MACHINE LEARNING:

Machine learning enables a machine to automatically learn from data, improve performance from experiences, and predict things without being explicitly programmed.

ACCORDING TO TOM MITCHELL:

A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.

Example: Imagine we have some sets of the pair of numbers. Then put only 1 number of the pair into a machine to predict the other half of the pair.(2,4),(3,6),(4,9) . The computer program has to predict the second number for (5,?)The program first needs to find the logic between the pairs and then apply the same logic to predict the number. To find that logic is called "machine learning". So that after finding the logic it can apply the same logic to predict each number.

DOMAINS AND APPLICATIONS:

1) **Image Recognition:**

2) **Speech Recognition**

3) **Traffic prediction:**

4) **Product recommendations**

5) **Self-driving cars**

6) **Email Spam and Malware Filtering**

7) **Virtual Personal Assistant**

8) **Online Fraud Detection**

9) **Stock Market trading**

10) **Medical Diagnosis**

11) **Automatic Language Translation**

TYPES OF MACHINE LEARNING

→Supervised machine learning algorithms can apply what has been learned in the past to new data using labeled examples to predict future events. Starting from the analysis of a known training dataset, the learning algorithm produces an inferred function to make predictions about the output values. The system is able to provide targets for any new input after sufficient training. The learning algorithm can also compare its output with the correct, intended output and find errors in order to modify the model accordingly.

→Unsupervised machine learning algorithms are used when the information used to train is neither classified nor labeled. Unsupervised learning studies how systems can infer a function to describe a hidden structure from unlabeled data. The system doesn't figure out the right output, but it explores the data and can draw inferences from datasets to describe hidden structures from unlabeled data.

→Semi-supervised machine learning algorithms fall somewhere in between supervised and unsupervised learning, since they use both labeled and unlabeled data for training – typically a small amount of labeled data and a large amount of unlabeled data. The systems that use this method are able to considerably improve learning accuracy. Usually, semi-supervised learning is chosen when the acquired labeled data requires skilled and relevant resources in order to train it / learn from it.

→Reinforcement machine learning algorithms is a learning method that interacts with its environment by producing actions and discovers errors or rewards. Trial and error search and delayed reward are the most relevant characteristics of reinforcement learning. This method allows machines and software agents to automatically determine the ideal behavior within a specific context in order to maximize its performance. Simple reward feedback is required for the agent to learn which action is best; this is known as the reinforcement signal.

MACHINE LEARNING LIFE CYCLE INVOLVES SEVEN MAJOR STEPS:

1. **Data Gathering: -**

Data Gathering is the first step of the machine learning life cycle. The goal of this step is to identify and obtain all data-related problems.

In this step, we need to identify the different data sources, as data can be collected from various sources such as files, database, internet, or mobile devices. It is one of the most important steps of the life cycle. The quantity and quality of the collected data will determine the efficiency of the output. The more will be the data, the more accurate will be the prediction.

2. **Data Preparation: -**After collecting the data, we need to prepare it for further steps. Data preparation is a step where we put our data into a suitable place and prepare it to use in our machine learning training**.** In this step, first, we put all data together, and then randomize the ordering of data.

3. **Data Wrangling: -**

Data wrangling is the process of cleaning and converting raw data into a useable format. It is the process of cleaning the data, selecting the variable to use, and transforming the data in a proper format to make it more suitable for analysis in the next step. It is one of the most important steps of the complete process. Cleaning of data is required to address the quality issues.

4. **Data Analysis: -**

Now the cleaned and prepared data is passed on to the analysis step. The aim of this step is to build a machine learning model to analyze the data using various analytical techniques and review the outcome. It starts with the determination of the type of the problems, where we select the machine learning techniques such as **Classification**, **Regression**, **Cluster analysis**, **Association**, etc. then buildthe model using prepared data, and evaluate the model.

5. **Training: -**

Now the next step is to train the model, in this step we train our model to improve its performance forbetter outcome of the problem.

We use datasets to train the model using various machine learning algorithms. Training a model isrequired so that it can understand the various patterns, rules, and, features.

6. **Testing: -**

Once our machine learning model has been trained on a given dataset, then we test the model. In thisstep, we check for the accuracy of our model by providing a test dataset to it.

