1-Machine Learning Paradigms

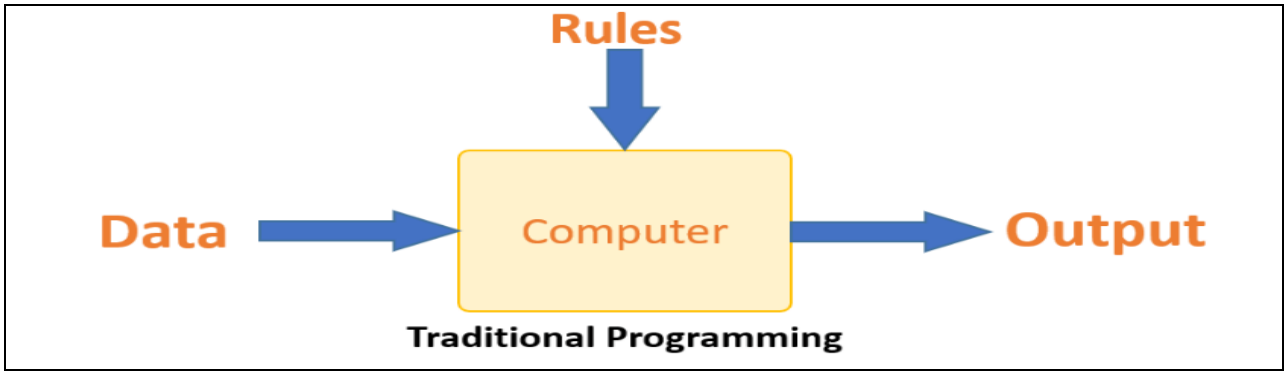
Introduction

- Machine Learning is a system that can learn from example through self-improvement and without being explicitly coded by programmer.
- The breakthrough comes with the idea that a machine can singularly learn from the data (i.e., example) to produce accurate results.
- Machine learning combines data with statistical tools to predict an output.
- This output is then used by corporate to makes actionable insights.
- Machine learning is closely related to data mining and Bayesian predictive modeling.
- The machine receives data as input, use an algorithm to formulate answers.
- Machine learning is also used for a variety of task like fraud detection, predictive maintenance, portfolio optimization, automatize task and so on.

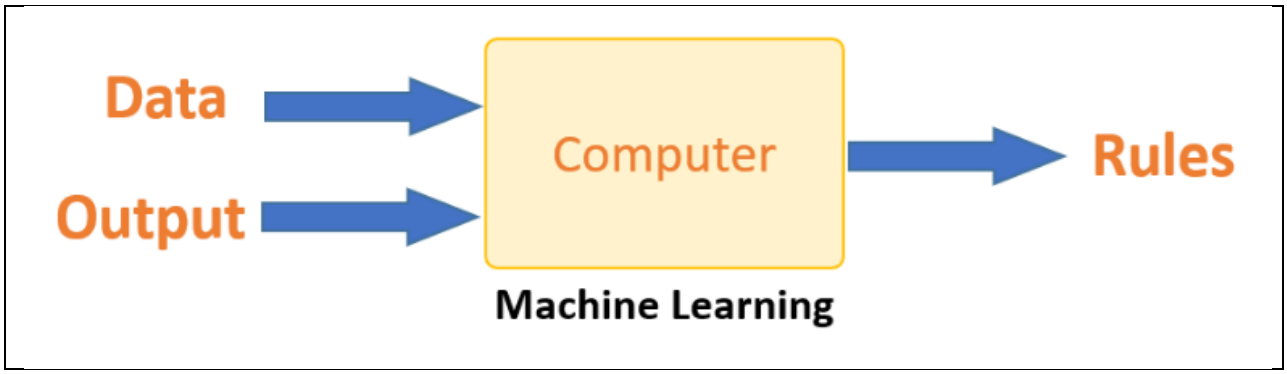
Machine Learning vs. Traditional Programming

Traditional programming differs significantly from machine learning.

- In traditional programming, a programmer code all the rules in consultation with an expert in the industry for which software is being developed. Each rule is based on a logical foundation; the machine will execute an output following the logical statement. When the system grows complex, more rules need to be written. It can quickly become unsustainable to maintain.



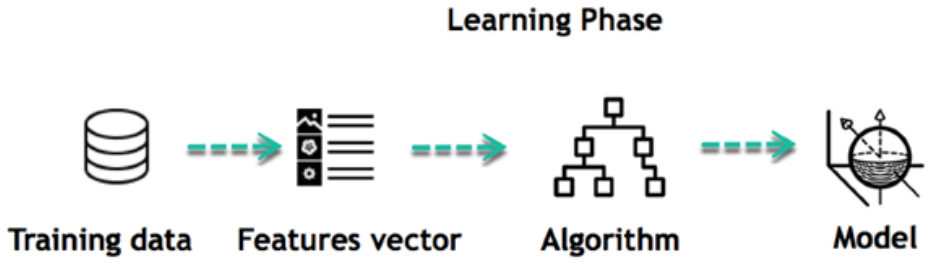
Machine learning is supposed to overcome this issue. The machine learns how the input and output data are correlated and it writes a rule. The programmers do not need to write new rules each time there is new data. The algorithms adapt in response to new data and experiences to improve efficacy over time.



