Introduction to ML

Unit #1

Marwadi University

Department of
Computer Engineering

Machine Learning
Sem 7
01CE0715
4 Credits

Prof. Urvi Bhatt

Course Outcomes

After completion of this course, students will be able to

- Understand machine-learning concepts.
- Understand and implement Classification concepts.
- Understand and analyse the different Regression algorithms.
- Apply the concept of Unsupervised Learning.
- Apply the concepts of Artificial Neural Networks.

Topics

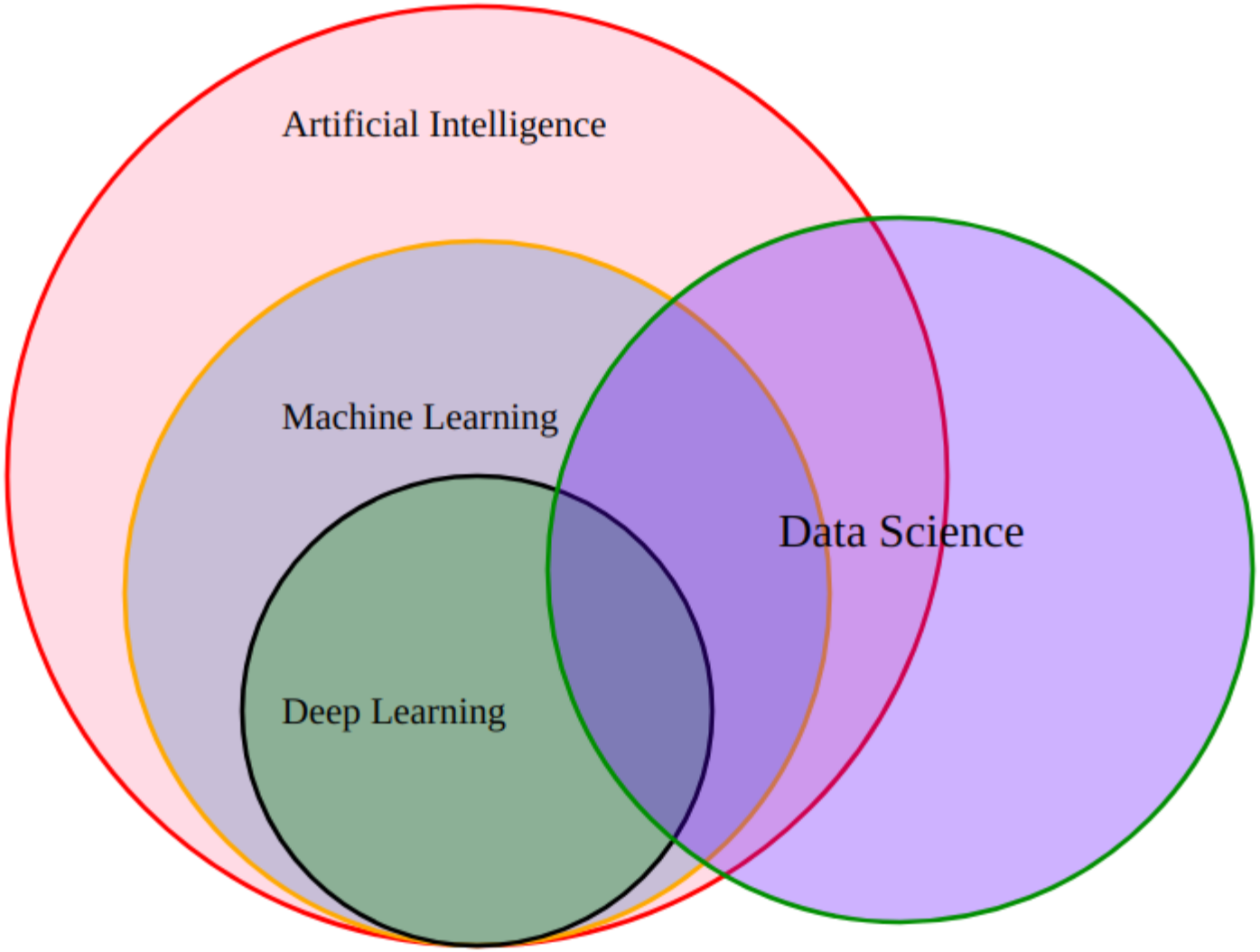
Introduction to ML:

- Motivation and Applications
- Importance of Data Visualization
- Basics of Supervised, Unsupervised, and Reinforcement Learning
- Current research trends in ML

Machine Learning Introduction

- ML is an interdisciplinary field:
  - **Data Analyst:** visualize, analyze data, optimization
  - **Data Engineers:** build and test scalable / stable / optimal ecosystems for data scientists to run their algorithms
  - **Database Administrator:** responsible for the proper functioning of all the databases.
  - **Data Scientist:** perform predictive analysis and offer actionable insights.
  - **Statistician:** extract and offer valuable insights from the data using statistical theory and tools.