Testing the model determines the percentage accuracy of the model as per the requirement of projector problem.

7. **Deployment: -**

The last step of machine learning life cycle is deployment, where we deploy the model in the real-world system.

If the above-prepared model is producing an accurate result as per our requirement with acceptable speed, then we deploy the model in the real system. But before deploying the project, we will check whether it is improving its performance using available data or not. The deployment phase is similar tomaking the final report for a project.

Supervised Learning

Supervised learning is the types of machine learning in which machines are trained using well "labelled" training data, and on basis of that data, machines predict the output. The labelled data means some input data is already tagged with the correct output.

In supervised learning, the training data provided to the machines work as the supervisor that teaches the machines to predict the output correctly. It applies the same concept as a student learns in the supervision of the teacher.

Supervised learning is a process of providing input data as well as correct output data to the

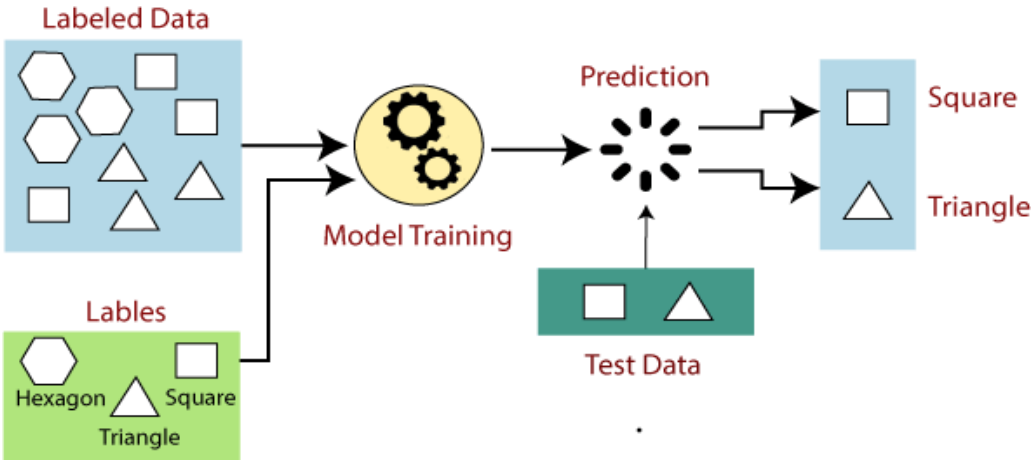
machine learning model. The aim of a supervised learning algorithm is to find a mapping function to map the input variable(x) with the output variable(y).

In the real-world, supervised learning can be used for Risk Assessment, Image classification, Fraud Detection, spam filtering, etc.

Working Methodology:

In supervised learning, models are trained using labelled dataset, where the model learns about each type of data. Once the training process is completed, the model is tested on the basis of test data (a subset of the training set), and then it predicts the output.

The working of Supervised learning can be easily understood by the below example and diagram:



Suppose we have a dataset of different types of shapes which includes square, rectangle, triangle, and Polygon. Now the first step is that we need to train the model for each shape.

- If the given shape has four sides, and all the sides are equal, then it will be labelled as a **Square**.
- If the given shape has three sides, then it will be labelled as a **triangle**.
- If the given shape has six equal sides then it will be labelled as **hexagon**.

Now, after training, we test our model using the test set, and the task of the model is to identify the shape.

The machine is already trained on all types of shapes, and when it finds a new shape, it classifies the shape on the bases of a number of sides, and predicts the output.

Steps Involved in Supervised Learning:

- First Determine the type of training dataset
- Collect/Gather the labelled training data.
- Split the training dataset into training **dataset, test dataset, and validation dataset**.
- Determine the input features of the training dataset, which should have enough knowledge so that the model can accurately predict the output.
- Determine the suitable algorithm for the model, such as support vector machine, decision tree, etc.
- Execute the algorithm on the training dataset. Sometimes we need validation sets as the control parameters, which are the subset of training datasets.
- Evaluate the accuracy of the model by providing the test set. If the model predicts the correct output, which means our model is accurate.

