# FOUNDATION OF MACHINE LEARNING(ML)

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# Learning Outcomes:-

- What is Machine Learning? Well-Posed learning Problem
- Types of Machine Learning:
- Supervised, Unsupervised, Reinforcement
- Reinforcement Learning:
  - **-Terms, Key features**
  - **-Approaches to implement reinforcement learning: Value based, Policy Based, Model based, -Elements of reinforcement learning- Policy, reward signal, value function, Model;**
  - **- Types of reinforcement learning: Positive and Negative Comparison**
- Comparison between Supervised, unsupervised and reinforcement learning

# INTRODUTION TO ML

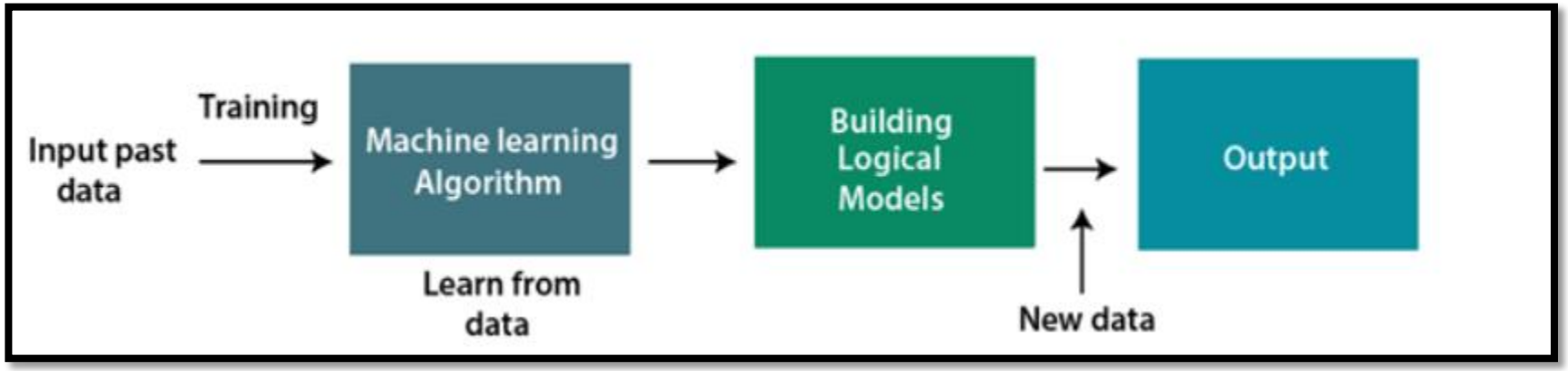
- **Machine learning enables a machine to automatically learn from data, improve performance from experiences, and predict things without being explicitly programmed.**
- With the help of sample historical data, which is known as training data, machine learning algorithms build a mathematical model that helps in making predictions or decisions without being explicitly programmed.
- Machine learning brings computer science and statistics together for creating predictive models.
- Machine learning constructs or uses the algorithms that learn from historical data. The more we will provide the information, the higher will be the performance.
- Machine learning uses various algorithms for building mathematical models and making predictions using historical data or information.

# INTRODUTION TO ML

- **Machine learning is a subset of AI, which enables the machine to automatically learn from data, improve performance from past experiences, and make predictions.**
- Machine learning contains a set of algorithms that work on a huge amount of data. Data is fed to these algorithms to train them, and on the basis of training, they build the model & perform a specific task
- A machine has the ability to learn if it can improve its performance by gaining more data.

# INTRODUTION TO ML

- Currently, it is being used for various tasks such as image recognition, speech recognition, email filtering, Facebook auto-tagging, recommender system, and many more.
- A Machine Learning system learns from historical data, builds the prediction models, and whenever it receives new data, predicts the output for it.
- The accuracy of predicted output depends upon the amount of data, as the huge amount of data helps to build a better model which predicts the output more accurately.



# INTRODUTION TO ML

## Features of Machine Learning:

- Machine learning uses data to detect various patterns in a given dataset.
- It can learn from past data and improve automatically.
- It is a data-driven technology.
- Machine learning is much similar to data mining as it also deals with the huge amount of the data.
- A machine has the ability to learn if it can improve its performance by gaining more data.

# Well Posed Learning Problem:

- The formal definition of Well posed learning problem is, "**A computer program is said to learn from Experience E when given a task T, and some performance measure P. If it performs on T with a performance measure P, then it upgrades with experience E**".
- The three important components of a well-posed learning problem are,
- **Task**
- **Performance Measure**
- **Experience**

# Well Posed Learning Problem:

**Learning to play Checkers:**

- A computer might improve its performance as an ability to win at the class of tasks that are about playing checkers.
- The performance keeps improving through experience by playing against itself.
- To simplify,
- **T -> Play the checkers game.**
- **P -> Percentage of games won against the opponent.**
- **E -> Playing practice games against itself.**

# Well Posed Learning Problem:

**Handwriting Recognition:**

- Handwriting recognition (HWR) is a technology that converts a user's handwritten letters or words into a computer-readable format (e.g., Unicode text).
- Its applications are numerous, it is used in reading postal addresses, bank forms, etc.