How does Machine learning work?

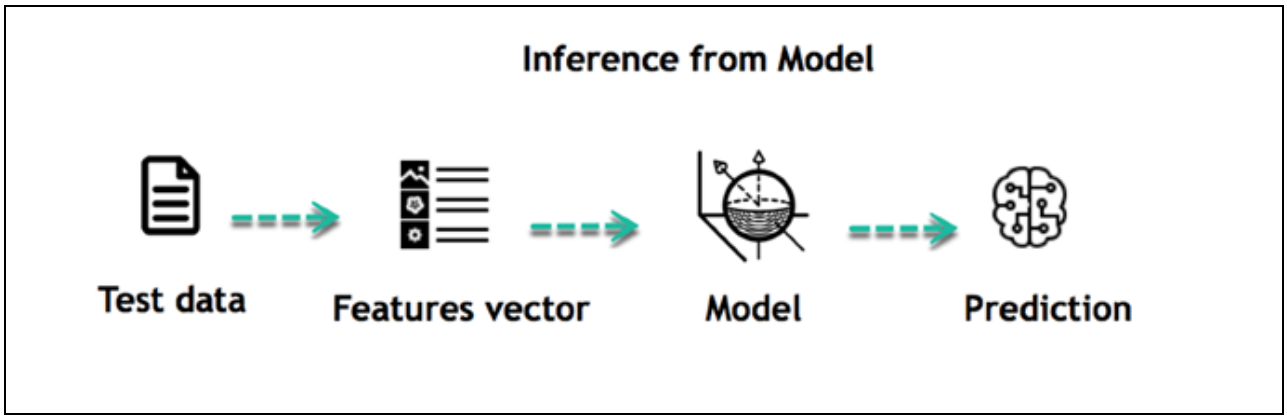
- Machine learning is the brain where all the learning takes place. The way the machine learns is similar to the human being. Humans learn from experience. The more we know, the more easily we can predict.
- By analogy, when we face an unknown situation, the likelihood of success is lower than the known situation.
- Machines are trained the same. To make an accurate prediction, the machine sees an example. When we give the machine a similar example, it can figure out the outcome. However, like a human, if its feed a previously unseen example, the machine has difficulties to predict.
- The core objective of machine learning is the **learning** and **inference**.
- First of all, the machine learns through the discovery of patterns. This discovery is made thanks to the **data**. One crucial part of the data scientist is to choose carefully which data to provide to the machine.
- The list of attributes used to solve a problem is called a **feature vector.** You can think of a feature vector as a subset of data that is used to tackle a problem.

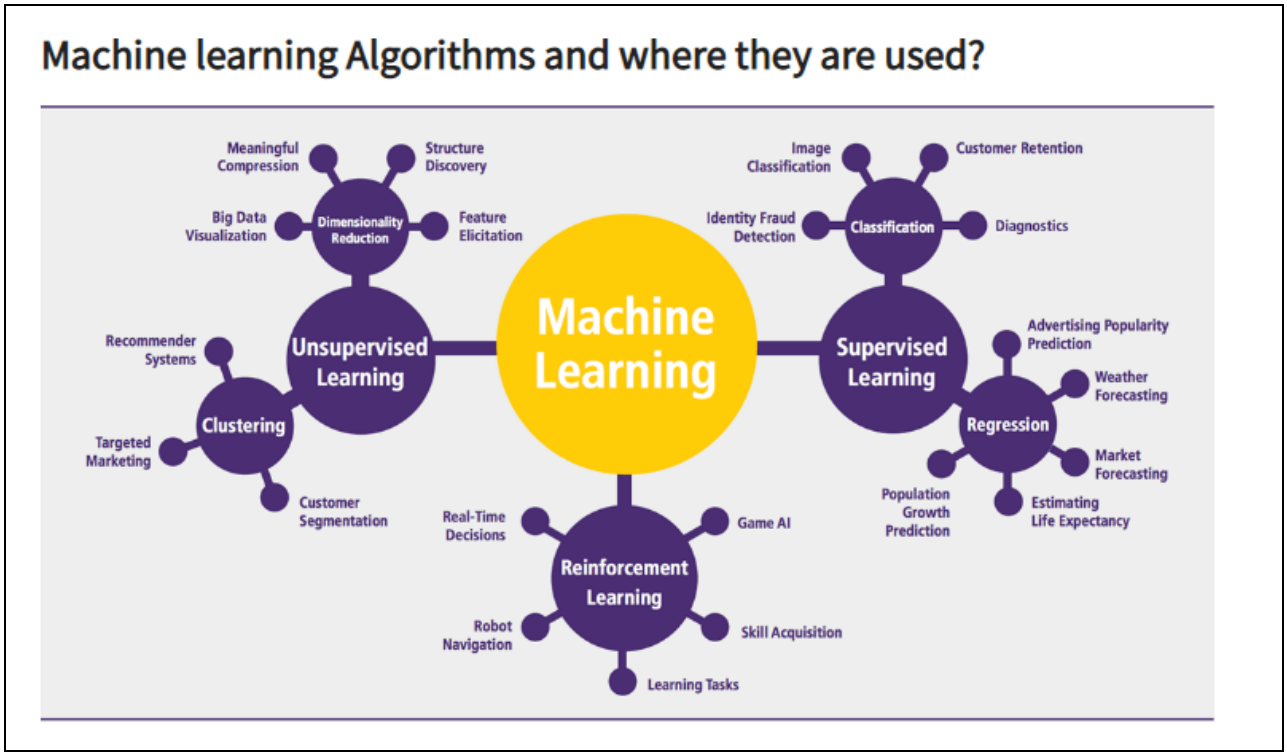
The machine uses some fancy algorithms to simplify the reality and transform this discovery into a **model**. Therefore, the learning stage is used to describe the data and summarize it into a model.



