What is Reinforcement Learning?

- Reinforcement Learning is a feedback-based Machine learning technique in which an agent learns to behave in an environment by performing the actions and seeing the results of actions. For each good action, the agent gets positive feedback, and for each bad action, the agent gets negative feedback or penalty.
- In Reinforcement Learning, the agent learns automatically using feedbacks without any labeled data, unlike supervised learning.
- Since there is no labeled data, so the agent is bound to learn by its experience only.
- 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.
- 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.

supervised learning Learning that takes place based on a class of examples is referred to as supervised learning. It is learning based on labelled data. In short, while learning, the system has knowledge of a set of labelled data. This is one of the most common and frequently used learning methods

The supervised learning method is comprised of a series of algorithms that build mathematical models of certain data sets that are capable of containing both inputs and the desired outputs for that particular machine.

The data being inputted into the supervised learning method is known as training data, and essentially consists of training examples which contain one or more inputs and typically only one desired output. This output is known as a "supervisory signal."

In the training examples for the supervised learning method, the training example is represented by an array, also known as a vector or a feature vector, and the training data is represented by a matrix.

The algorithm uses the iterative optimization of an objective function to predict the output that will be associated with new inputs.

Ideally, if the supervised learning algorithm is working properly, the machine will be able to correctly determine the output for the inputs that were not a part of the training data.

• Supervised learning uses classification and regression techniques to develop predictive models.

Classification techniques predict categorical responses,

• Regression techniques predict continuous responses, for example, changes in temperature or fluctuations in power demand. Typical applications include electricity load forecasting and algorithmic trading.

Let us begin by considering the simplest machine-learning task: supervised learning for classification. Let us take an example of classification of documents. In this particular case a learner learns based on the available documents and their classes. This is also referred to as labelled data.

The program that can map the input documents to appropriate classes is called a classifier, because it assigns a class (ie., document type) to an object (ie., a document). The task of supervised learning is to construct a classifier given a set of classified training examples. A typical classification is depicted in

represents a hyperplane that has been generated after learning, separating two classes - class A and class B in different parts. Each input point presents input-output instance from sample space. In case of document classification, these points are documents.

Application ML

Speech Recognition: While using Google, we get an option of "**Search by voice**," it comes under speech recognition, and it's a popular application of machine learning. Speech recognition is a process of converting voice instructions into text, and it is also known as "**Speech to text**", or "**Computer speech recognition**." At present, machine learning algorithms are widely used by various applications of speech recognition. **Google assistant**, **Siri**, **Cortana**, and **Alexa** are using speech recognition technology to follow the voice instructions.

Traffic prediction: If we want to visit a new place, we take help of Google Maps, which shows us the correct path with the shortest route and predicts the traffic conditions. It predicts the traffic conditions such as whether traffic is cleared, slow-moving, or heavily congested with the help of two ways:

Real Time location of the vehicle form Google Map app and sensors

Average time has taken on past days at the same time.

Self-driving cars: One of the most exciting applications of machine learning is self-driving cars. Machine learning plays a significant role in self-driving cars. Tesla, the most popular car manufacturing company is working on self-driving car. It is using unsupervised learning method to train the car models to detect people and objects while driving.

Stock Market trading: Machine learning is widely used in stock market trading. In the stock market, there is always a risk of up and downs in shares, so for this machine learning's **long short term memory neural network** is used for the prediction of stock market trends.

Medical Diagnosis:

In medical science, machine learning is used for diseases diagnoses. With this, medical technology is growing very fast and able to build 3D models that can predict the exact position of lesions in the brain.It helps in finding brain tumors and other brain-related diseases easily.