**T -> recognizing and classifying handwritten words from images.**

**P -> Percentage of correctly identified words.**

**E -> set of handwritten words with their classifications in a database.**

# Well Posed Learning Problem:

## A Robot Driving Problem

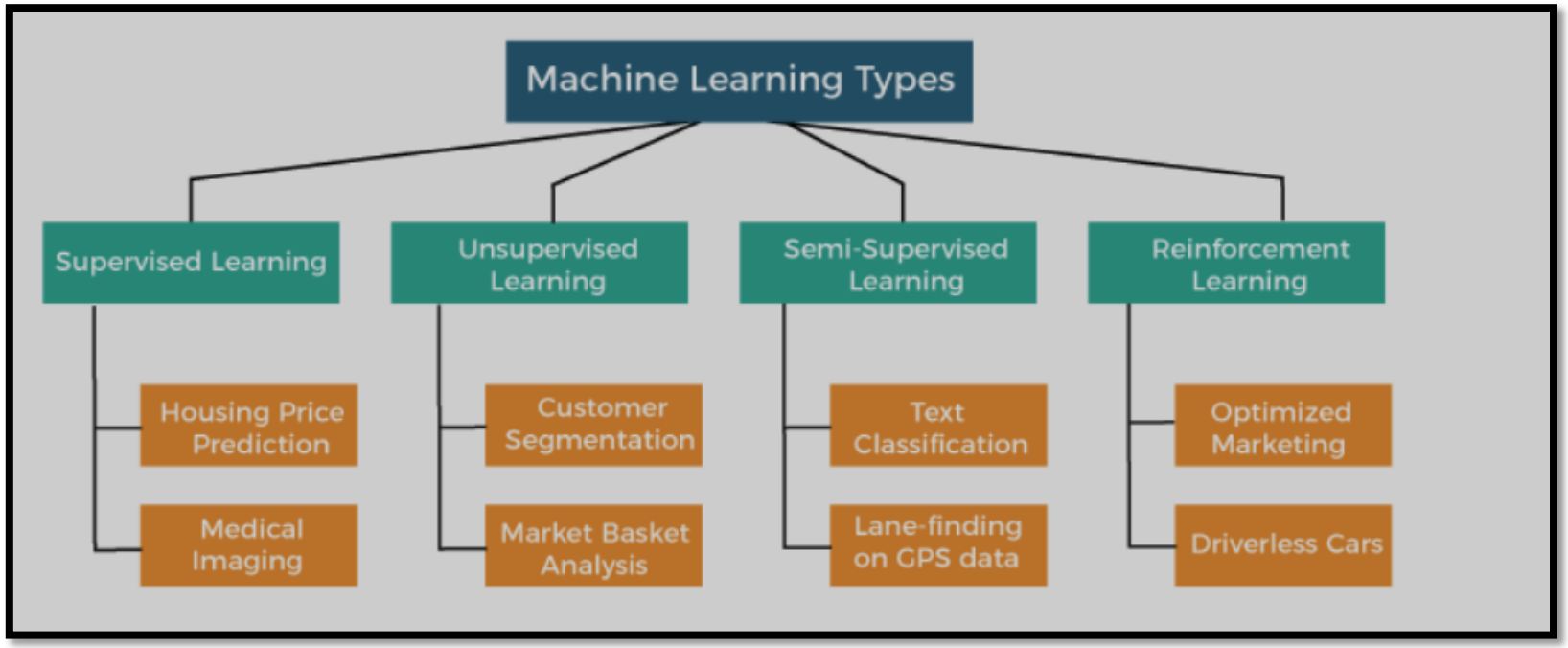
- Task – driving on public four-lane highways using sight scanners
- Performance Measure – average distance progressed before a fallacy
- Experience – order of images and steering instructions noted down while observing a human driver.

## Face Recognition Problem

- Task – predicting different types of faces
- Performance Measure – able to predict maximum types of faces
- Experience – training machine with maximum amount of datasets of different face images

# Types of Machine Learning

- Supervised Machine Learning
- Unsupervised Machine Learning
- Semi-Supervised Machine Learning
- Reinforcement Learning

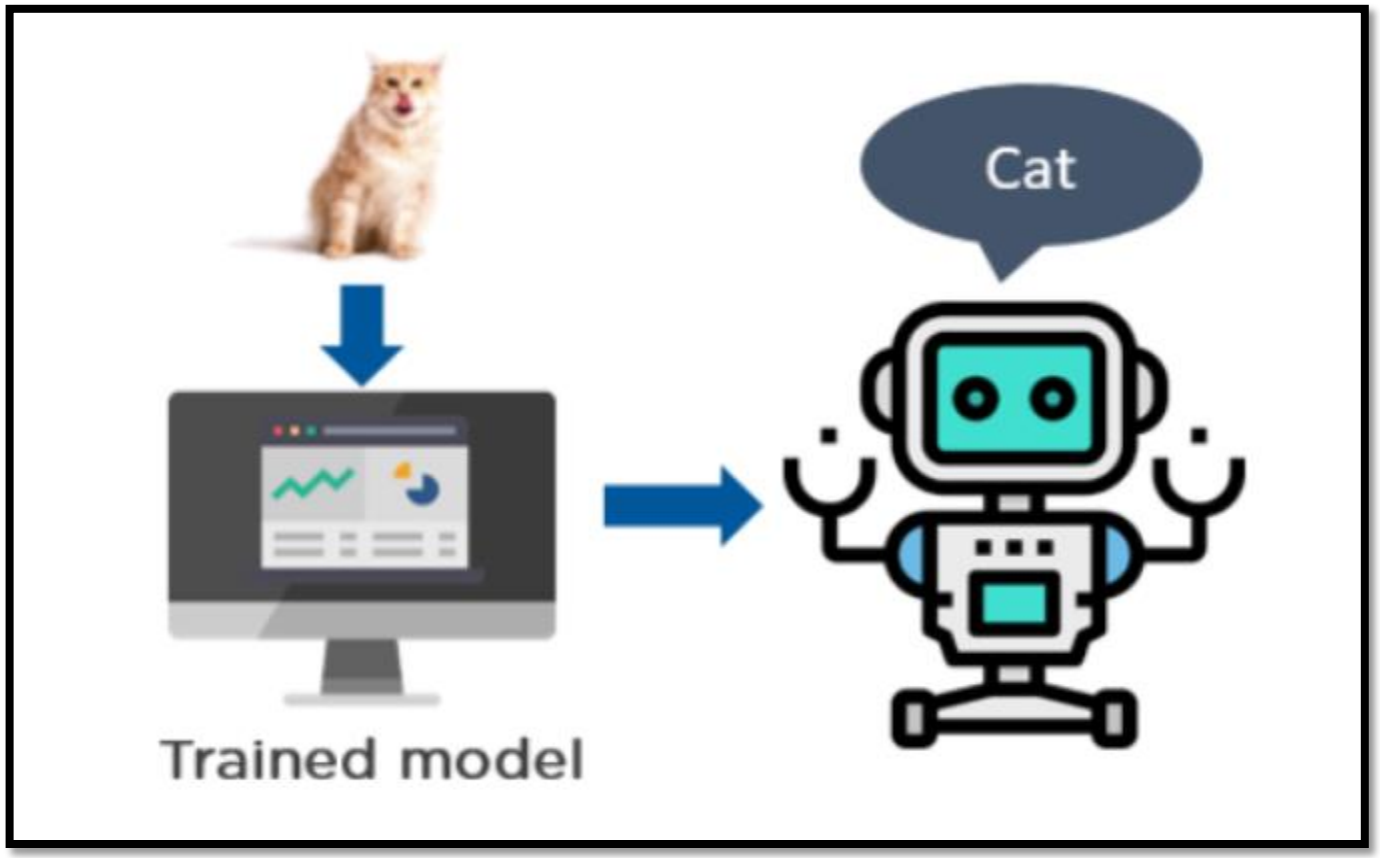


# Types of Machine Learning

- **Supervised Machine Learning:-**
- Supervised learning is a type of machine learning method in which we provide sample labeled data to the machine learning system in order to train it, and on that basis, it predicts the output.
- The system creates a model using labeled data to understand the datasets and learn about each data, once the training and processing are done then we test the model by providing a sample data to check whether it is predicting the exact output or not.
- The goal of supervised learning is to map input data with the output data.
- The supervised learning is based on supervision, and it is the same as when a student learns things in the supervision of the teacher.
- The examples of supervised learning are **spam filtering, Risk Assessment and Fraud Detection.**