Inferring

When the model is built, it is possible to test how powerful it is on never-seen-before data. The new data are transformed into a features vector, go through the model and give a prediction. This is all the beautiful part of machine learning. There is no need to update the rules or train again the model. You can use the model previously trained to make inference on new data.

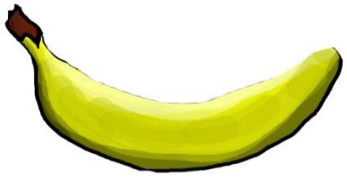




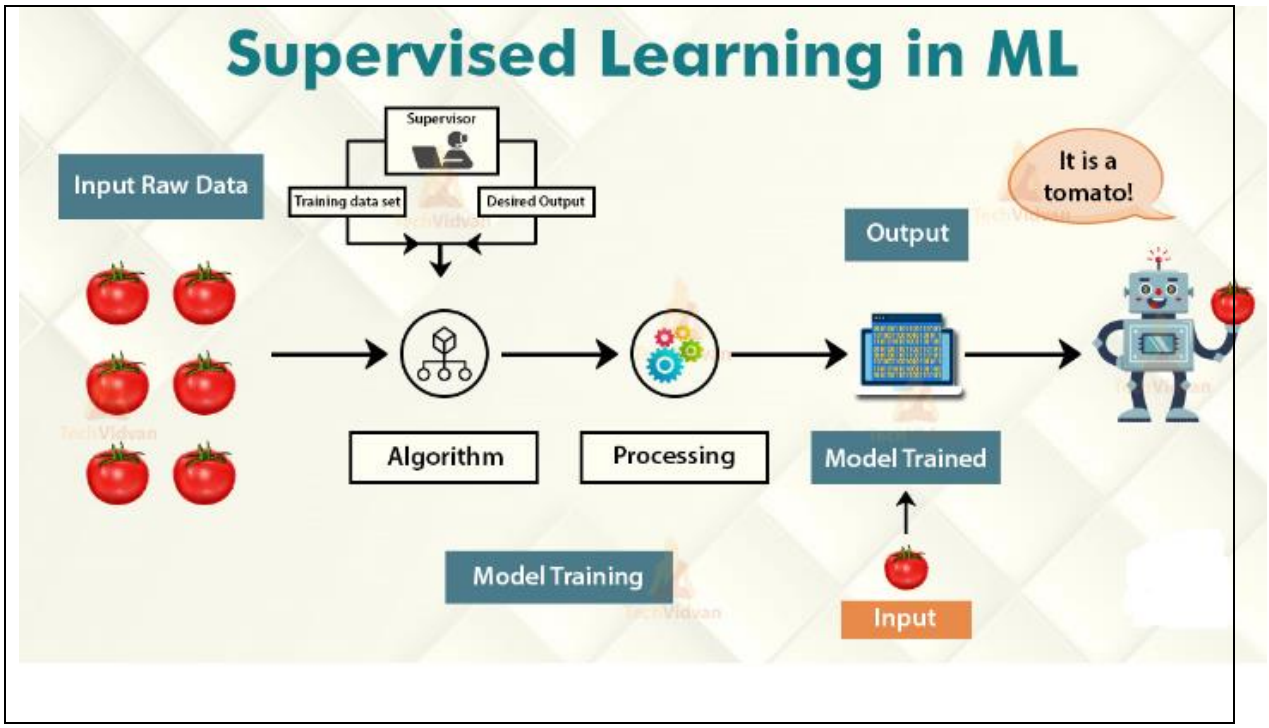
Supervised learning

- Supervised learning as the name indicates the presence of a supervisor as a teacher.
- Basically supervised learning is a learning in which we teach or train the machine using data which is well labeled that means some data is already tagged with the correct answer.
- After that, the machine is provided with a new set of examples(data) so that supervised learning algorithm analyses the training data(set of training examples) and produces a correct outcome from labeled data.
- For instance, suppose you are given an basket filled with different kinds of fruits. Now the first step is to train the machine with all different fruits one by one like this:

- If shape of object is rounded and depression at top having color Red then it will be labelled as –Apple.
- If shape of object is long curving cylinder having color Green-Yellow then it will be labelled as –Banana.
- Now suppose after training the data, you have given a new separate fruit say Banana from basket and asked to identify it.