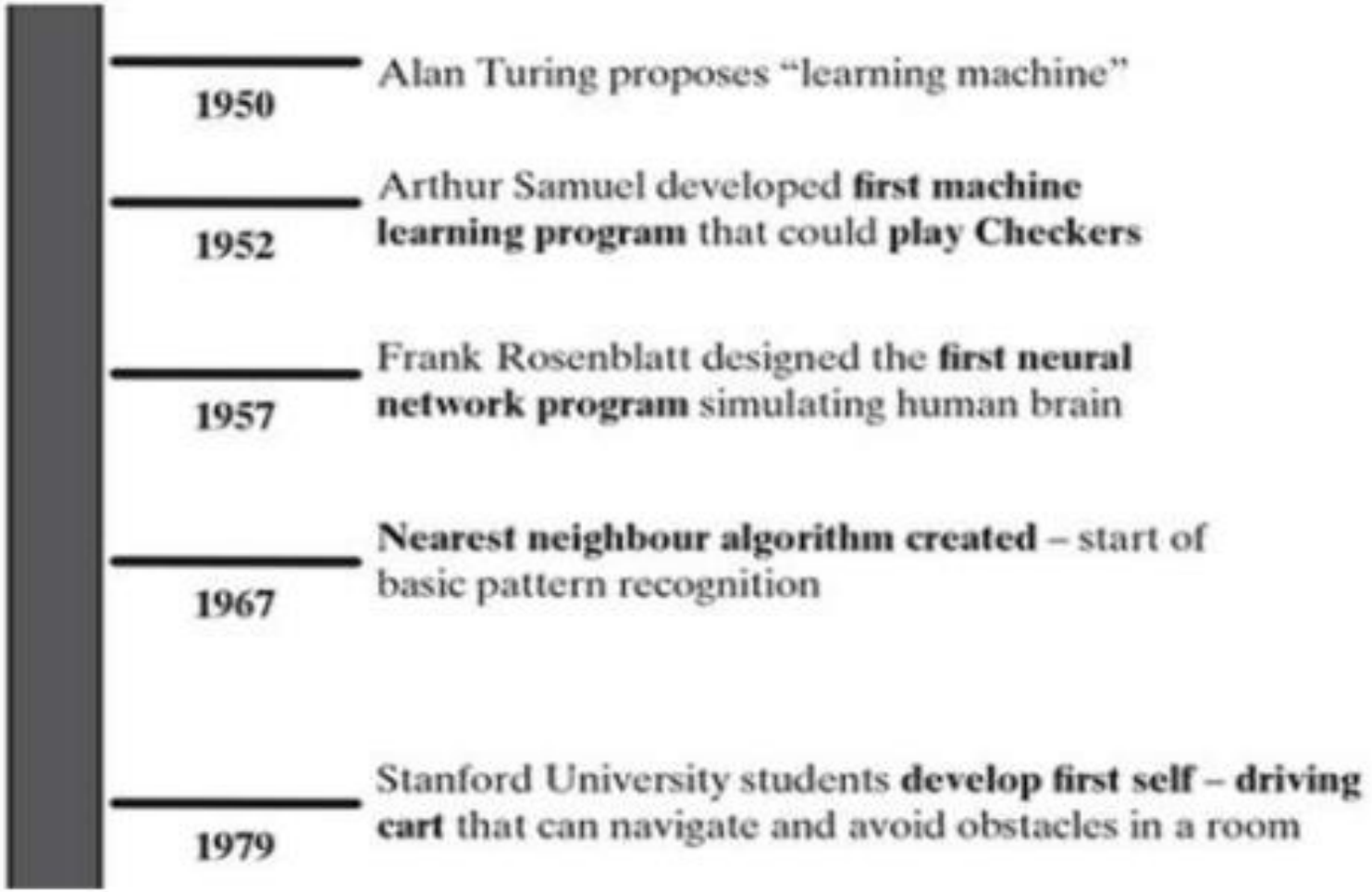
Machine Learning Introduction



Machine Learning Introduction

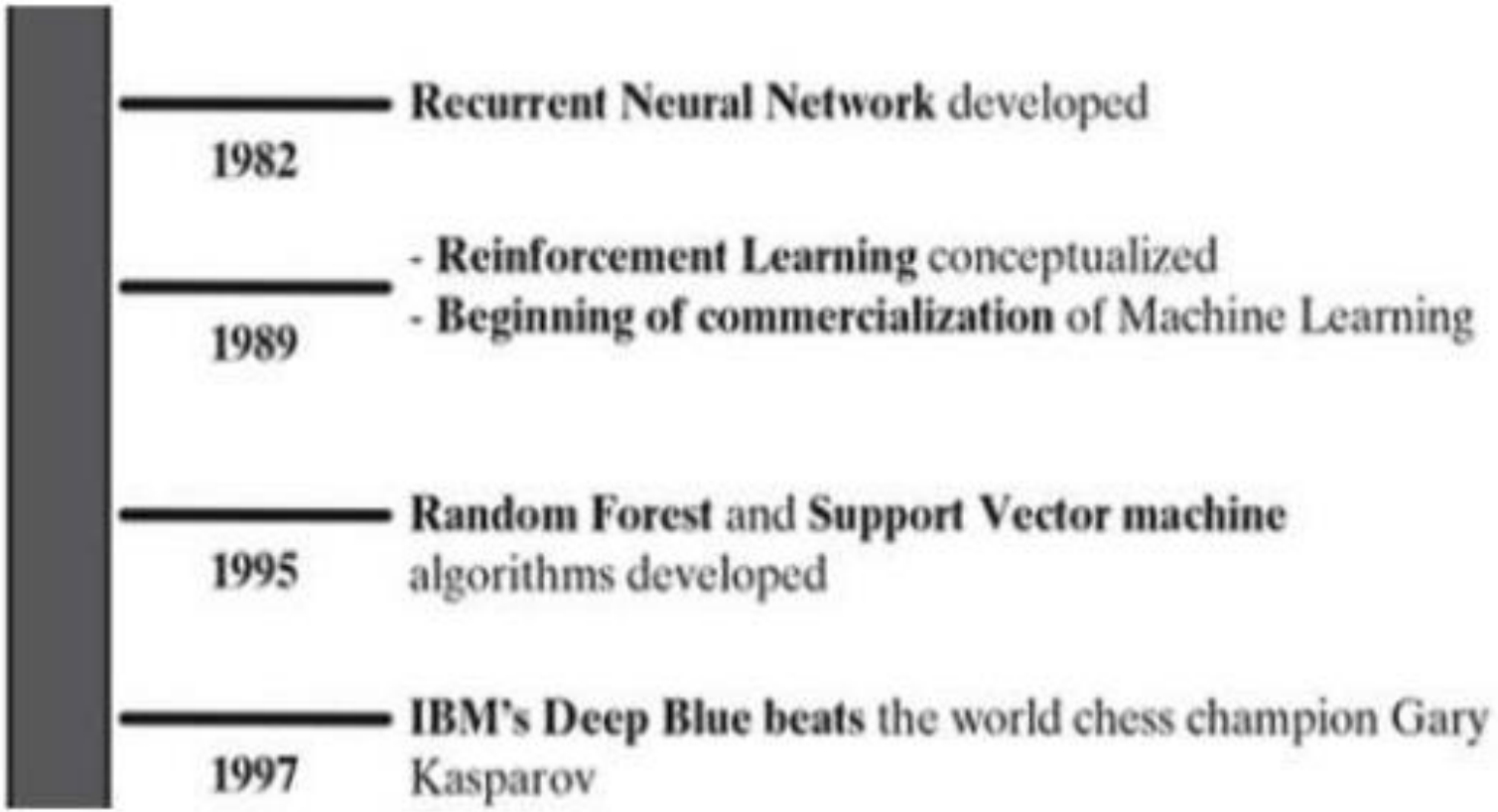
- AI stands for **Artificial Intelligence**, and is basically the study/process which enables machines to mimic human behavior through particular algorithm.
- ML stands for **Machine Learning**, and is the study that uses statistical methods enabling machines to improve with experience.
- DL stands for **Deep Learning**, and is the study that makes use of Neural Networks(similar to neurons present in human brain) to imitate functionality just like a human brain.
- **Data science** is the field of applying advanced analytics techniques and scientific principles to extract valuable information from data for business decision-making, strategic planning and other uses.