Criteria	Supervised ML	Unsupervised ML	Reinforcement ML
Definition	Learns by using labelled data	Trained using unlabelled data without any guidance.	Works on interacting with the environment
Type of data	Labelled data	Unlabelled data	No – predefined data
Type of problems	Regression and classification	Association and Clustering	Exploitation or Exploration
Supervision	Extra supervision	No supervision	No supervision
Algorithms	Linear Regression, Logistic Regression, SVM, KNN etc.	K – Means, C – Means, Apriori	Q – Learning, SARSA
Aim	Calculate outcomes	Discover underlying patterns	Learn a series of action
Application	Risk Evaluation, Forecast Sales	Recommendation System, Anomaly Detection	Self Driving Cars, Gaming, Healthcare

Aspects	Data Science	Machine Learning	Artificial Intelligence
Job roles	Data Engineer, Data Scientist, Data Analyst, Data Architect,Database Administrator, Machine Learning Engineer, Statistician,Business Analyst, Data and Analytics Manager.	Machine Learning Engineer, Data Architect, Data Scientist, Data Mining Specialist, Cloud Architect, and Cyber Security Analyst, and more.	Machine Learning Engineer, Data Scientist,Business Intelligence Developer,Big Data Architect, Research Scientist.
Skills	Programming Skills.Statistics.Machine Learning. Multivariable Calculus & Linear AlgebraData Visualization & CommunicationSoftware Engineering.Data Intuition.	StatisticsProbabilityData ModelingPrograming SkillsApplying ML Libraries & Algorithms, Software Design, Python	Mathematical and Algorithms skills, Probability and Statistics knowledge, Expertise In Programming – Python, C++, R, JavaWell-versed with Unix Tools, Awareness about Advanced Signal Processing Techniques.
Salary	1050k/year Average base pay	1123k/year. Average base pay	Rs 14.3 lakhs per annum

Introduction to Matrix Factorization

Matrix factorization is a way to generate latent features when multiplying two different kinds of entities. Collaborative filtering is the application of matrix factorization to identify the relationship between items' and users' entities. With the input of users' ratings on the shop items, we would like to predict how the users would rate the items so the users can get the recommendation based on the prediction.

Assume we have the customers' ranking table of 5 users and 5 movies, and the ratings are integers ranging from 1 to 5, the matrix is provided by the table below.

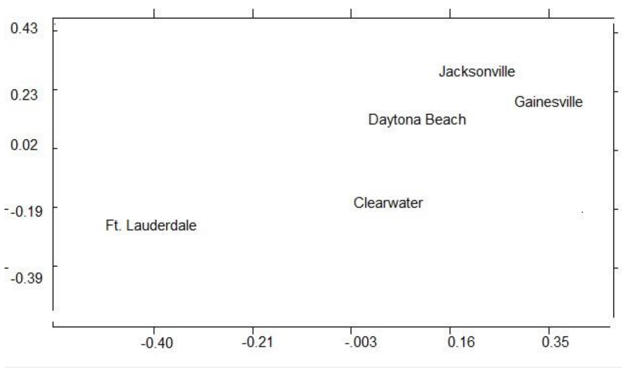
	Movie1	Movie2	Movie3	Movie4	Movie5
U1		5	4	2	1
U2	1			5	3
U3	1	4	4	1	
U4			2		2
U5	3	1	1		

a scenario, user 4 didn't give a rating to the movie 4. We'd like to know if user 4 would like movie 4. The method is to discover other users with similar preferences of user 4 by taking the ratings given by users of similar preferences to the movie 4 and predict whether the user 4 would like the movie 4 or not

Multidimensional scaling is a **visual representation of distances or dissimilarities between sets of objects**. “Objects” can be colors, faces, map coordinates, political persuasion, or any kind of real or conceptual stimuli (Kruskal and Wish, 1978). Objects that are more similar (or have shorter distances) are closer together on the graph than objects that are less similar (or have longer distances). As well as interpreting dissimilarities as distances on a graph, MDS can also serve as a dimension reduction technique for high-dimensional data

For a simple example, let’s say you had a set of cities in Florida and their distances:

CITY	Clearwater	Daytona Beach	Ft. Lauderdale	Gainesville	Jacksonville
Clearwater	0	159	247	131	197
Daytona Beach	159	0	230	97	89
Ft. Lauderdale	247	230	0	309	317
Gainesville	131	97	309	0	68
Jacksonville	197	89	317	68	0



The scaling produces a graph like the one below.
The very simple example above shows cities and distances, which are easy to visualize as a map. However, multidimensional scaling can work on “theoretically” mapped data as well. For example, Kruskal and Wish (1978) outlined how the method could be used to uncover the answers to a variety of questions about people’s viewpoints on political candidates. This could be achieved by reducing the data and issues (say, partisanship and ideology) to a two-dimensional map.

Basic steps:

Assign a number of points to coordinates in n-dimensional space. *N*-dimensional space could be 2-dimensional, 3-dimensional, or higher spaces.

Calculate Euclidean distances for all pairs of points. The Euclidean distance is the “as the crow flies” straight-line distance between two points x and y in Euclidean space.

Compare the similarity matrix with the original input matrix by evaluating the stress function. *Stress* is a goodness-of-fit measure, based on differences between predicted and actual distances. , Kruskal wrote that fits close to zero are excellent

Adjust coordinates, if necessary, to minimize stress.

Principal component analysis, or PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set.

Reducing the number of variables of a data set naturally comes at the expense of accuracy, but the trick in dimensionality reduction is to trade a little accuracy for simplicity.

reduce the number of variables of a data set, while preserving as much information as possible.

STEP 1: STANDARDIZATION

The aim of this step is to standardize the range of the continuous initial variables so that each one of them contributes equally to the analysis.

More specifically, the reason why it is critical to perform standardization prior to PCA, is that the latter is quite sensitive regarding the variances of the initial variables

. $$z = \frac{value - mean}{standard\ deviation}$$

Once the standardization is done, all the variables will be transformed to the same scale.

STEP 2: COVARIANCE MATRIX COMPUTATION

The aim of this step is to understand how the variables of the input data set are varying from the mean with respect to each other, or in other words, to see if there is any relationship between them

$$\begin{bmatrix} Cov(x,x) & Cov(x,y) & Cov(x,z) \\ Cov(y,x) & Cov(y,y) & Cov(y,z) \\ Cov(z,x) & Cov(z,y) & Cov(z,z) \end{bmatrix}$$

Covariance Matrix for 3-Dimensional Data

Since the covariance of a variable with itself is its variance (Cov(a,a)=Var(a)), in the main diagonal (Top left to bottom right) we actually have the variances of each initial variable. And since the covariance is commutative (Cov(a,b)=Cov(b,a))

STEP 3: COMPUTE THE EIGENVECTORS

Eigenvectors and eigenvalues are the linear algebra concepts that we need to compute from the covariance matrix in order to determine the principal components of the data. Before getting to the explanation of these concepts, let’s first understand what do we mean by principal components.

1)Min-Max scaler

$$x_{new} = \frac{x - x_{min}}{x_{max} - x_{min}}$$

Transform features by scaling each feature to a given range. This estimator scales and translates each feature individually such that it is in the given range on the training set This Scaler responds well if the standard deviation is small and when a distribution is **not Gaussian**. This Scaler is **sensitive to outliers**.

2) Standard Scaler

$$x_{new} = \frac{x - \mu}{\sigma}$$

The Standard Scaler assumes data is normally distributed within each feature and scales them such that the distribution centered around 0, with a standard deviation of 1.

Z-Score Normalization

Z-Score helps in the normalization of data. If we normalize the data into a simpler form with the help of z score normalization, then it's very easy to understand by our brains

Box cox

A Box Cox transformation is a transformation of non-normal dependent variables into a normal shape. Normality is an important assumption for many statistical techniques; if your data isn't normal, applying a Box-Cox means that you are able to run a broader number of tests