- Since the machine has already learned the things from previous data and this time have to use it wisely.
- It will first classify the fruit with its shape and color and would confirm the fruit name as BANANA and put it in Banana category.
- Thus the machine learns the things from training data(basket containing fruits) and then apply the knowledge to test data(new fruit).

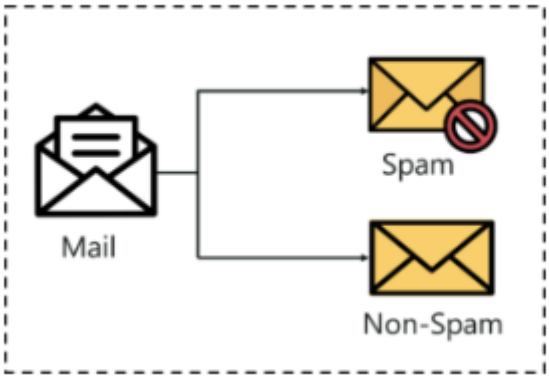


There are two categories of supervised learning:

- Classification task
- Regression task

Classification task

- In **machine learning**, **classification** refers to a predictive modeling problem where a class label is predicted for a given example of input data.
- Classification in machine learning and statistics is a supervised learning approach in which the computer program learns from the data given to it and make new observations or classifications.
- Classification is a process of categorizing a given set of data into classes, It can be performed on both structured or unstructured data. The process starts with predicting the class of given data points. The classes are often referred to as target, label or categories.
- The classification predictive modeling is the task of approximating the mapping function from input variables to discrete output variables. The main goal is to identify which class/category the new data will fall into.



Regression task

- **Regression** analysis consists of a set of **machine learning** methods that allow us to predict a continuous outcome variable (y) based on the value of one or multiple predictor variables (x). Briefly, the goal of **regression** model is to build a mathematical equation that defines y as a function of the x variables.
- Regression models are used to predict a continuous value. Predicting prices of a house given the features of house like size, price etc is one of the common examples of Regression. It is a supervised technique.

Types of Regression

1. Simple Linear Regression
2. Polynomial Regression
3. Support Vector Regression
4. Decision Tree Regression
5. Random Forest Regression