Evaluation of Machine Learning



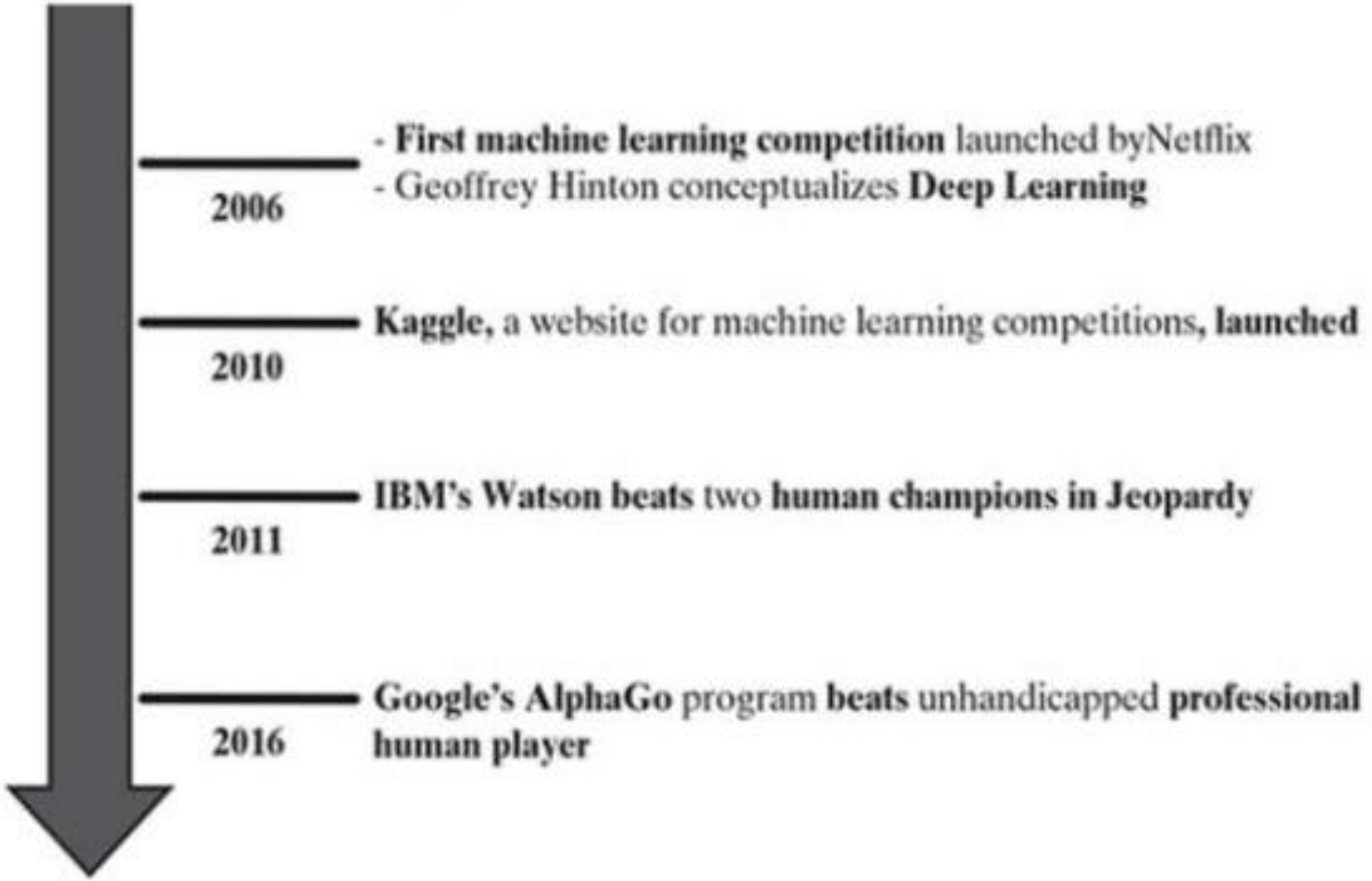
Evaluation of Machine Learning

- Continued



Evaluation of Machine Learning

- Continued



What is Human Learning?

- In cognitive science, learning is typically referred to as the process of **gaining information through observation**.
- A task can be as simple as walking down the street or doing the homework; or as complex as deciding the angle in which a rocket should be launched so that it can have a particular trajectory.
- Why do we need to learn?
- **With more knowledge, the ability to do homework with less number of mistakes increases**
- Thus, With more learning, tasks can be performed more efficiently.

Types of Human Learning

1. Learning under expert guidance

- Somebody who is an expert in the subject directly teaches us.
- The process of gaining information from a person having sufficient knowledge due to past experience. (e.g. learning of child)

2. Learning guided by knowledge gained from experts

- we build our own notion indirectly based on what we have learnt from the expert in the past
- learning also happens with the knowledge which has been imparted by teacher or mentor at some point of time in some other form
- E.g. a kid can select one odd word from a set of words because it is a verb and other words being all nouns, due to English learned in school

Types of Human Learning

- **3. Learning by self**
- We do it ourselves, may be after multiple attempts, some being unsuccessful.
- Learning from our mistakes in past.
- E.g. Child learning to walk through obstacles.

What is Machine Learning?

- "Machine learning is the field of study that gives computers the ability to learn without being explicitly programmed"

  - Arthur Samuel, AI pioneer, 1959

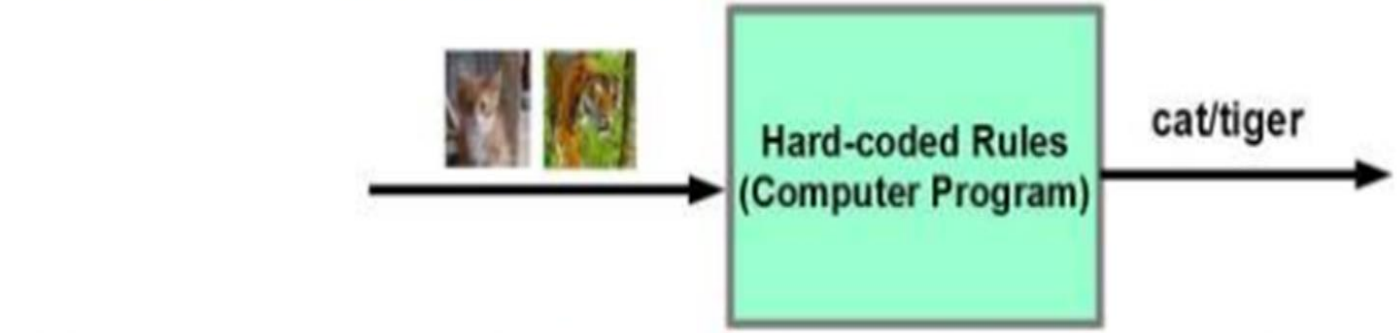
- "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E"