# Types of Machine Learning

- **Supervised Machine Learning:-**
- It can be grouped further in two categories of algorithms:
- **Classification**
- **Regression**



# Types of Machine Learning

- **Supervised Machine Learning:-**
- **Classification:-**
- Classification algorithms are used to solve the classification problems in which the output variable is categorical, such as "Yes" or No, Male or Female, Red or Blue, etc.
- The classification algorithms predict the categories present in the dataset. Some real-world examples of classification algorithms are Spam Detection, Email filtering, etc.
- Some popular classification algorithms are given below:
- **Random Forest Algorithm**
- **Decision Tree Algorithm**
- **Logistic Regression Algorithm**
- **Support Vector Machine Algorithm**

# Types of Machine Learning

- **Supervised Machine Learning:-**
- **Regression**
- Regression algorithms are used to solve regression problems in which there is a linear relationship between input and output variables.
- These are used to predict continuous output variables, such as market trends, weather prediction, etc.
- Some popular Regression algorithms are given below:
- **Simple Linear Regression Algorithm**
- **Multivariate Regression Algorithm**
- **Decision Tree Algorithm**
- **Lasso Regression**

# Types of Machine Learning

- **Supervised Machine Learning:-**

**Advantages:**

- Since supervised learning work with the labelled dataset so we can have an exact idea about the classes of objects.
- These algorithms are helpful in predicting the output on the basis of prior experience.

**Disadvantages:**

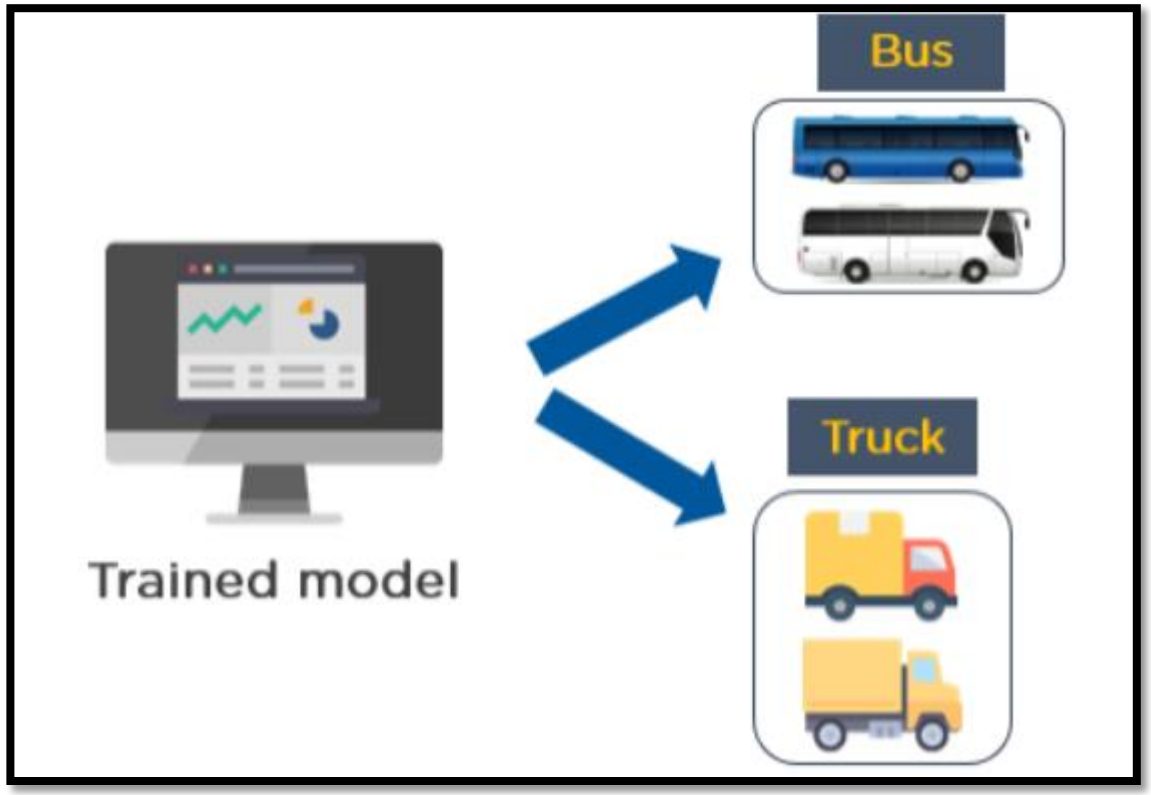
- These algorithms are not able to solve complex tasks.
- It may predict the wrong output if the test data is different from the training data.
- It requires lots of computational time to train the algorithm.

# Types of Machine Learning

- **Unsupervised Machine Learning:-**
- Unsupervised learning is a learning method in which a machine learns without any supervision.
- The training is provided to the machine with the set of data that has not been labeled, classified, or categorized, and the algorithm needs to act on that data without any supervision.
- The goal of unsupervised learning is to restructure the input data into new features or a group of objects with similar patterns.
- In unsupervised learning, we don't have a predetermined result.
- The machine tries to find useful insights from the huge amount of data.

# Types of Machine Learning

- **Unsupervised Machine Learning:-**
- It can be grouped further in two categories of algorithms:
- **Clustering**
- **Association**



# Types of Machine Learning

- **Unsupervised Machine Learning:-**
- **Clustering:-**
- The clustering technique is used when we want to find the inherent groups from the data.
- It is a way to group the objects into a cluster such that the objects with the most similarities remain in one group and have fewer or no similarities with the objects of other groups.
- An example of the clustering algorithm is grouping the customers by their purchasing behaviour.
- Some of the popular clustering algorithms are given below:
- K-Means Clustering algorithm
- Mean-shift algorithm
- DBSCAN Algorithm
- Principal Component Analysis

# Types of Machine Learning

- **Unsupervised Machine Learning:-**
- **Association:-**
- Association rule learning is an unsupervised learning technique, which finds interesting relations among variables within a large dataset.
- The main aim of this learning algorithm is to find the dependency of one data item on another data item and map those variables accordingly so that it can generate maximum profit.
- This algorithm is mainly applied in Market Basket analysis, Web usage mining, continuous production, etc.
- Some popular algorithms of Association rule learning are Apriori Algorithm, Eclat, FP-growth algorithm.

# Types of Machine Learning

- **Unsupervised Machine Learning:-**

**Advantages:**

- These algorithms can be used for complicated tasks compared to the supervised ones because these algorithms work on the unlabeled dataset.
- Unsupervised algorithms are preferable for various tasks as getting the unlabeled dataset is easier as compared to the labelled dataset.