Types of supervised Machine Learning Algorithms:

Regression: -

Regression algorithms are used if there is a relationship between the input variable and the output variable. It is used for the prediction of continuous variables, such as Weather forecasting, Market Trends, etc. Below are some popular Regression algorithms which come under supervised learning:

- Linear Regression

- Regression Trees
- Non-Linear Regression
- Bayesian Linear Regression
- Polynomial Regression

Classification: -

Classification algorithms are used when the output variable is categorical, which means there are two classes such as Yes-No, Male-Female, True-false, etc.

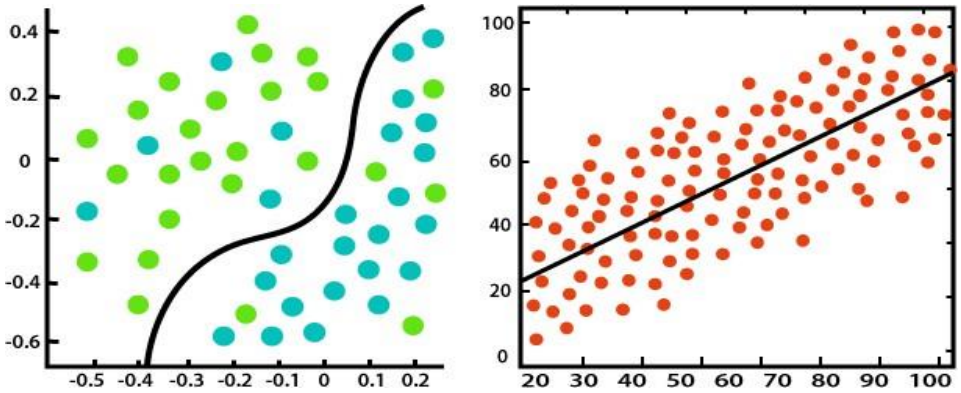
Spam Filtering,

- Random Forest
- Decision Trees
- Logistic Regression
- Support vector Machines

Classification and Regression: -

Regression and Classification algorithms are Supervised Learning algorithms. Both the algorithms are used for prediction in Machine learning and work with the labeled datasets. But the difference between both is how they are used for different machine learning problems.

The main difference between Regression and Classification algorithms that Regression algorithms are used to **predict the continuous** values such as price, salary, age, etc. and Classification algorithms are used to **predict/Classify the discrete values** such as Male or Female, True or False, Spam or Not Spam, etc.



Classification:

Classification is a process of finding a function which helps in dividing the dataset into classes based on different parameters. In Classification, a computer program is trained on the training dataset and based on that training, it categorizes the data into different classes.

The task of the classification algorithm is to find the mapping function to map the input(x) to the discrete output(y).

Example: The best example to understand the Classification problem is Email Spam Detection. The model is trained on the basis of millions of emails on different parameters, and whenever it receives a new email, it identifies whether the email is spam or not. If the email is spam, then it is moved to the Spam folder.

Regression:

Regression is a process of finding the correlations between dependent and independent variables. It helps in predicting the continuous variables such as prediction of Market Trends, prediction of House prices, etc.

The task of the Regression algorithm is to find the mapping function to map the input variable(x) to the continuous output variable(y).

Example: Suppose we want to do weather forecasting, so for this, we will use the Regression algorithm. In weather prediction, the model is trained on the past data, and once the training is completed, it can easily predict the weather for future days.

Difference between Regression and Classification

Regression Algorithm	Classification Algorithm
In Regression, the output variable must be of continuous nature or real value.	In Classification, the output variable must be a discrete value.
The task of the regression algorithm is to map the input value (x) with the continuous output variable(y).	The task of the classification algorithm is to map the input value(x) with the discrete output variable(y).
In Regression, we try to find the best fit line, which can predict the output more accurately.	In Classification, we try to find the decision boundary, which can divide the dataset into different classes.

Regression algorithms can be used to solve the regression problems such as Weather Prediction, House price prediction, etc.	Classification Algorithms can be used to solve classification problems such as Identification of spam emails, Speech Recognition, Identification of cancer cells, etc.
The regression Algorithm can be further divided into Linear and Non-linear Regression.	The Classification algorithms can be divided into Binary Classifier and Multi-class Classifier.

Unsupervised Learning: -

In supervised machine learning in which models are trained using labeled data under the supervision of training data. But there may be many cases in which we do not have labeled data and need to find the hidden patterns from the given dataset. So, to solve such types of cases in machine learning, we need unsupervised learning techniques.