  - Tom Mitchell, ML Professor at CMU

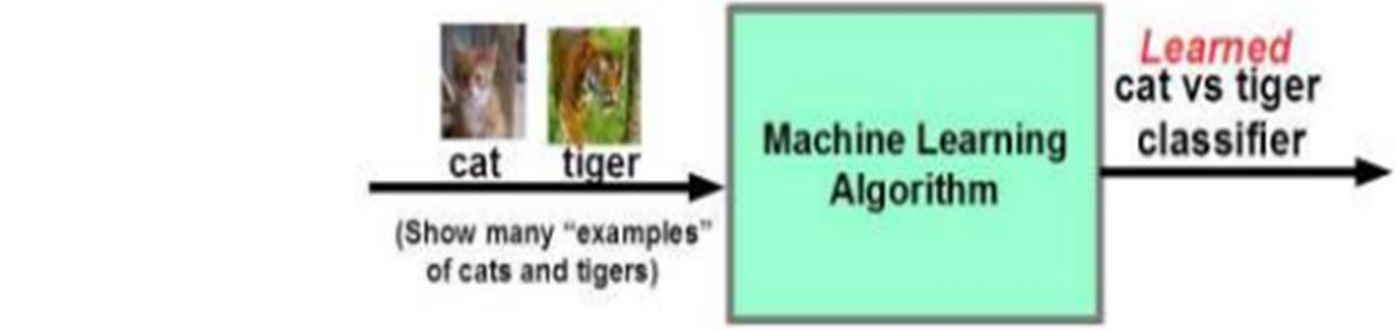
- Algorithms that
  - improve their performance (P)
  - at some task (T)
  - with experience (E)

Traditional v/s Machine Learning

- Traditional: Write programs using hard-coded (fixed) rules

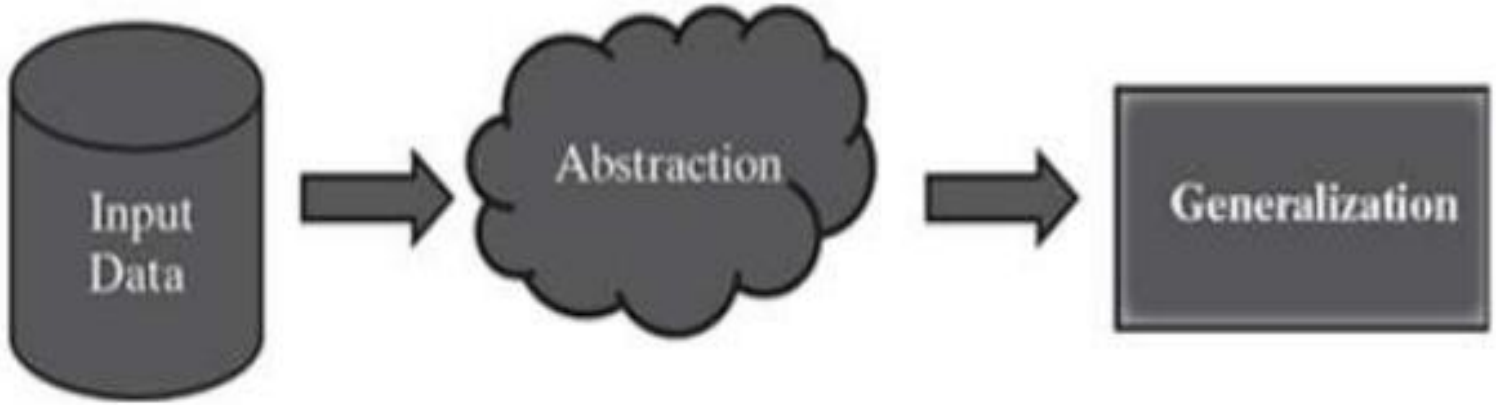


- Machine Learning (ML): Learn rules by looking at some training data



How do machine learn?

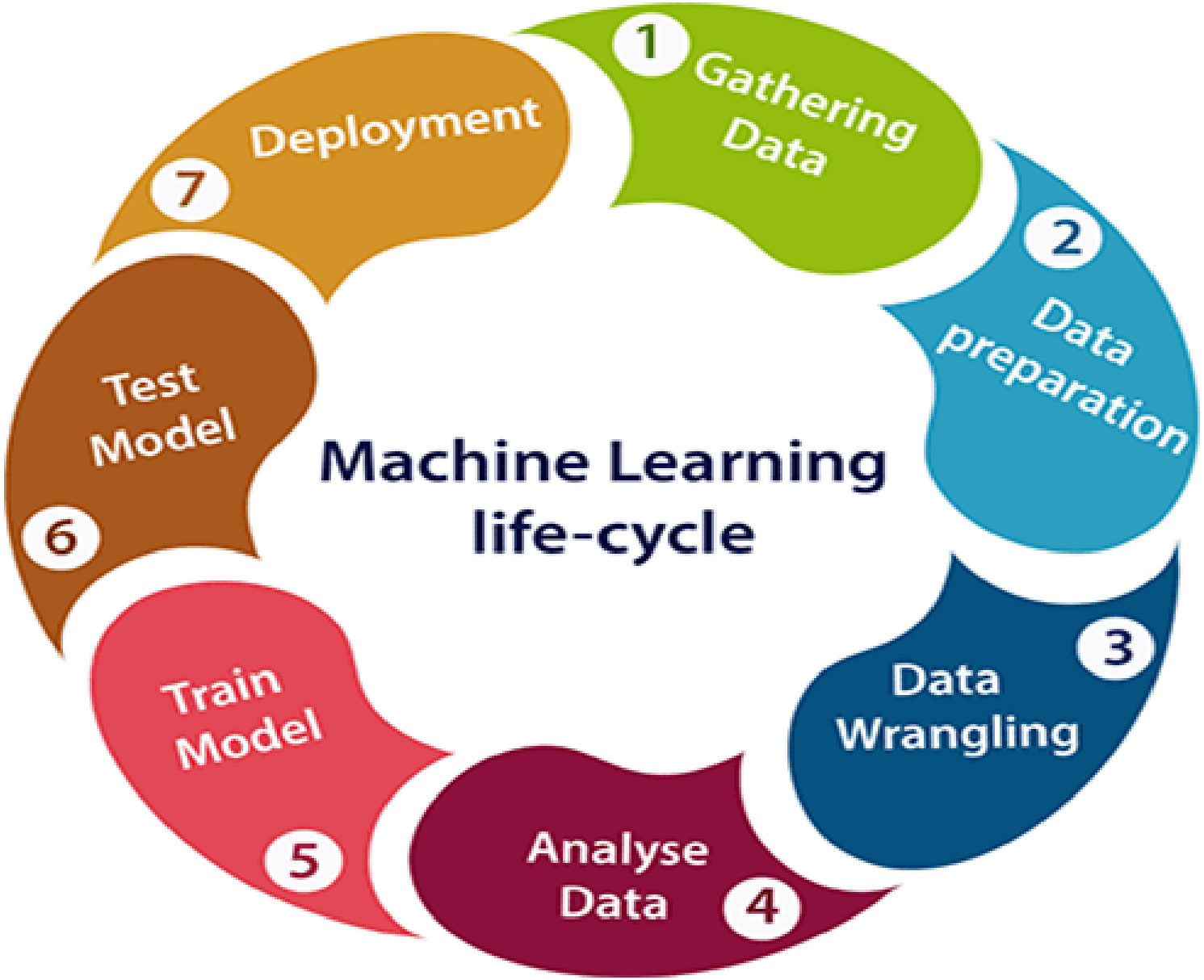
- Data Input: Past data or information is utilized as a basis for future decision-making
- Abstraction: The input data is represented in a broader way through the underlying algorithm
- Generalization: The abstracted representation is generalized to form a framework for making decisions



Well-posed Learning Problem

- For defining a new problem, which can be solved using ML, a simple framework can be used. **The framework involves answering three questions:**
- **What is the problem?**
- **Describe** the problem informally and formally and list assumptions and similar problems.
- **Why does the problem need to be solved?**
- List the **motivation** for solving the problem, the benefits that the solution will provide and how the solution will be used.
- **How would I solve the problem?**
- Describe how the problem would be solved manually to flush domain knowledge.