**Disadvantages:**

- The output of an unsupervised algorithm can be less accurate as the dataset is not labelled, and algorithms are not trained with the exact output in prior.
- Working with Unsupervised learning is more difficult as it works with the unlabelled dataset that does not map with the output.

# Types of Machine Learning

- **Semi-Supervised Machine Learning:-**
- Semi-Supervised learning is a type of Machine Learning algorithm that lies between Supervised and Unsupervised machine learning.
- It represents the intermediate ground between Supervised (With Labelled training data) and Unsupervised learning (with no labelled training data) algorithms and uses the combination of labelled and unlabeled datasets during the training period.
- Although Semi-supervised learning is the middle ground between supervised and unsupervised learning and operates on the data that consists of a few labels, it mostly consists of unlabeled data.
- To overcome the drawbacks of supervised learning and unsupervised learning algorithms, the concept of Semi-supervised learning is introduced.

# Types of Machine Learning

- **Semi-Supervised Machine Learning:-**
- The main aim of semi-supervised learning is to effectively use all the available data, rather than only labelled data like in supervised learning.
- Initially, similar data is clustered along with an unsupervised learning algorithm, and further, it helps to label the unlabeled data into labelled data. It is because labelled data is a comparatively more expensive acquisition than unlabeled data.
- We can imagine these algorithms with an example.
- Supervised learning is where a student is under the supervision of an instructor at home and college. Further, if that student is self-analysing the same concept without any help from the instructor, it comes under unsupervised learning. Under semi-supervised learning, the student has to revise himself after analyzing the same concept under the guidance of an instructor at college.

# Types of Machine Learning

- **Semi-supervised Machine Learning:-**

**Advantages:**

- It is simple and easy to understand the algorithm.
- It is highly efficient.
- It is used to solve drawbacks of Supervised and Unsupervised Learning algorithms.

**Disadvantages:**

- Iterations results may not be stable.
- We cannot apply these algorithms to network-level data.
- Accuracy is low.

# Types of Machine Learning

- **Reinforcement Machine Learning:-**
- Reinforcement learning works on a feedback-based process, in which an AI agent (A software component) automatically explore its surrounding by hitting & trail, taking action, learning from experiences, and improving its performance.
- Agent gets rewarded for each good action and get punished for each bad action; hence the goal of reinforcement learning agent is to maximize the rewards.
- In reinforcement learning, there is no labelled data like supervised learning, and agents learn from their experiences only.
- The reinforcement learning process is similar to a human being; for example, a child learns various things by experiences in his day-to-day life.
- An example of reinforcement learning is to play a game, where the Game is the environment, moves of an agent at each step define states, and the goal of the agent is to get a high score. Agent receives feedback in terms of punishment and rewards.

# Types of Machine Learning

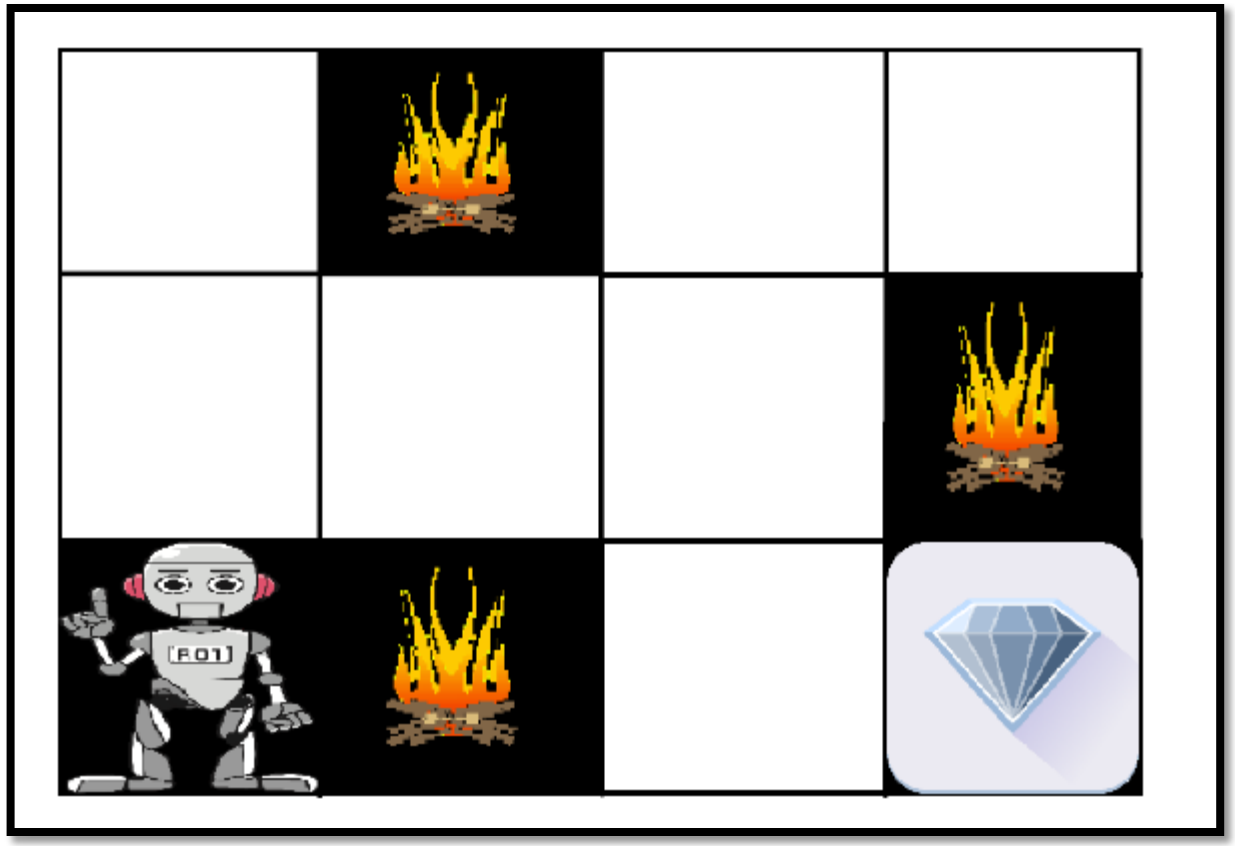
- **Reinforcement Machine Learning:-**
- Due to its way of working, reinforcement learning is employed in different fields such as Game theory, Operation Research, Information theory, multi-agent systems.
- RL solves a specific type of problem where decision making is sequential, and the goal is long-term, such as game-playing, robotics, etc.
- The agent interacts with the environment and explores it by itself. The primary goal of an agent in reinforcement learning is to improve the performance by getting the maximum positive rewards.
- The agent learns with the process of hit and trial, and based on the experience, it learns to perform the task in a better way.
- Hence, we can say that "**Reinforcement learning is a type of machine learning method where an intelligent agent (computer program) interacts with the environment and learns to act within that.**"
- How a Robotic dog learns the movement of his arms is an example of Reinforcement learning.