Definition:

As the name suggests, unsupervised learning is a machine learning technique in which models are not supervised using training dataset. Instead, models itself find the hidden patterns and insights from the given data. It can be compared to learning which takes place in the human brain while learning new things. It can be defined as: ***Unsupervised learning is a type of machine learning in which models are trained using unlabeled dataset and are allowed to act on that data without any supervision.***

Unsupervised learning cannot be directly applied to a regression or classification problem because unlike supervised learning, we have the input data but no corresponding output data. The goal of unsupervised learning is to **find the underlying structure of dataset, group that data according to similarities, and represent that dataset in a compressed format**.

Example: Suppose the unsupervised learning algorithm is given an input dataset containing images of different types of cats and dogs. The algorithm is never trained upon the given dataset, which means it does not have any idea about the features of the dataset. The task of the unsupervised learning algorithm is to identify the image features on their own. Unsupervised learning algorithm will perform this task by clustering the image dataset into the groups according to similarities between images.

Features of Unsupervised Learning:

Below are some main reasons which describe the importance of Unsupervised Learning:

- Unsupervised learning is helpful for finding useful insights from the data.
- Unsupervised learning is much similar as a human learns to think by their own experiences, which makes it closer to the real AI.
- Unsupervised learning works on unlabeled and uncategorized data which make unsupervised learning more important.
- In real-world, we do not always have input data with the corresponding output so to solve such cases, we need unsupervised learning.

Types:

- **Clustering**: Clustering is a method of grouping the objects into clusters such that objects with most similarities remains into a group and has less or no similarities with the objects of another group. Cluster analysis finds the commonalities between the data objects and categorizes them as per the presence and absence of those commonalities.
- **Association**: An association rule is an unsupervised learning method which is used for finding the relationships between variables in the large database. It determines the set of items that occurs together in the dataset. Association rule makes marketing strategy more effective. Such as people who buy X item (suppose a bread) are also tend to purchase Y (Butter/Jam) item. A typical example of Association rule is Market Basket Analysis.

Unsupervised Learning algorithms:

Below is the list of some popular unsupervised learning algorithms:

- **K-means clustering**
- **KNN (k-nearest neighbors)**
- **Hierarchal clustering**
- **Anomaly detection**
- **Neural Networks**
- **Principle Component Analysis**
- **Independent Component Analysis**
- **Apriori algorithm**
- **Singular value decomposition**

Advantages of Unsupervised Learning

- Unsupervised learning is used for more complex tasks as compared to supervised learning because, in unsupervised learning, we don't have labeled input data.
- Unsupervised learning is preferable as it is easy to get unlabeled data in comparison to labeled data.

Disadvantages of Unsupervised Learning

- Unsupervised learning is intrinsically more difficult than supervised learning as it does not have corresponding output.
- The result of the unsupervised learning algorithm might be less accurate as input data is not labeled, and algorithms do not know the exact output in advance.

Differences between Supervised and Unsupervised Learning:

Supervised Learning	Unsupervised Learning
Supervised learning algorithms are trained using labeled data.	Unsupervised learning algorithms are trained using unlabeled data.
Supervised learning model takes direct feedback to check if it is predicting correct output or not.	Unsupervised learning model does not take any feedback.
In supervised learning, input data is provided to the model along with the output.	In unsupervised learning, only input data is provided to the model.
The goal of supervised learning is to train the model so that it can predict the output when it is given new data.	The goal of unsupervised learning is to find the hidden patterns and useful insights from the unknown dataset.
Supervised learning needs supervision to train the model.	Unsupervised learning does not need any supervision to train the model.
Supervised learning can be categorized in **Classification** and **Regression** problems.	Unsupervised Learning can be classified in **Clustering** and **Associations** problems.
Supervised learning can be used for those cases where we know the input as well as corresponding outputs.	Unsupervised learning can be used for those cases where we have only input data and no corresponding output data.
It includes various algorithms such as Linear Regression, Logistic Regression, Support Vector Machine, Multi-class Classification, Decision tree, Bayesian Logic, etc.	It includes various algorithms such as Clustering, KNN, and Apriori algorithm.