Machine learning Life cycle



Machine learning Life cycle

Machine learning life cycle involves seven major steps, which are given below:

- **Gathering Data**
- **Data preparation**
- **Data Wrangling**
- **Analyse Data**
- **Train the model**
- **Test the model**
- **Deployment**

1. Gathering Data

- 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.
- This step includes the below tasks:
  - **Identify various data sources**
  - **Collect data**
  - **Integrate the data obtained from different sources**
- By performing the above task, we get a coherent set of data, also called as a **dataset**. It will be used in further steps.

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.
- **Data exploration:** It is used to understand the nature of data that we have to work with. We need to understand the characteristics, format, and quality of data.
- A better understanding of data leads to an effective outcome. In this, we find Correlations, general trends, and outliers.

3. Data Wrangling / Data pre-processing

- 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.
- It is not necessary that data we have collected is always of our use as some of the data may not be useful. In real-world applications, collected data may have various issues, including:
  - **Missing Values**
  - **Duplicate data**
  - **Invalid data**
  - **Noise**
- So, we use various filtering techniques to clean the data.
- It is mandatory to detect and remove the above issues because it can negatively affect the quality of the outcome.

4. Data Analysis

- Now the cleaned and prepared data is passed on to the analysis step. This step involves:
  - **Selection of analytical techniques**
  - **Building models**
  - **Review the result**
- 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 build the model using prepared data, and evaluate the model.
- Hence, in this step, we take the data and use machine learning algorithms to build the model.

5. Train Model

- Now the next step is to train the model, in this step we train our model to improve its performance for better outcome of the problem.
- We use datasets to train the model using various machine learning algorithms. Training a model is required so that it can understand the various patterns, rules, and, features.

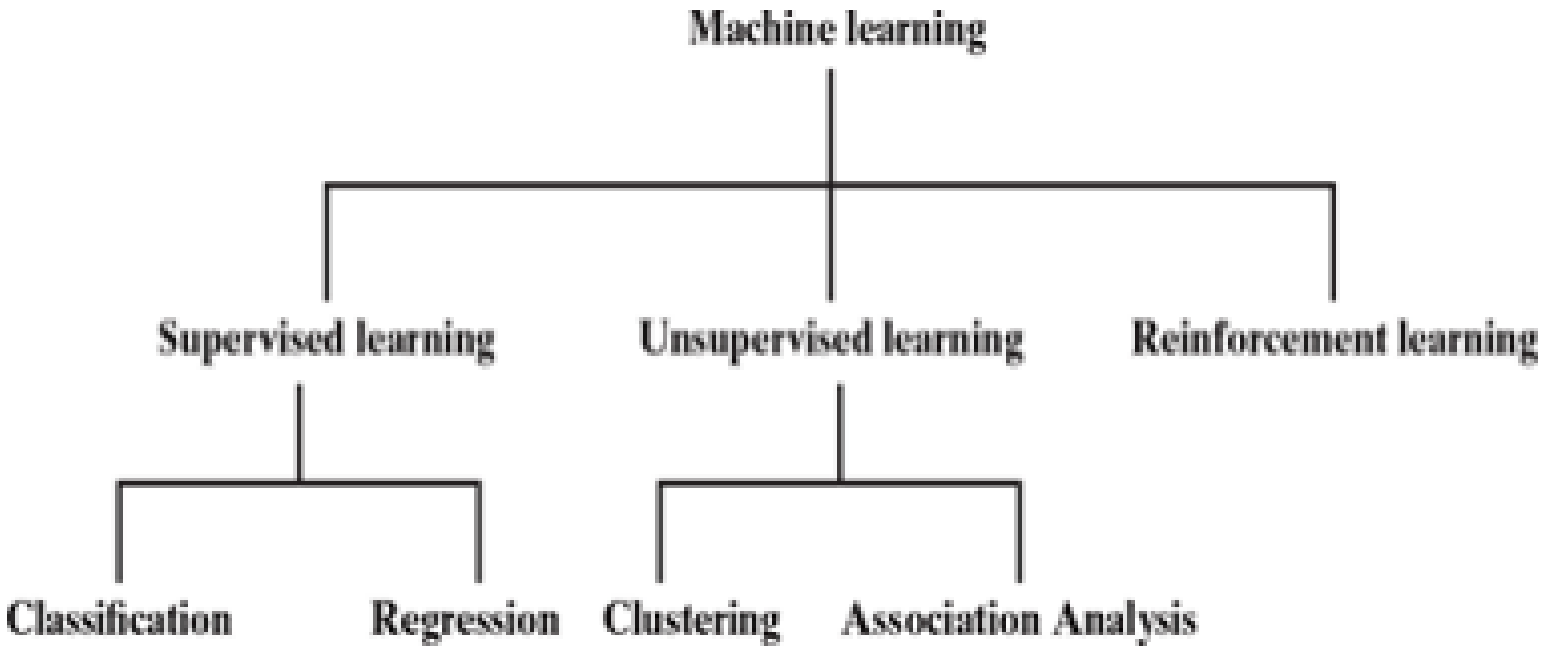
6. Test Model

- Once our machine learning model has been trained on a given dataset, then we test the model. In this step, 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 project or problem.