# Types of Machine Learning

- **Reinforcement Machine Learning:-**
- It is a core part of Artificial intelligence, and all AI agent works on the concept of reinforcement learning. Here we do not need to pre-program the agent, as it learns from its own experience without any human intervention.
- Example: Suppose there is an AI agent present within a maze environment, and his goal is to find the diamond. The agent interacts with the environment by performing some actions, and based on those actions, the state of the agent gets changed, and it also receives a reward or penalty as feedback.
- The agent continues doing these three things (take action, change state/remain in the same state, and get feedback), and by doing these actions, he learns and explores the environment.
- The agent learns that what actions lead to positive feedback or rewards and what actions lead to negative feedback penalty. As a positive reward, the agent gets a positive point, and as a penalty, it gets a negative point.

# Types of Machine Learning

- **Reinforcement Machine Learning:-**

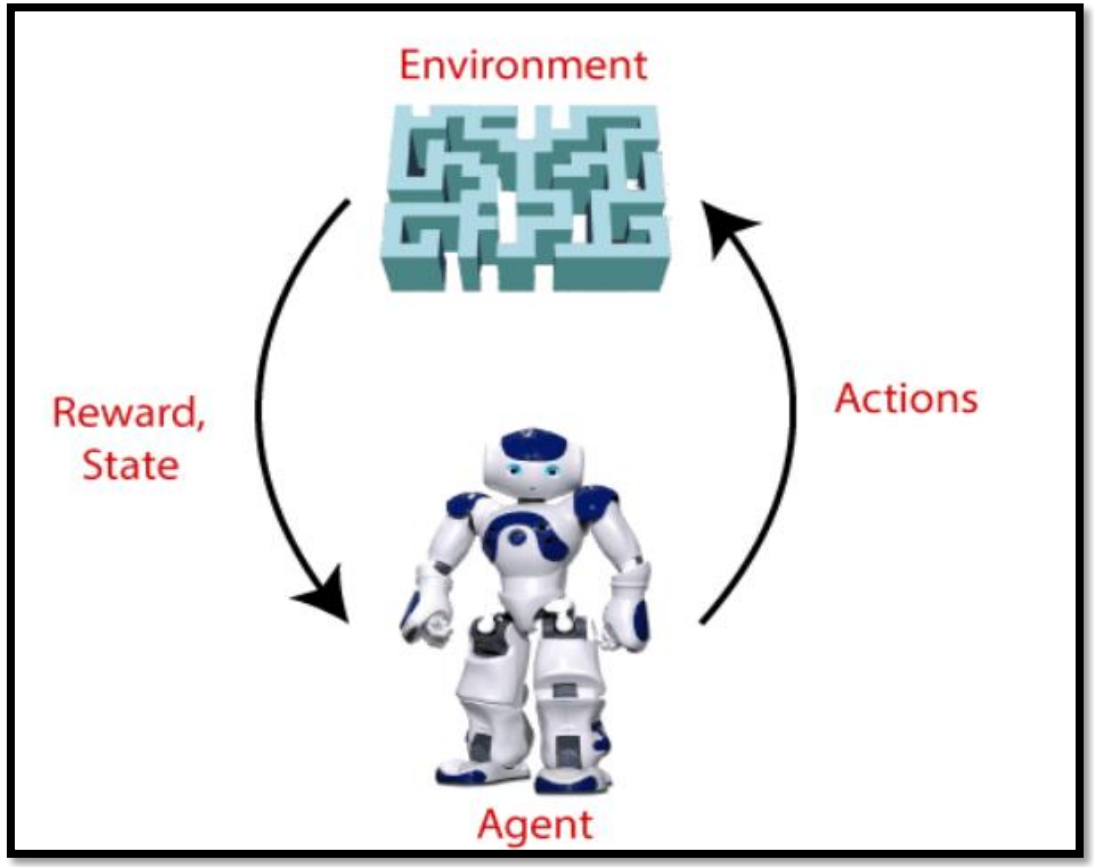


# Types of Machine Learning

- **Reinforcement Machine Learning:-**
- Reinforcement Learning (RL) is the science of decision making.
- It is about learning the optimal behavior in an environment to obtain maximum reward.
- In RL, the data is accumulated from machine learning systems that use a trial-and-error method. Data is not part of the input that we would find in supervised or unsupervised machine learning.
- Reinforcement learning uses algorithms that learn from outcomes and decide which action to take next.
- After each action, the algorithm receives feedback that helps it determine whether the choice it made was correct, neutral or incorrect.
- It is a good technique to use for automated systems that have to make a lot of small decisions without human guidance.

# Types of Machine Learning

- **Reinforcement Machine Learning:-**




# Types of Machine Learning

- **Applications Reinforcement Machine Learning:-**

### Video Games:

- RL algorithms are much popular in gaming applications. It is used to gain super-human performance. Some popular games that use RL algorithms are AlphaGO and AlphaGO Zero.

### Resource Management:

- The "Resource Management with Deep Reinforcement Learning" paper showed that how to use RL in computer to automatically learn and schedule resources to wait for different jobs in order to minimize average job slowdown.

### Robotics:

- RL is widely being used in Robotics applications. Robots are used in the industrial and manufacturing area, and these robots are made more powerful with reinforcement learning. There are different industries that have their vision of building intelligent robots using AI and Machine learning technology.

### Text Mining:

- Text-mining, one of the great applications of NLP, is now being implemented with the help of Reinforcement Learning by Salesforce company.

# Types of Machine Learning

- **Reinforcement Machine Learning:-**

**Advantages:**

- Reinforcement learning can be used to solve very complex problems that cannot be solved by conventional techniques
- The model can correct the errors that occurred during the training process.
- In RL, training data is obtained via the direct interaction of the agent with the environment.
- Reinforcement learning can handle environments that are non-deterministic, meaning that the outcomes of actions are not always predictable. This is useful in real-world applications where the environment may change over time or is uncertain.
- Reinforcement learning can be used to solve a wide range of problems, including those that involve decision making, control, and optimization.
- Reinforcement learning is a flexible approach that can be combined with other machine learning techniques, such as deep learning, to improve performance.

# Types of Machine Learning

- **Reinforcement Machine Learning:-**

**Disadvantages:**

- Reinforcement learning is not preferable to use for solving simple problems.
- Reinforcement learning needs a lot of data and a lot of computation
- Reinforcement learning is highly dependent on the quality of the reward function. If the reward function is poorly designed, the agent may not learn the desired behavior.
- Reinforcement learning can be difficult to debug and interpret. It is not always clear why the agent is behaving in a certain way, which can make it difficult to diagnose and fix problems.