CLASSIFICATION AND REGRESSION

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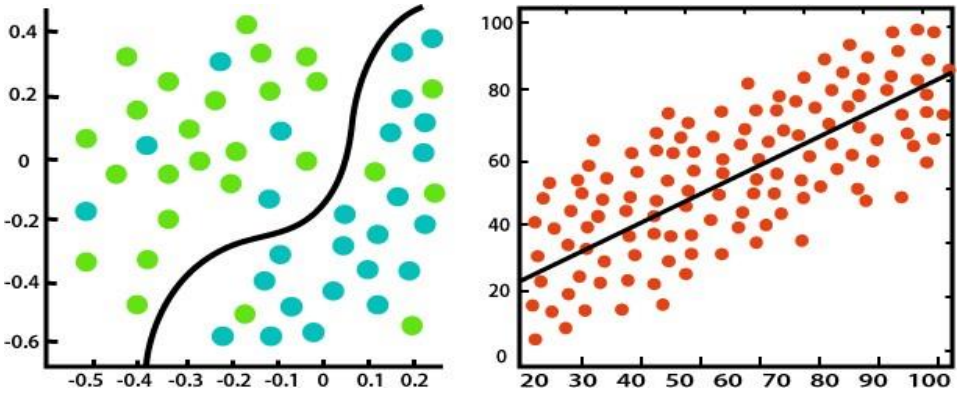

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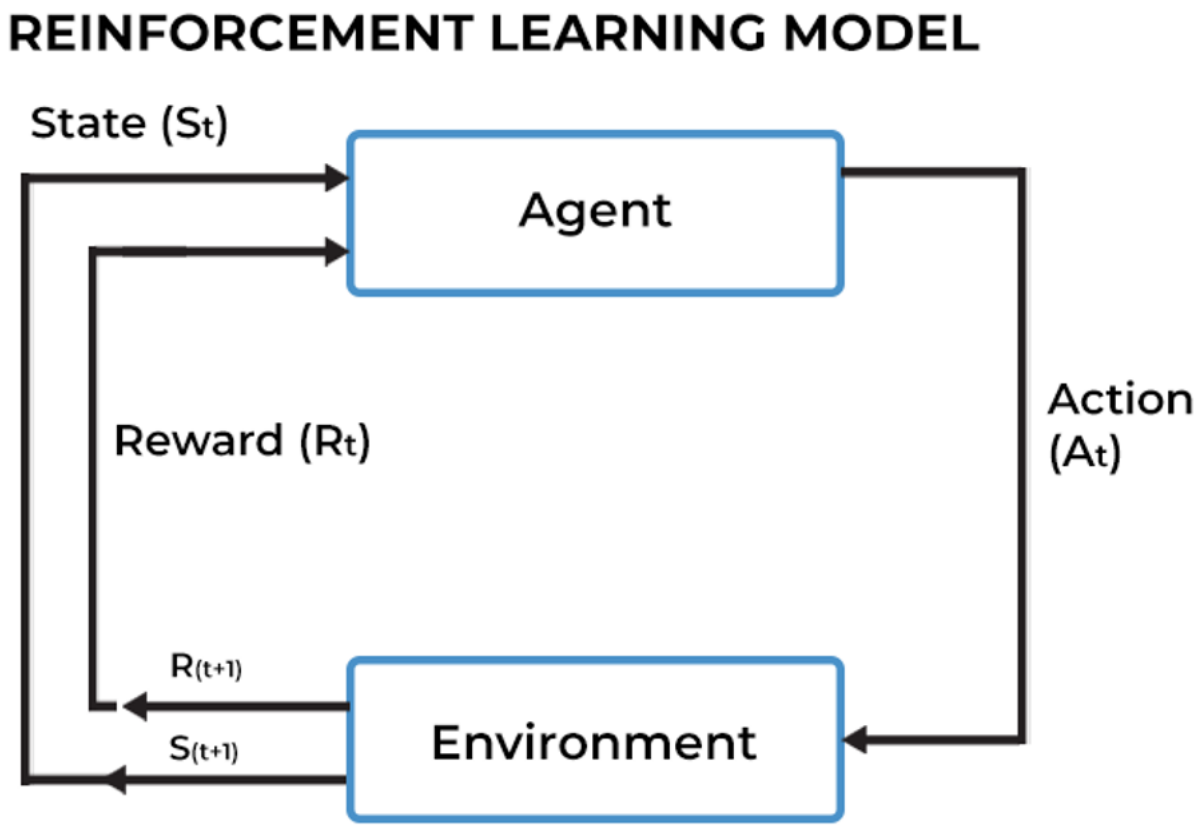
Reinforcement learning (RL)