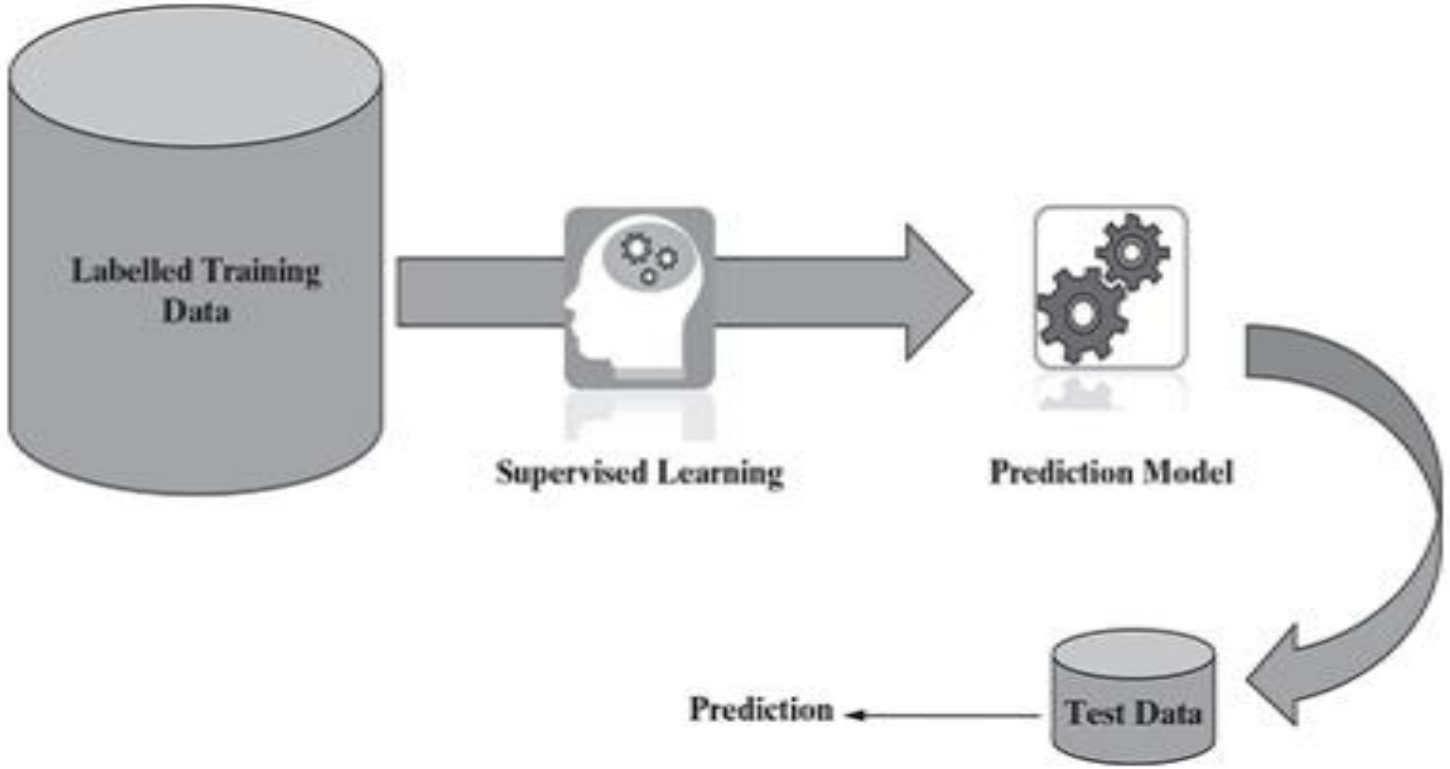
7. Deployment

- 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 to making the final report for a project

Types of Machine Learning

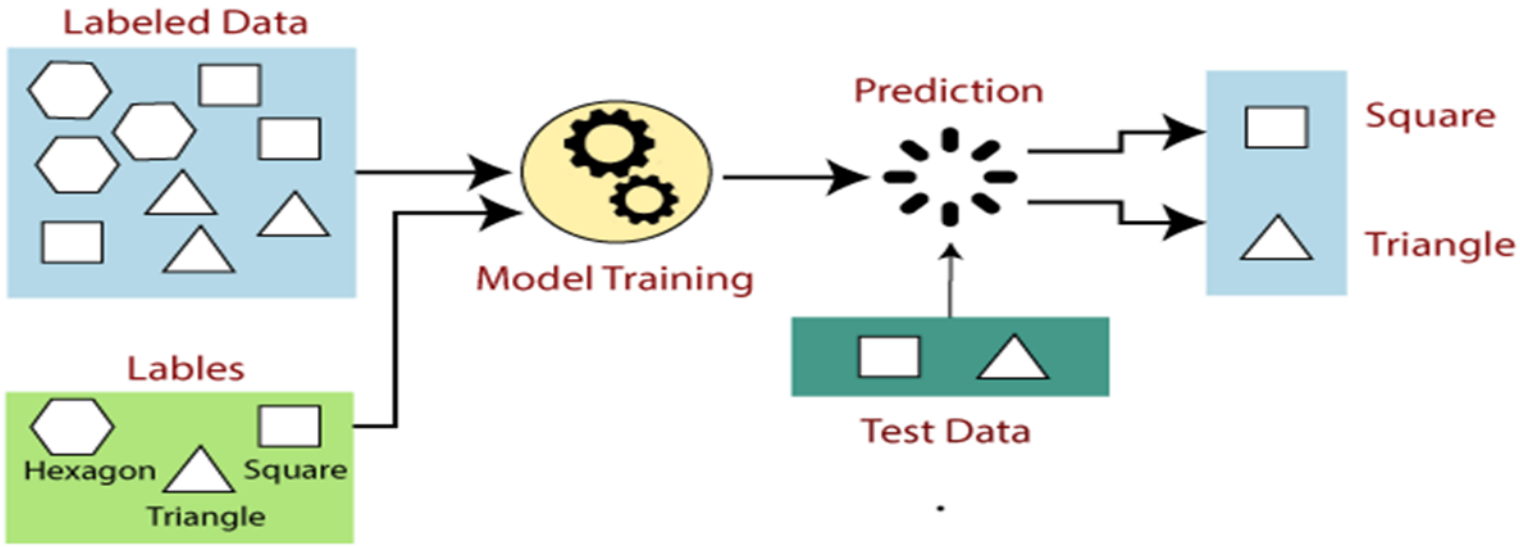


Supervised Learning



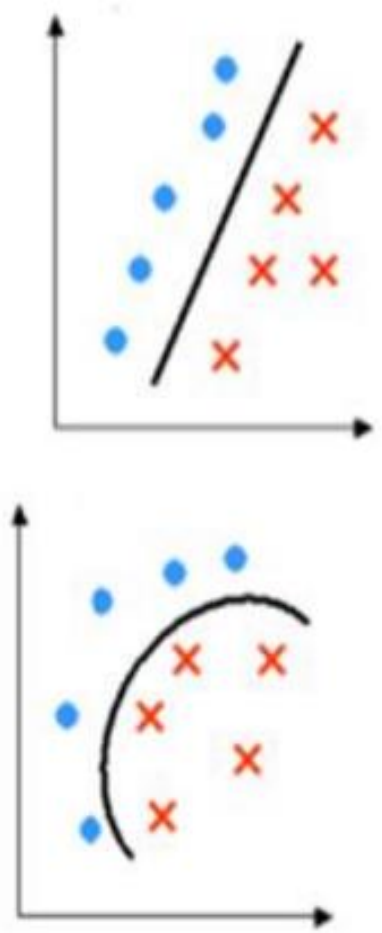
Supervised Learning

- 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.