# Reinforcement Machine Learning

**Terms used in Reinforcement Learning:-**

- **Agent():** An entity that can perceive/explore the environment and act upon it.
- **Environment():** A situation in which an agent is present or surrounded by. In RL, we assume the stochastic environment, which means it is random in nature.
- **Action():** Actions are the moves taken by an agent within the environment.
- **State():** State is a situation returned by the environment after each action taken by the agent.
- **Reward():** A feedback returned to the agent from the environment to evaluate the action of the agent.
- **Policy():** Policy is a strategy applied by the agent for the next action based on the current state.
- **Value():** It is expected long-term retuned with the discount factor and opposite to the short-term reward.
- **Q-value():** It is mostly similar to the value, but it takes one additional parameter as a current action (a).

# Reinforcement Machine Learning

## Key Features of Reinforcement Learning :-

- In RL, the agent is not instructed about the environment and what actions need to be taken.
- It is based on the hit and trial process.
- The agent takes the next action and changes states according to the feedback of the previous action.
- The agent may get a delayed reward.
- The environment is stochastic, and the agent needs to explore it to reach to get the maximum positive rewards.

# Reinforcement Machine Learning

## Types of Environment:-

- **Deterministic:** This refers to the case where both the state transition model and reward model are deterministic functions.
- Simply put, an agent can expect the same reward and next state if it repeats an action in a particular state.
- **Stochastic:** Stochastic refers to something that has a random probability of occurrence.
- Within such an environment, if an agent takes action in a state repeatedly, they cannot be guaranteed to receive the same reward or the next state.

# Reinforcement Machine Learning

## Approaches to implement Reinforcement Learning :-

- There are mainly three ways to implement reinforcement-learning in ML.
- **Value Based**
- **Policy Based**
- **Model Based**

# Reinforcement Machine Learning

## Approaches to implement Reinforcement Learning :-

- **Value Based:-**
- Value-based reinforcement learning is a subfield of reinforcement learning that focuses on estimating the value of taking different actions in a given state.
- The value-based approach is about to find the optimal value function, which is the maximum value at a state under any policy.
- Therefore, the agent expects the long-term return at any state(s) under policy π.
- Within Value-based method, we try to maximize the value function V(s).
- In this approach method, the agent can be dreamt of a long-term return at any state under policy (π) at any state.
- The primary goal of value-based methods is to learn a value function that quantifies how good it is for an agent to be in a particular state and take a specific action. This value function is typically denoted as the Q-value or the state-action value function

# Reinforcement Machine Learning

**key components and concepts associated with value-based reinforcement learning:**

- **Q-Value (State-Action Value Function):**
- The Q-value of a state-action pair (s, a) represents the expected cumulative reward an agent can achieve by starting in state s, taking action a, and then following a certain policy for the rest of the episode.
- Mathematically, the Q-value is often denoted as Q(s, a), and it is defined as the expected sum of rewards:

$$Q(s,a) = \mathbb{E}\left[\sum_{t=0}^{\infty} \gamma^t R_t \middle| S_0 = s, A_0 = a\right]$$

- γ (gamma) is the discount factor, which determines the weight given to future rewards. It typically ranges between 0 and 1.

# Reinforcement Machine Learning

## Bellman Equation:

- The Bellman equation is a fundamental equation in value-based reinforcement learning that relates the Q-values of state-action pairs.
- It is used for iterative updates of Q-values and is crucial for learning optimal policies.
- The Bellman equation for Q-values is expressed as:

$$Q(s,a) = \mathbb{E}\left[R_t + \gamma \max_{a'} Q(S_{t+1}, a') \middle| S_t = s, A_t = a\right]$$

- It states that the Q-value of a state-action pair is equal to the immediate reward plus the discounted maximum Q-value of the next state.

# Reinforcement Machine Learning

## Approaches to implement Reinforcement Learning :-

- **Policy Based:-**
- Policy-based reinforcement learning is a subfield of reinforcement learning (RL) that focuses on learning an optimal policy directly, rather than estimating value functions (like Q-values).
- In policy-based RL, the goal is to find a policy (a mapping from states to actions) that maximizes the expected cumulative reward.
- Policy-based approach is to find the optimal policy for the maximum future rewards without using the value function.
- In this approach, the agent tries to apply such a policy that the action performed in each step helps to maximize the future reward.

# Reinforcement Machine Learning

**key components and concepts associated with policy-based reinforcement learning:**

- **Policy Function:**
- In policy-based RL, the policy is represented by a function, often denoted as π, that maps states to actions.
- For a given state s, π(s) represents the action selected by the policy in that state.
- The policy-based approach has mainly two types of policy:
- **Deterministic:** The same action is produced by the policy (π) at any state.
- **Stochastic:** In this policy, probability determines the produced action.

# Reinforcement Machine Learning

## Approaches to implement Reinforcement Learning :-

- **Model Based:-**
- In the model-based approach, a virtual model is created for the environment, and the agent explores that environment to learn it.
- There is no particular solution or algorithm for this approach because the model representation is different for each environment.
- Model-based reinforcement learning (MBRL) is an approach to reinforcement learning that involves learning an explicit model of the environment, which includes the transition dynamics and reward function.
- In MBRL, the agent builds a representation of how the environment works and uses that model to make decisions and plan actions.

# Reinforcement Machine Learning

- **Model Learning:**
- In MBRL, the agent aims to learn a model that can predict the next state and associated reward given the current state and action. This model is often referred to as the transition model or dynamics model.
- The transition model can be learned using various techniques, including neural networks, Gaussian processes, or other machine learning models.
- Model learning can be done from real interaction data collected by the agent or through simulated data generation.
- **Model-Based Planning:**
- Once the agent has a learned model of the environment, it can use this model for planning. Planning involves simulating possible sequences of actions and states to select the best actions to maximize the expected cumulative reward.
- Common planning algorithms in MBRL include Monte Carlo Tree Search (MCTS), model predictive control (MPC), and various search and optimization methods.

# Reinforcement Machine Learning

## Elements of Reinforcement Learning :-

- There are four main elements of Reinforcement Learning, which are given below:
- **Policy**
- **Reward Signal**
- **Value Function**
- **Model of the environment**

# Reinforcement Machine Learning

## Elements of Reinforcement Learning :-

- **Policy:-**
- A policy can be defined as a way how an agent behaves at a given time, specifying the action an agent should take in a given state or state-action pair.
- It maps the perceived states of the environment to the actions taken on those states.
- A policy is the core element of the RL as it alone can define the behavior of the agent. In some cases, it may be a simple function or a lookup table, whereas, for other cases, it may involve general computation as a search process.
- The policy represents the decision-making process of the agent.
- It could be deterministic or a stochastic policy.