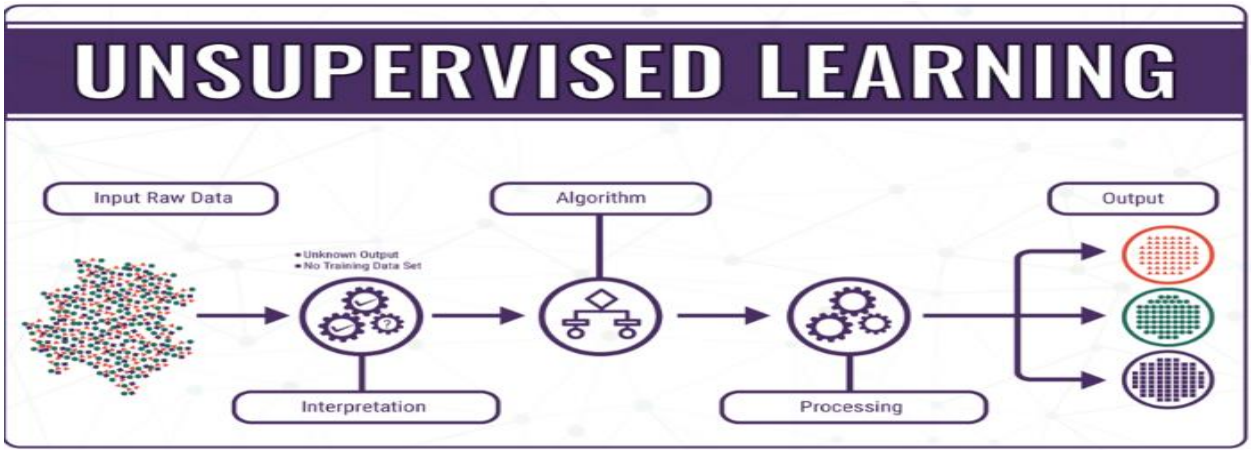
Unsupervised learning

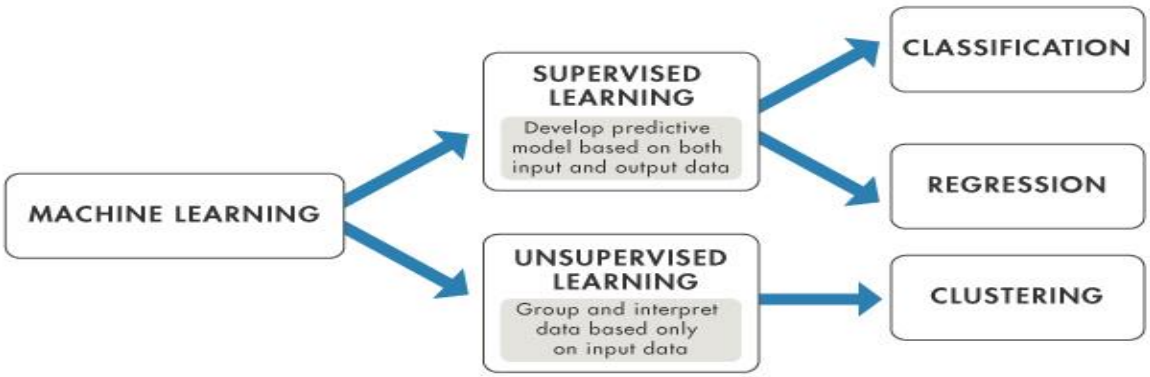
- Unsupervised learning is the training of machine using information that is neither classified nor labeled and allowing the algorithm to act on that information without guidance.
- Here the task of machine is to group unsorted information according to similarities, patterns and differences without any prior training of data.
- Unlike supervised learning, no teacher is provided that means no training will be given to the machine.
- Therefore machine is restricted to find the hidden structure in unlabeled data by our-self.
- For instance, suppose it is given an image having both dogs and cats which have not seen ever.

- Thus the machine has no idea about the features of dogs and cat so we can't categorize it in dogs and cats.
- But it can categorize them according to their similarities, patterns, and differences i.e., we can easily categorize the above picture into two parts.
- First first may contain all pics having dogs in it and second part may contain all pics having cats in it.
- Here you didn't learn anything before, means no training data or examples.

Clustering

- **Cluster** analysis, or **clustering**, is an unsupervised **machine learning** task. It involves automatically discovering natural grouping in data.
- Unlike supervised **learning** (like predictive modeling), **clustering** algorithms only interpret the input data and find natural groups or **clusters** in feature space.
- Clustering is the assignment of a set of observations into subsets (called clusters) so that observations in the same cluster are similar in some sense.
- Clustering is a method of unsupervised learning, and a common technique for statistical data analysis used in many fields.