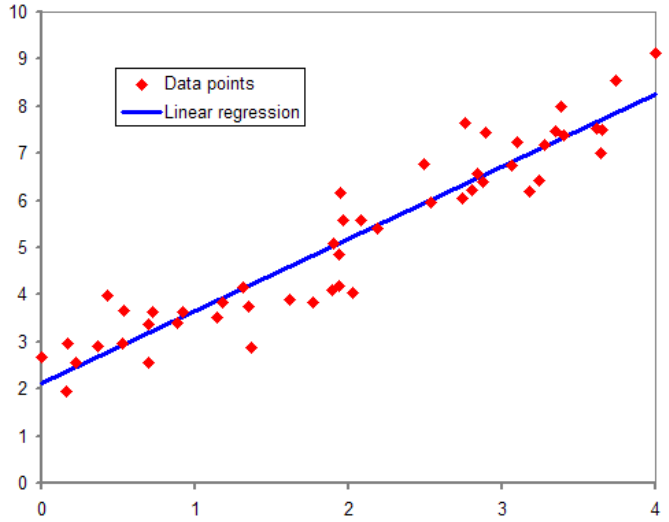


Types of Supervised Learning

Classification (Discrete value output)

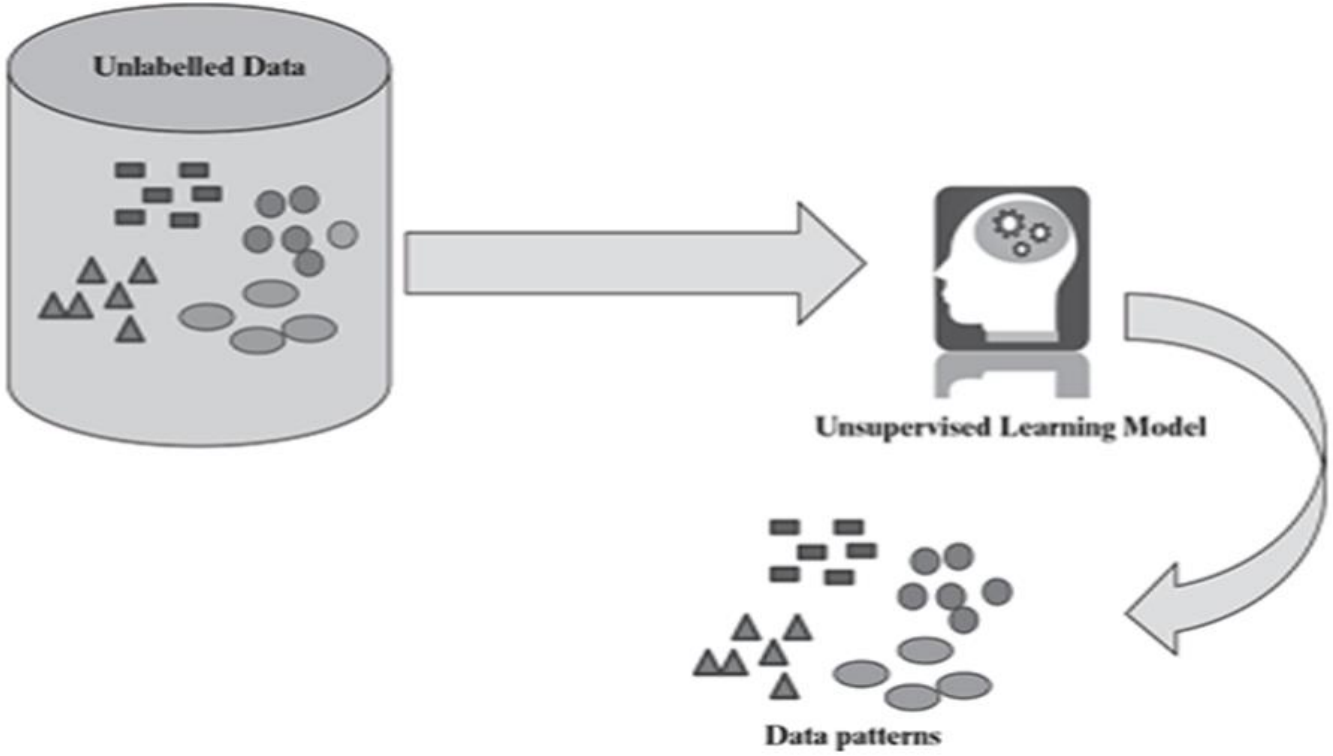


Regression (Predict real value output)



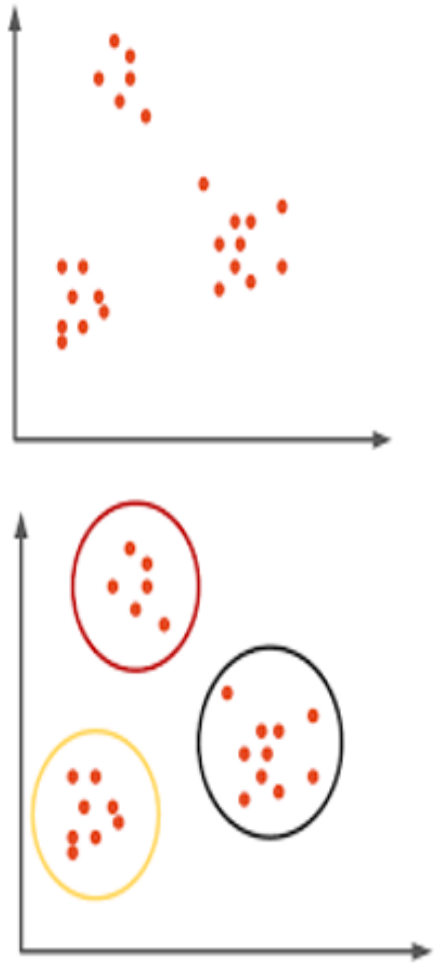
Unsupervised Learning

- **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.