Reinforcement learning (RL) is a machine learning (ML) technique that trains software to make decisions to achieve the most optimal results. It mimics the trial-and-error learning process that humans use to achieve their goals. Software actions that work towards your goal are reinforced, while actions that detract from the goal are ignored. It is an area of Machine Learning. It is about taking suitable action to maximize reward in a particular situation. It is employed by various software and machines to find the best possible behavior or path it should take in a specific situation. Reinforcement learning differs from supervised learning in a way that in supervised learning the training data has the answer key with it so the model is trained with the correct answer itself whereas in reinforcement learning, there is no answer but the reinforcement agent decides what to do to perform the given task. In the absence of a training dataset, it is bound to learn from its experience.

RL algorithms use a reward-and-punishment paradigm as they process data. They learn from the feedback of each action and self-discover the best processing paths to achieve final outcomes. The algorithms are also capable of delayed gratification. The best overall strategy may require short-term sacrifices, so the best approach they discover may include some punishments or backtracking along the way. RL is a powerful method to help artificial intelligence (AI) systems achieve optimal outcomes in unseen environments.



What are the benefits of reinforcement learning?

There are many benefits to using reinforcement learning (RL). However, these three often stand out.

Excels in complex environments

RL algorithms can be used in complex environments with many rules and dependencies. In the same environment, a human may not be capable of determining the best path to take, even with superior knowledge of the environment. Instead, model-free RL algorithms adapt quickly to continuously changing environments and find new strategies to optimize results.

Requires less human interaction

In traditional ML algorithms, humans must label data pairs to direct the algorithm. When you use an RL algorithm, this isn't necessary. It learns by itself. At the same time, it offers mechanisms to integrate human feedback, allowing for systems that adapt to human preferences, expertise, and corrections.

Optimizes for long-term goals

RL inherently focuses on long-term reward maximization, which makes it apt for scenarios where actions have prolonged consequences. It is particularly well-suited for real-world situations where feedback isn't immediately available for every step, since it can learn from delayed rewards.

For example, decisions about energy consumption or storage might have long-term consequences. RL can be used to optimize long-term energy efficiency and cost. With appropriate architectures, RL agents can also generalize their learned strategies across similar but not identical tasks.

What are the use cases of reinforcement learning?

Reinforcement learning (RL) can be applied to a wide range of real-world use cases. We give some examples next.

Marketing personalization

In applications like recommendation systems, RL can customize suggestions to individual users based on their interactions. This leads to more personalized experiences. For example, an application may display ads to a user based on some demographic information. With each ad interaction, the application learns which ads to display to the user to optimize product sales.

Optimization challenges

Traditional optimization methods solve problems by evaluating and comparing possible solutions based on certain criteria. In contrast, RL introduces learning from interactions to find the best or close-to-best solutions over time.

For example, a cloud spend optimizing system uses RL to adjust to fluctuating resource needs and choose optimal instance types, quantities, and configurations. It makes decisions based on factors like current and available cloud infrastructure, spending, and utilization.

Financial predictions

The dynamics of financial markets are complex, with statistical properties that change over time. RL algorithms can optimize long-term returns by considering transaction costs and adapting to market shifts.

For instance, an algorithm could observe the rules and patterns of the stock market before it tests actions and records associated rewards. It dynamically creates a value function and develops a strategy to maximize profits.

How does Reinforcement Learning work?

The learning process of reinforcement learning (RL) algorithms is similar to animal and human reinforcement learning in the field of behavioural psychology. For instance, a child may discover that they receive parental praise when they help a sibling or clean but receive negative reactions when they throw toys or yell. Soon, the child learns which combination of activities results in the end reward.

An RL algorithm mimics a similar learning process. It tries different activities to learn the associated negative and positive values to achieve the end reward outcome.