# Reinforcement Machine Learning

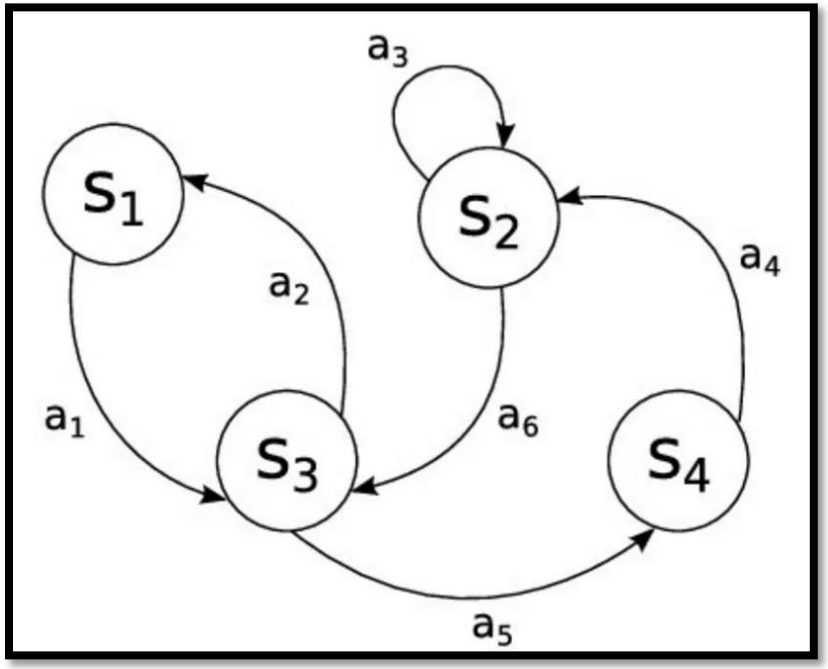
## Elements of Reinforcement Learning - Policy:-

- **For deterministic policy: $a = \pi(s)$**
- Here, for each state s, the policy directly maps to a specific action a.
- For example, in a game of chess, a deterministic policy might specify exactly which piece to move to which square in response to a particular board configuration
- **For stochastic policy: $\pi(a \mid s) = P[At = a \mid St = s]$**
- Here, for each state s, the policy defines a probability distribution over possible actions.
- Stochastic policies introduce randomness or uncertainty into the agent's decision-making process.
- For example, in a game-playing AI, a stochastic policy might assign probabilities to various moves in a game, allowing the AI to explore different actions.

# Reinforcement Machine Learning

## Elements of Reinforcement Learning - Policy:-

- For example, imagine that you're in state S2.
- Notice that you can go to either state S3 (taking action a6), or stay in the same state S2 (take action a3). The policy tells that you should take action a6 and go to state S3.
- So again, a policy π is a function that takes as an input a state "S" (S2 in our example) and returns an action "a" (a6 in our example).
- That is: $\pi(s) \rightarrow a$
- Or in our example, $\pi(S2) \rightarrow a6$



# Reinforcement Machine Learning

## Elements of Reinforcement Learning :-

- **Reward Signal :-**
- The goal of reinforcement learning is defined by the reward signal.
- At each state, the environment sends an immediate signal to the learning agent, and this signal is known as a reward signal.
- These rewards are given according to the good and bad actions taken by the agent.
- The agent's main objective is to maximize the total number of rewards for good actions.
- The reward signal can change the policy, such as if an action selected by the agent leads to low reward, then the policy may change to select other actions in the future.

# Reinforcement Machine Learning

## Elements of Reinforcement Learning - Reward Signal :-

- The reward signal thus tells the agent what are the good and what are the bad decisions (e.g. low reward = bad, high reward = good).
- The reward signal is the primary basis for altering the policy.
- Meaning, if the policy tells the agent to select an action when it's in specific state (e.g. choose action "a6" when you're in state "S2"), and that action is followed by a low reward, then the policy may be changed to select some other action in that situation (i.e. state) in the future.

# Reinforcement Machine Learning

## Elements of Reinforcement Learning :-

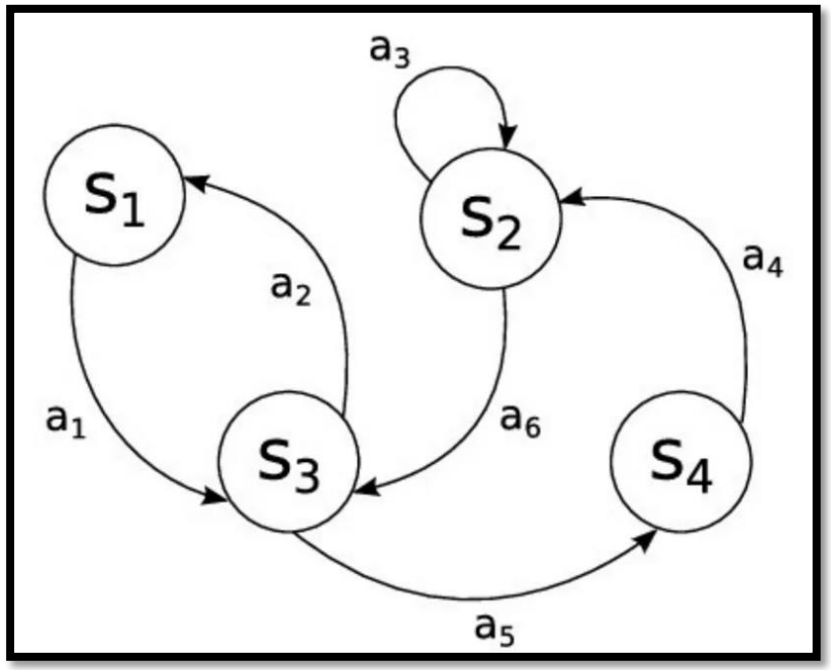
### ❑Value Function :-

- ❑The value function gives information about how good the situation and action are and how much reward an agent can expect.
- ❑A reward indicates the immediate signal for each good and bad action, whereas a value function specifies the good state and action for the future.
- ❑The value function depends on the reward as, without reward, there could be no value.
- ❑The goal of estimating values is to achieve more rewards.
- ❑The value function takes into account the states that are likely to follow, and the rewards available in those states.
- ❑The value of a state is the total amount of reward an agent can expect to accumulate over the future, starting from that state.