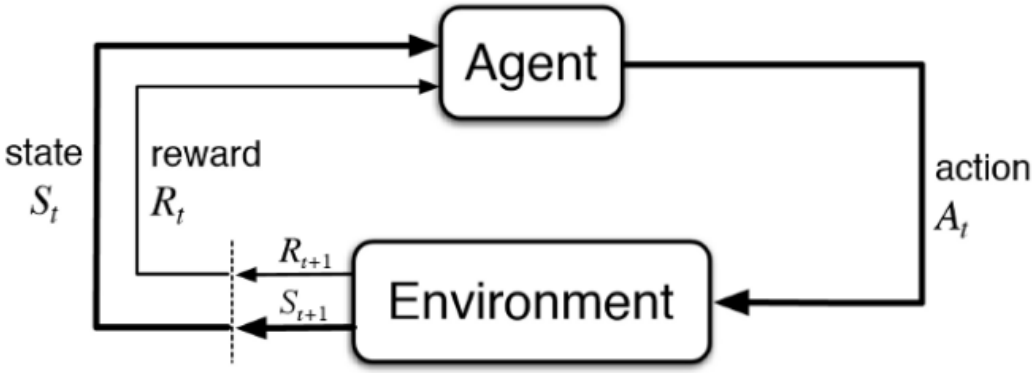


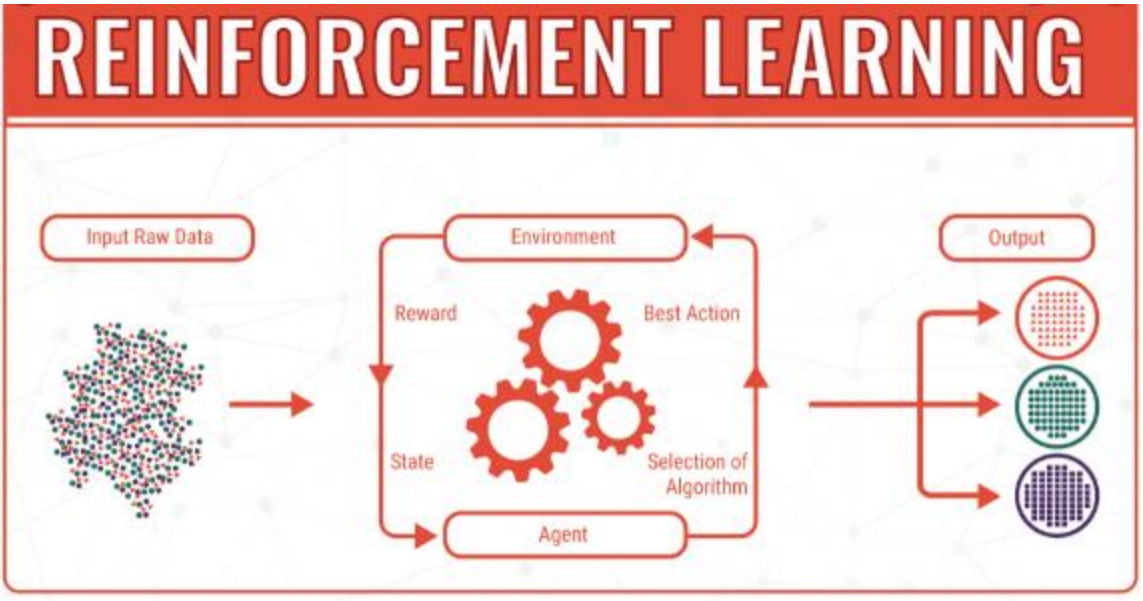
Reinforcement Learning

- 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.
- 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.

As compared to unsupervised learning, reinforcement learning is different in terms of goals. While the goal in unsupervised learning is to find similarities and differences between data points, in the case of reinforcement learning the goal is to find a suitable action model that would maximize the **total cumulative reward** of the agent. The figure below illustrates the **action-reward feedback loop** of a generic RL model.



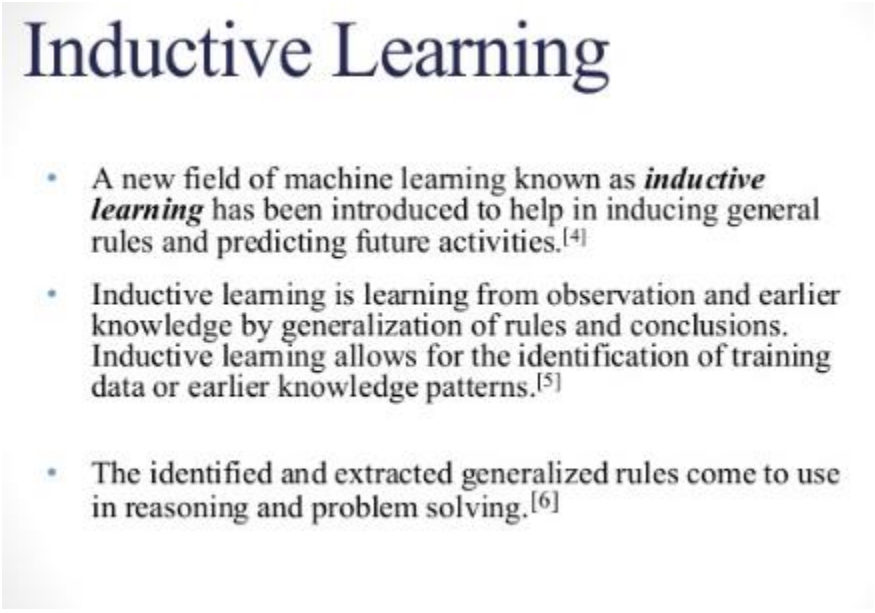


Inductive Learning

- Inductive learning: system tries to induce a "general rule" from a set of observed instances.
- Inductive Learning is where we are given examples of a function in the form of data (x) and the output of the function (f(x)). The goal of inductive learning is to learn the function for new data (x).
- From the perspective of inductive learning, we are given input samples (x) and output samples (f(x)) and the problem is to estimate the function (f). Specifically, the problem is to generalize from the samples and the mapping to be useful to estimate the output for new samples in the future.

Example:
System tries to make a "general rule" from a set of observed data.
Mango -> f(Mango) -> sweet(e1)
Banana -> f(Banana) -> sweet(e2)
Apple -> f(Apple) -> sweet(e3)
…….
…..
Machine makes a general rule as
Fruits -> f(Fruits) -> sweet general rule

Summary of Inductive Learning



Deductive learning

- Deductive learning is a subclass of machine learning that studies algorithms for learning provably correct knowledge.
- Typically such methods are used to speedup problem solvers by adding knowledge to them that is deductively entailed by existing knowledge, but that may result in faster solutions.