Key concepts

In reinforcement learning, there are a few key concepts to familiarize yourself with:

The agent is the ML algorithm (or the autonomous system)

The environment is the adaptive problem space with attributes such as variables, boundary values, rules, and valid actions

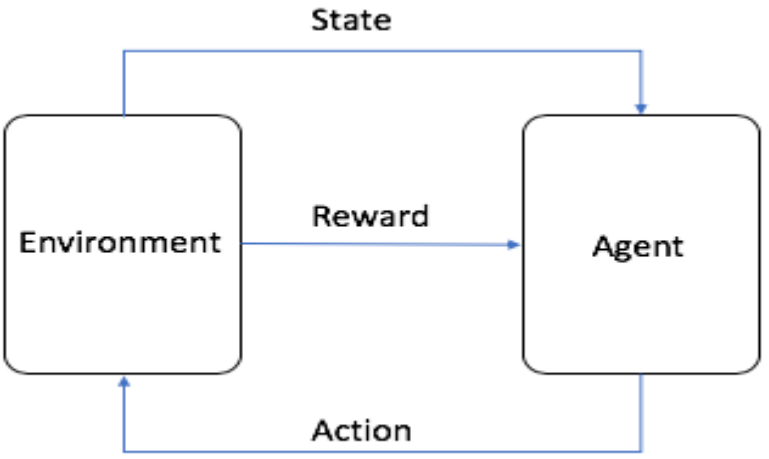
The action is a step that the RL agent takes to navigate the environment

- The state is the environment at a given point in time
- The reward is the positive, negative, or zero value—in other words, the reward or punishment—for taking an action
- The cumulative reward is the sum of all rewards or the end value

Algorithm basics

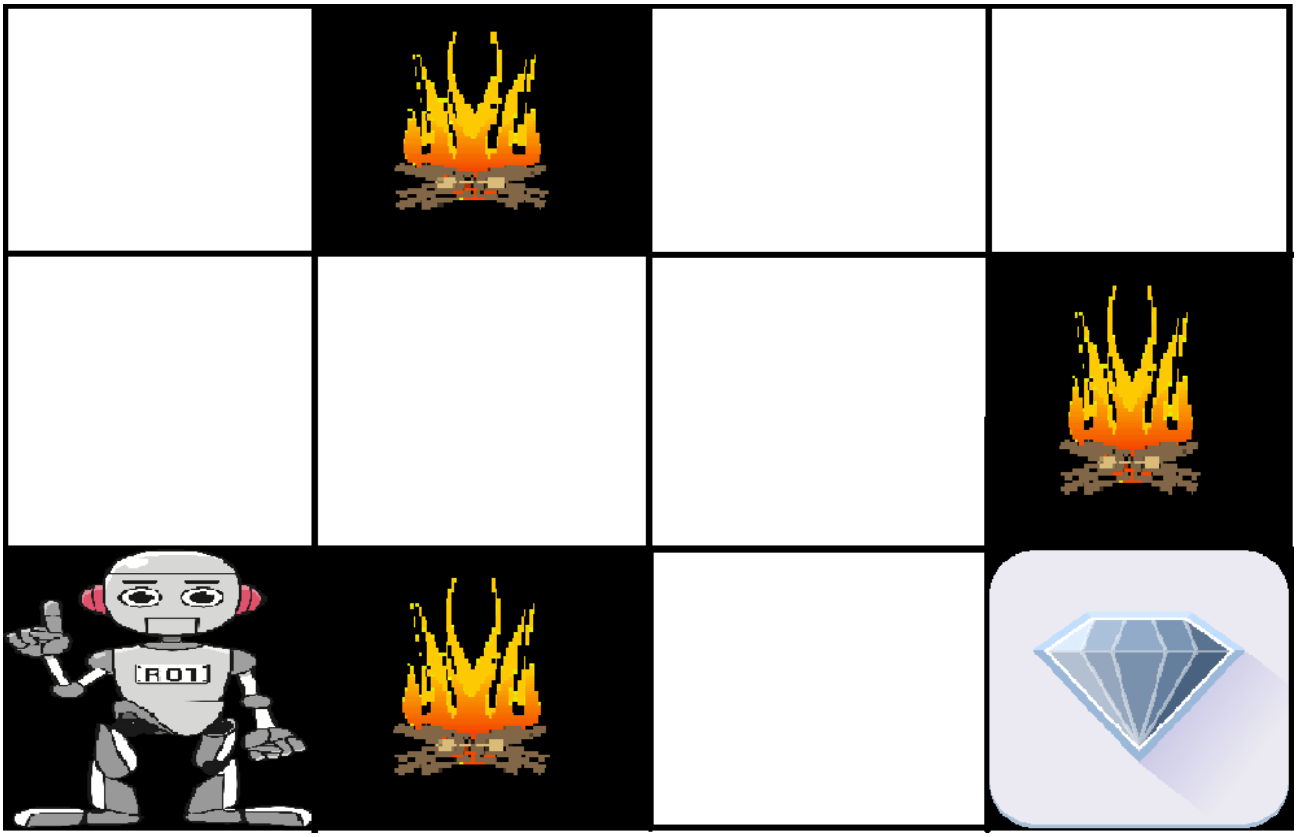
Reinforcement learning is based on the Markov decision process, a mathematical modelling of decision-making that uses discrete time steps. At every step, the agent takes a new action that results in a new environment state. Similarly, the current state is attributed to the sequence of previous actions.

