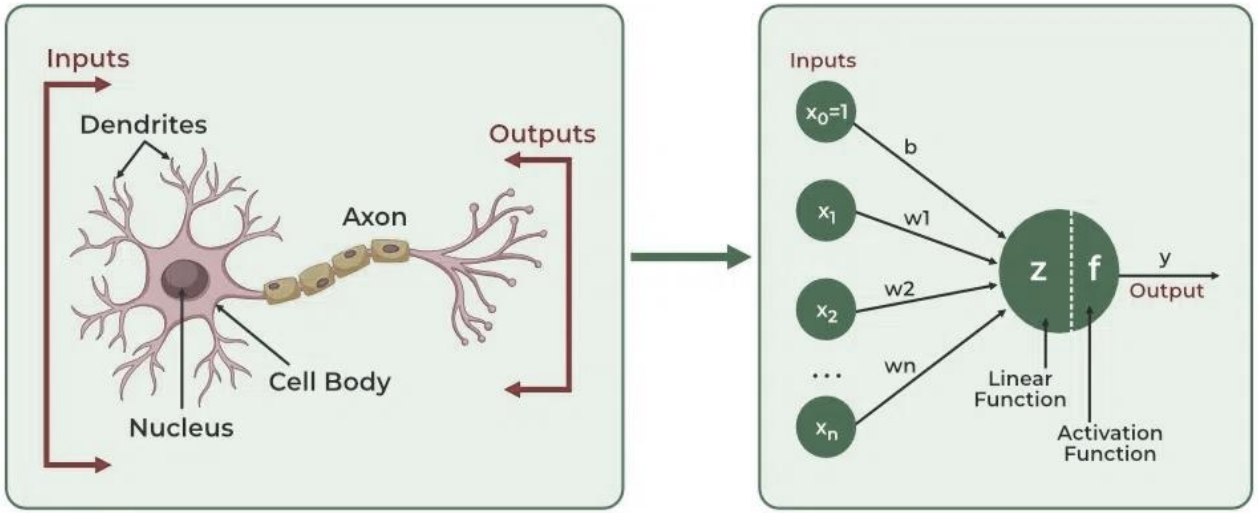
- Input Computation: Data is fed into the network.
- Output Generation: Based on the current parameters, the network generates an output.
- Iterative Refinement: The network refines its output by adjusting weights and biases, gradually improving its performance on diverse tasks.

[6]. What is a Neural Network?,GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/neural-networks-a-beginners-guide/

Learning in neural networks

In an adaptive learning environment:

- The neural network is exposed to a simulated scenario or dataset.
- Parameters such as weights and biases are updated in response to new data or conditions.
- With each adjustment, the network's response evolves, allowing it to adapt effectively to different tasks or environments.



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Learning of a Neural Network

1. Learning with Supervised Learning

- In supervised learning, a neural network learns from labeled input-output pairs provided by a teacher.
- The network generates outputs based on inputs, and by comparing these outputs to the known desired outputs, an error signal is created. The network iteratively adjusts its parameters to minimize errors until it reaches an acceptable performance level.

2. Learning with Unsupervised Learning

- Unsupervised learning involves data without labeled output variables.
- The primary goal is to understand the underlying structure of the input data (X).
- The focus is on modeling data patterns and relationships, with techniques like clustering and association commonly used.

Learning of a Neural Network

3. Learning with Reinforcement Learning

- Reinforcement learning enables a neural network to learn through interaction with its environment.
- The network receives feedback in the form of rewards or penalties, guiding it to find an optimal policy or strategy that maximizes cumulative rewards over time.