Example :
A = B
B = C
Then we can deduce much confidence that
A = C (Deductive learning)

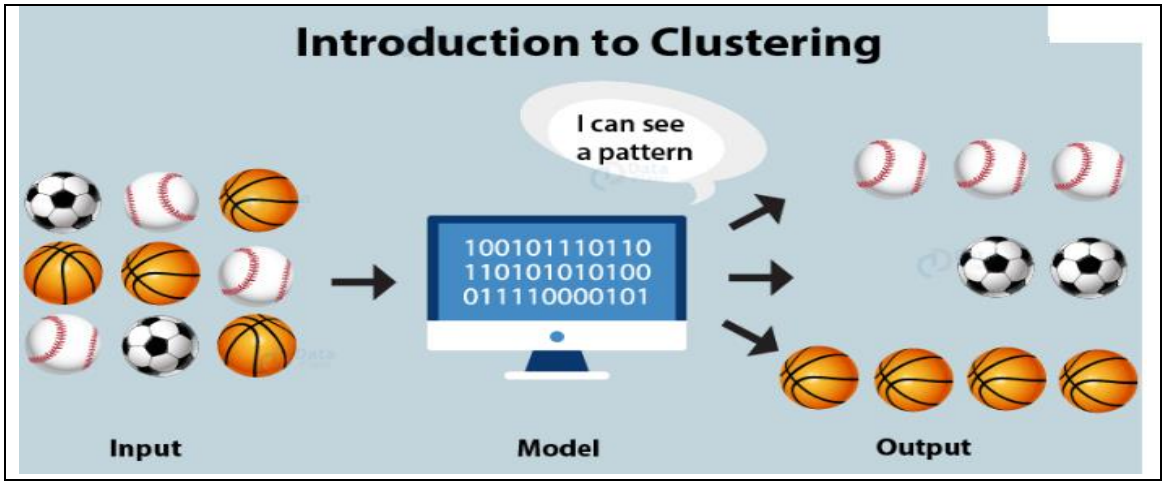
Basis for comparison	Deductive Reasoning	Inductive Reasoning
Definition	Deductive reasoning is the form of valid reasoning, to deduce new information or conclusion from known related facts and information.	Inductive reasoning arrives at a conclusion by the process of generalization using specific facts or data.
Approach	Deductive reasoning follows a top-down approach.	Inductive reasoning follows a bottom-up approach.
Starts from	Deductive reasoning starts from Premises.	Inductive reasoning starts from the Conclusion.
Validity	In deductive reasoning conclusion must be true if the premises are true.	In inductive reasoning, the truth of premise does not guarantee the truth of conclusions.
Usage	Use of deductive reasoning is difficult, as we need facts which must be true.	Use of inductive reasoning is fast and easy, as we need evidence instead of true facts. We often use it in our daily life.
Process	Theory→ hypothesis→ patterns→confirmation.	Observations- →patterns→hypothesis→Theory.
Argument	In deductive reasoning, arguments may be valid or invalid.	In inductive reasoning, arguments may be weak or strong.
Structure	Deductive reasoning reaches from general facts to specific facts.	Inductive reasoning reaches from specific facts to general facts.

Inductive Machine Learning	Deductive Machine Learning
Observe and learn from the set of instances and then draw the conclusion	Derives conclusion and then work on it based on the previous decision
It is Statistical machine learning like KNN (K-nearest neighbor) or SVM (Support Vector Machine)	Machine learning algorithm to deductive reasoning using a decision tree
$A \bigwedge B \vdash A \rightarrow B$ (Induction)	$A \bigwedge (A \rightarrow B) \vdash B$ (Deduction)

Clustering

- Clustering is the task of dividing the population or data points into a number of groups such that data points in the same groups are more similar to other data points in the same group and dissimilar to the data points in other groups.
- It is basically a collection of objects on the basis of similarity and dissimilarity between them.
- Cluster analysis, or clustering, is an unsupervised machine learning task.
- It involves automatically discovering natural grouping in data.
- Unlike supervised learning (like predictive modeling), clustering algorithms only interpret the input data and find natural groups or clusters in feature space.

For example, when you go out for grocery shopping, you easily distinguish between apples and oranges in a given set containing both of them. You distinguish these two objects based on their color, texture and other sensory information that is processed by your brain. Clustering is an emulation of this process so that machines are able to distinguish between different objects.



Cased based reasoning and learning

- Case-based reasoning (CBR), broadly construed, is the process of solving new problems based on the solutions of similar past problems.[1] An auto mechanic who fixes an engine by recalling another car that exhibited similar symptoms is using case-based reasoning.
- Case-based reasoning has been formalized for purposes of computer reasoning as a four-step process:

Retrieve:

Given a target problem, retrieve from memory cases relevant to solving it. A case consists of a problem, its solution, and, typically, annotations about how the solution was derived.