Through trial and error in moving through the environment, the agent builds a set of if-then rules or policies. The policies help it decide which action to take next for optimal cumulative reward. The agent must also choose between further environment exploration to learn new state-action rewards or select known high-reward actions from a given state. This is called the *exploration-exploitation trade-off*.



Example:

The problem is as follows: We have an agent and a reward, with many hurdles in between. The agent is supposed to find the best possible path to reach the reward. The following problem explains the problem more easily.



The above image shows the robot, diamond, and fire. The goal of the robot is to get the reward that is the diamond and avoid the hurdles that are fired. The robot learns by trying all the possible paths and then choosing the path which gives him the reward with the least hurdles. Each right step will give the robot a reward and each wrong step will subtract the reward of the robot. The total reward will be calculated when it reaches the final reward that is the diamond.

Types of Reinforcement:

There are two types of Reinforcement:

1. **Positive:** Positive Reinforcement is defined as when an event, occurs due to a particular behavior, increases the strength and the frequency of the behavior. In other words, it has a positive effect on behavior.

   Advantages of reinforcement learning are:

   - Maximizes Performance
   - Sustain Change for a long period of time
   - Too much Reinforcement can lead to an overload of states which can diminish the results

Negative: Negative Reinforcement is defined as strengthening of behavior because a negative condition is stopped or avoided.

Advantages of reinforcement learning:

- Increases Behavior

- Provide defiance to a minimum standard of performance
- It Only provides enough to meet up the minimum behavior

Elements of Reinforcement Learning

Reinforcement learning elements are as follows:

1. Policy
2. Reward function
3. Value function
4. Model of the environment

Policy: Policy defines the learning agent behavior for given time period. It is a mapping from perceived states of the environment to actions to be taken when in those states.
Reward function: Reward function is used to define a goal in a reinforcement learning problem. A reward function is a function that provides a numerical score based on the state of the environment
Value function: Value functions specify what is good in the long run. The value of a state is the total amount of reward an agent can expect to accumulate over the future, starting from that state.
Model of the environment: Models are used for planning.

Reinforcement learning vs. Supervised learning

In supervised learning, you define both the input and the expected associated output. For instance, you can provide a set of images labelled dogs or cats, and the algorithm is then expected to identify a new animal image as a dog or cat.

Supervised learning algorithms learn patterns and relationships between the input and output pairs. Then, they predict outcomes based on new input data. It requires a supervisor, typically a human, to label each data record in a training data set with an output.

In contrast, *Reinforcement learning* has a well-defined end goal in the form of a desired result but no supervisor to label associated data in advance. During training, instead of trying to map inputs with known outputs, it maps inputs with possible outcomes. By rewarding desired behaviours, you give weightage to the best outcomes.

Reinforcement learning vs. Unsupervised learning

Unsupervised learning algorithms receive inputs with no specified outputs during the training process. They find hidden patterns and relationships within the data using statistical means. For instance, you could provide a set of documents, and the algorithm may group them into categories it identifies based on the words in the text. You do not get any specific outcomes; they fall within a range.

Conversely, RL has a predetermined end goal. While it takes an exploratory approach, the explorations are continuously validated and improved to increase the probability of reaching the end goal. It can teach itself to reach very specific outcomes.