[6]. What is a Neural Network?,GeeksforGeeks, GeeksforGeeks, 2025. https://www.geeksforgeeks.org/neural-networks-a-beginners-guide/

Types of Neural Networks

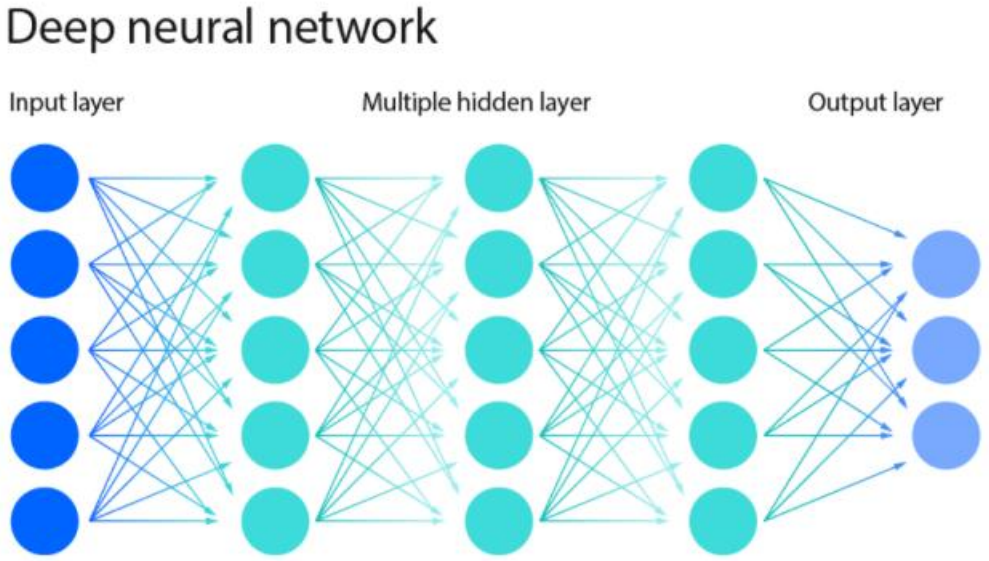
- **Feedforward Networks:** a simple artificial neural network architecture in which data moves from input to output in a single direction.
- **Single layer Perceptron**: - consists of only one layer of neurons . It takes inputs, applies weights, sums them up, and uses an activation function to produce an output.
- **Multilayer Perceptron (MLP):-** a type of feedforward neural network with three or more layers, including an input layer, one or more hidden layers, and an output layer. It uses nonlinear activation functions.
- **Convolutional Neural Network (CNN):** a specialized artificial neural network designed for image processing. It employs convolutional layers to automatically learn hierarchical features from input images, enabling effective image recognition and classification.

Types of Neural Networks

- **Recurrent Neural Network (RNN):** An artificial neural network type intended for sequential data processing is called a Recurrent Neural Network (RNN).
  - It is appropriate for applications where contextual dependencies are critical, such as time series prediction and natural language processing, since it makes use of feedback loops, which enable information to survive within the network.
- **Long Short-Term Memory (LSTM):** LSTM is a type of RNN that is designed to overcome the vanishing gradient problem in training RNNs.
  - It uses memory cells and gates to selectively read, write, and erase information

Neural networks vs. deep learning

- Deep Learning and neural networks tend to be used interchangeably in conversation, which can be confusing. As a result, it's worth noting that the "deep" in deep learning is just referring to the depth of layers in a neural network.
- A neural network that consists of more than three layers, which would be inclusive of the inputs and the output, can be considered a deep learning algorithm.
- A neural network that only has two or three layers is just a basic neural network.



[7]. AI vs. Machine Learning vs. Deep Learning vs. Neural Networks, IBM Data and AI Team, IBM, 2023. https://www.ibm.com/think/topics/ai-vs-machine-learning-vs-deep-learning-vs-neural-networks

Summary

- Machine learning algorithms are essentially sets of instructions that allow computers to learn from data, make predictions, and improve their performance over time without being explicitly programmed.
- Machine learning algorithms are broadly categorized into three, types: Supervised Learning, Unsupervised Learning, reinforcement Learning.
- Machine learning is important because it allows computers to learn from data and improve their performance on specific tasks without being explicitly programmed.
- Machine learning can be used Predictive modeling, Natural language processing, Computer vision, Freud detection, and Recommendation systems.
- A machine learning algorithm works by learning patterns and relationships from data to make predictions or decisions without being explicitly programmed for each task.
- Deep Learning and neural networks tend to be used interchangeably in conversation, which can be confusing. As a result, it's worth noting that the "deep" in deep learning is just referring to the depth of layers in a neural network.

References

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Thank You!

For your attention