# Reinforcement Machine Learning

## Elements of Reinforcement Learning - Value Function :-

- In our example, the value of state S3 takes into account the fact that after going into S3, you could also go to states S1 and S4.
- The value of state S2 takes into account the fact that after going into S2, you could also go to states S3 and S2.
- It's important because a state might always gives an agent a low immediate reward, but if that state have a high value, it means that it's often followed by other states that yield high rewards (hence, the agent should still go to that state).



# Reinforcement Machine Learning

## Elements of Reinforcement Learning - Value Function :-

- So for example, imagine again that the agent is at state S2, and that taking action “a3” yields a reward with a value of 5. And that taking the action “a6” yields a reward with a value of 3. Maybe the reason the policy told the agent to go to state S3 from state S2 (taking action “a6”) is that once the agent is on state S3, it can take action “a2” that yields a 100 reward value.
- Rewards are given directly by the environment, but values must be estimated and re-estimated from the observations an agent makes over its lifetime.
- That is, because the value of a state will change depending on what the agent knows about futures possibilities from that state. And since the agent continuously explore, it will discover more possibilities.
- Without rewards there will be no values, and the only reason to estimate values is to achieve more rewards in the long run.
- Hence, you can think about rewards as primary, and values as secondary (they are just used as predictions of future rewards).

# Reinforcement Machine Learning

## Elements of Reinforcement Learning :-

- **Model :-**

- The last element of reinforcement learning is the model, which mimics the behavior of the environment.
- With the help of the model, one can make inferences about how the environment will behave. Such as, if a state and an action are given, then a model can predict the next state and reward.
- The model is used for planning, which means it provides a way to take a course of action by considering all future situations before actually experiencing those situations.
- The approaches for solving the RL problems with the help of the model are termed as the model-based approach. Comparatively, an approach without using a model is called a model-free approach.

# Reinforcement Machine Learning

## Types of Reinforcement Learning :-

- There are mainly two types of reinforcement learning:
- **Positive Reinforcement**
- **Negative Reinforcement**

# Reinforcement Machine Learning

## Types of Reinforcement Learning - Positive Reinforcement:-

- The positive reinforcement learning means adding something to increase the tendency that expected behavior would occur again.
- It impacts positively on the behavior of the agent and increases the strength of the behavior.
- This type of reinforcement can sustain the changes for a long time, but too much positive reinforcement may lead to an overload of states that can reduce the consequences.
- The goal of positive reinforcement is to increase the likelihood that the agent will select actions that lead to desirable outcomes by associating those actions with positive rewards.
- Examples: In a game-playing scenario, an agent might receive positive rewards (e.g., points, bonuses) for successfully completing a level, making a correct move, or achieving specific goals.

# Reinforcement Machine Learning

## Types of Reinforcement Learning - Positive Reinforcement:-

- Positive reinforcement is widely used in various contexts, including education, parenting, psychology, and behavioral therapy.
- It can be a powerful tool for encouraging desired behaviors and achieving behavioral change by making actions more rewarding and enjoyable.
- **Advantages:-**
- Maximizes Performance
- Sustain Change for a long period of time
- **Disadvantages:-**
- Excess reinforcement can lead to an overload of states which would minimize the results.

# Reinforcement Machine Learning

**Types of Reinforcement Learning - Negative Reinforcement:-**

- The negative reinforcement learning is opposite to the positive reinforcement as it increases the tendency that the specific behavior will occur again by avoiding the negative condition.
- It can be more effective than the positive reinforcement depending on situation and behavior, but it provides reinforcement only to meet minimum behavior.
- Negative comparison learning, sometimes referred to as avoidance learning, focuses on situations where an agent learns to avoid actions or behaviors that lead to negative outcomes or penalties.
- The main goal of negative comparison learning is to reduce the likelihood of specific behaviors occurring by associating them with negative consequences.
- Examples: In negative comparison learning, an agent might receive negative rewards (penalties) when it performs actions that are detrimental to its objectives. For instance, in an autonomous driving system, the agent may receive negative rewards for actions that lead to collisions or violations of traffic rules.

# Reinforcement Machine Learning

**Types of Reinforcement Learning - Negative Reinforcement:-**

- **Advantages:-**
- Maximized behavior
- Provide a decent to minimum standard of performance
- **Disadvantage:-**
- It just limits itself enough to meet up a minimum behavior

# Positive V/S Negative Reinforcement learning

| Criteria | Positive | Negative |
|---|---|---|
| **Definition** | Positive reinforcement involves the presentation of a pleasant or rewarding stimulus immediately following a desired behavior, with the goal of increasing the likelihood of that behavior occurring again in the future. | Negative reinforcement involves the removal or avoidance of an aversive or unpleasant stimulus immediately following a desired behavior, with the goal of increasing the likelihood of that behavior occurring again in the future. |
| **Stimulus Type** | a positive or rewarding stimulus is added or introduced to the individual's environment as a consequence of the desired behavior. | an aversive or unpleasant stimulus is removed or avoided as a consequence of the desired behavior. |
| **Behavioural Outcome** | It encourages the repetition or continuation of the desired behavior because the individual associates it with the receipt of a pleasant outcome or reward.. | It encourages the repetition or continuation of the desired behavior because the individual associates it with the relief or escape from an aversive or unpleasant situation. |
| **Examples** | Giving a child a piece of candy (reward) for completing their homework (desired behavior) is an example of positive reinforcement. Similarly, providing praise (reward) for a job well done (desired behavior) is another example. | Wearing a seatbelt (desired behavior) to turn off the annoying seatbelt warning sound (aversive stimulus) is an example of negative reinforcement. Similarly, taking pain medication (desired behavior) to alleviate physical pain (aversive stimulus) is another example. |

# Supervised V/S Unsupervised V/S Reinforcement learning

| Criteria | Supervised Learning | Unsupervised Learning | Reinforcement Learning |
|---|---|---|---|
| **Input Data** | Input data is labelled. | Input data is not labelled. | Input data is not predefined. |
| **Problem** | Learn pattern of inputs and their labels. | Divide data into classes. | Find the best reward between a start and an end state. |
| **Solution** | Finds a mapping equation on input data and its labels. | Finds similar features in input data to classify it into classes. | Maximizes reward by assessing the results of state-action pairs |
| **Model Building** | Model is built and trained prior to testing. | Model is built and trained prior to testing. | The model is trained and tested simultaneously. |
| **Applications** | Deal with regression and classification problems. | Deals with clustering and associative rule mining problems. | Deals with exploration and exploitation problems. |
| **Algorithms Used** | Decision trees, linear regression, K-nearest neighbors | K-means clustering, k-medoids clustering, agglomerative clustering | Q-learning, SARSA, Deep Q Network |
| **Examples** | Image detection, Population growth prediction | Customer segmentation, feature elicitation, targeted marketing, etc | Drive-less cars, self-navigating vacuum cleaners, etc |