Reuse:

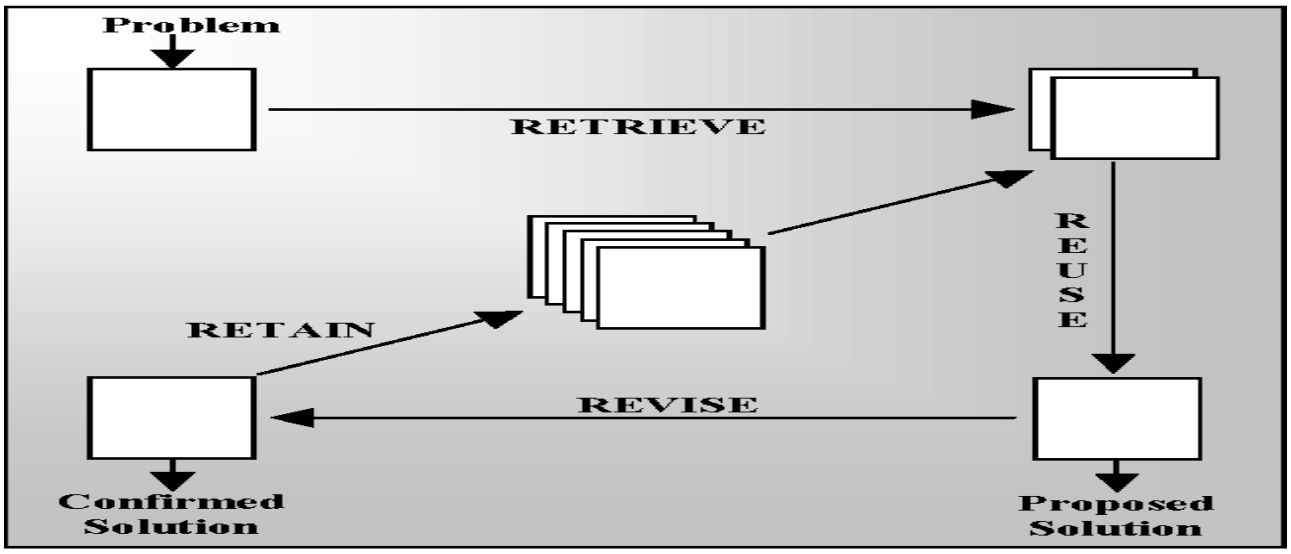
Map the solution from the previous case to the target problem. This may involve adapting the solution as needed to fit the new situation.

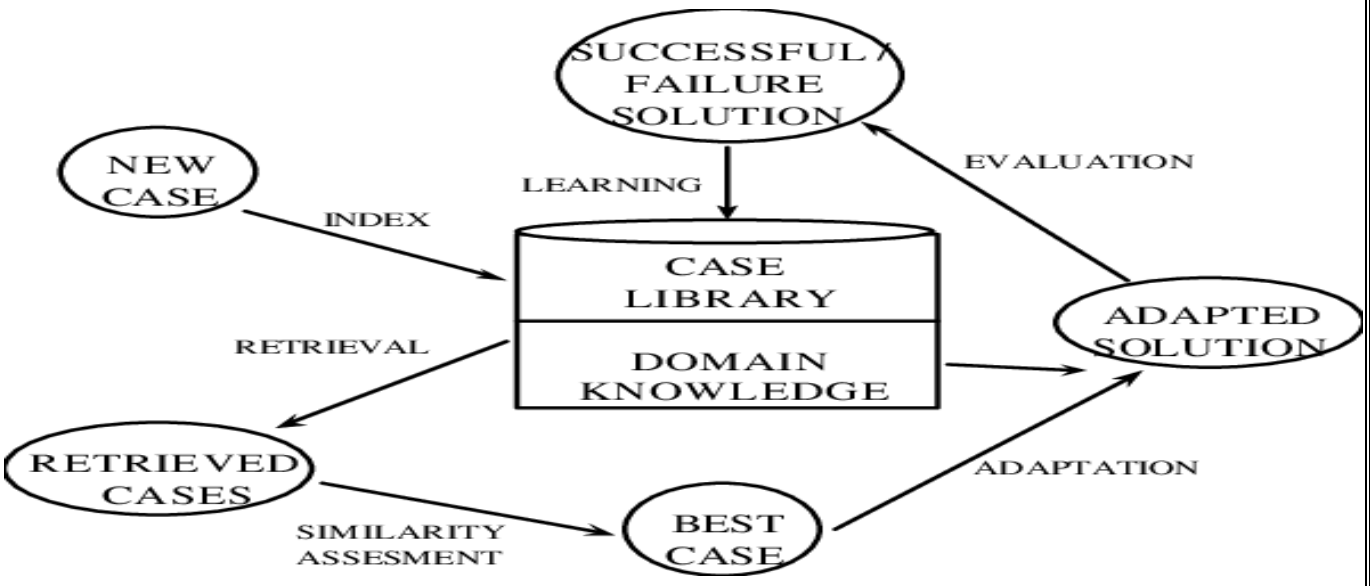
Revise:

Having mapped the previous solution to the target situation, test the new solution in the real world (or a simulation) and, if necessary, revise.

Retain:

After the solution has been successfully adapted to the target problem, store the resulting experience as a new case in memory.




SUCCESSFUL / FAILURE SOLUTION
NEW CASE
INDEX
LEARNING
EVALUATION
CASE LIBRARY
DOMAIN KNOWLEDGE
ADAPTED SOLUTION
RETRIEVAL
RETRIEVED CASES
SIMILARITY ASSESMENT
BEST CASE
ADAPTATION