Types of Unsupervised Learning

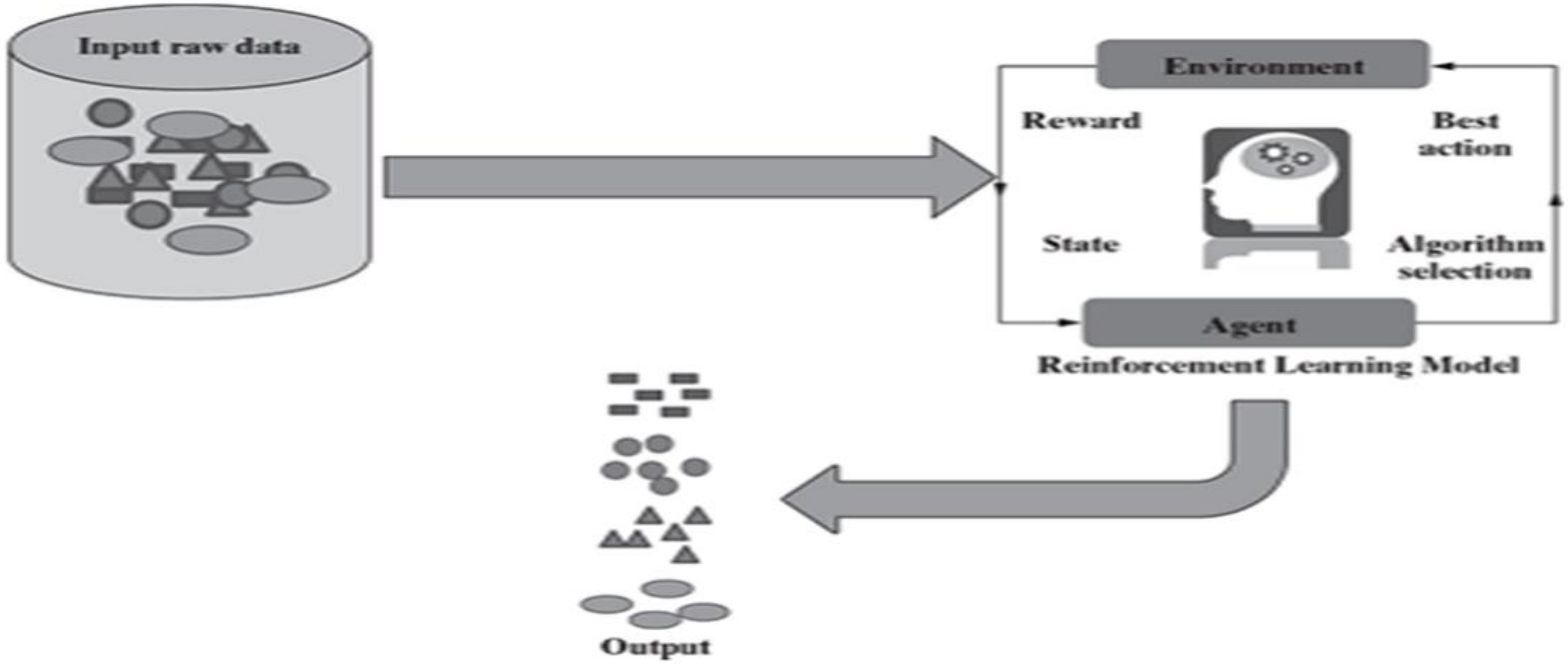
Clustering



Association

Reinforcement Learning

- Reinforcement Learning is a feedback-based (reward) 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.



Comparison – Supervised, Unsupervised and Reinforcement Learning

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 (reward based)
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, NB, DT.	K – Means, PCA, DBSCAN, 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

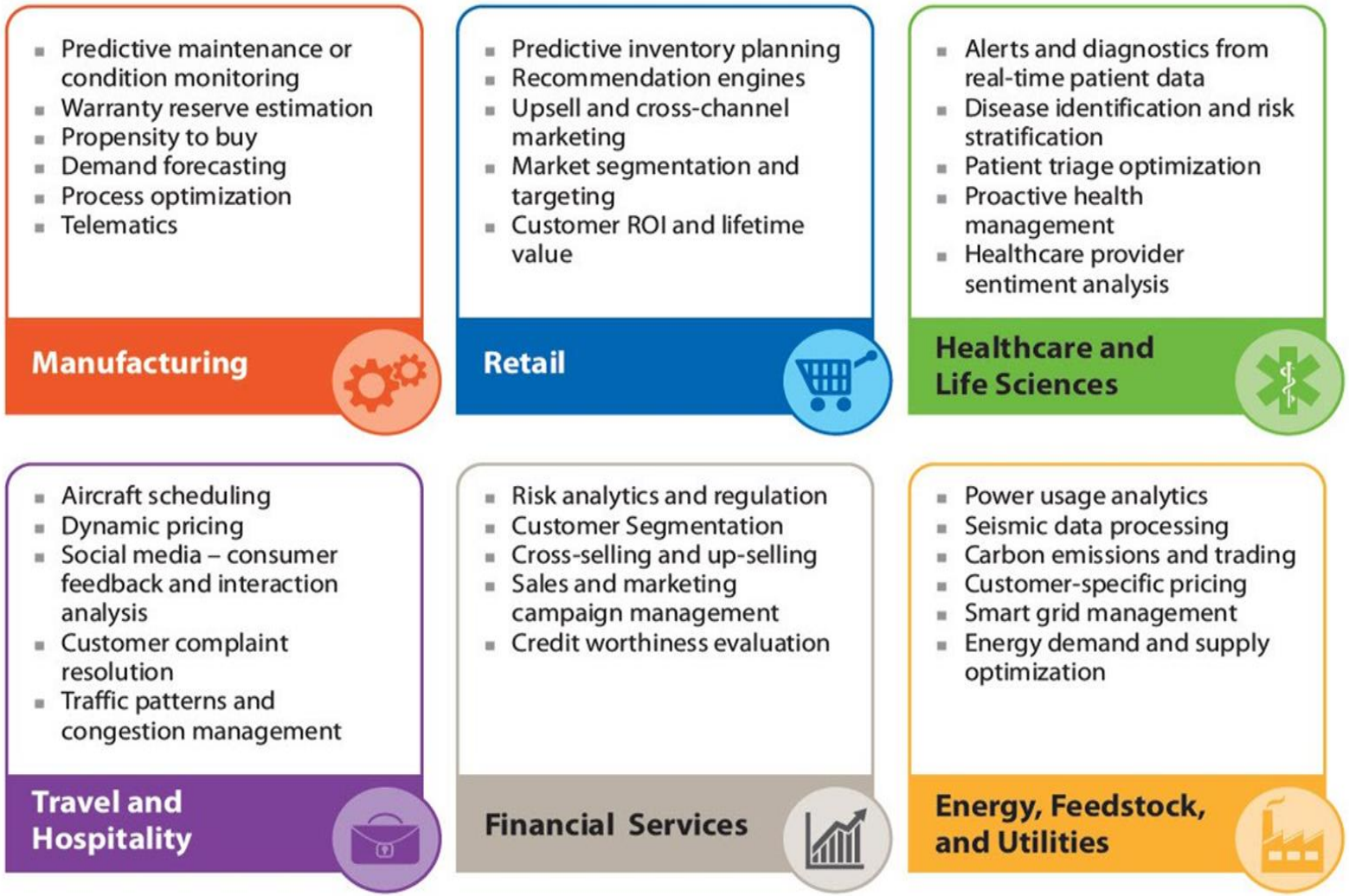
Did you know?

- Many video games are based on artificial intelligence technique called **Expert System**. This technique can imitate areas of human behavior, with a goal to mimic the human ability of senses, perception, and reasoning.

When not to use ML?

- Machine learning should not be applied to tasks in which humans are very effective or frequent human intervention is needed.
- For example, air traffic control is a **very complex task needing intense human involvement**.
- Also, for very simple tasks which can be implemented using traditional programming paradigms, there is no sense of using machine learning.
- For example, simple rule-driven or formula-based applications like price calculator engine, dispute tracking application, etc. do not need machine learning techniques.

Application of ML



Tools for Machine Learning

- **Programming**: Python, R, Matlab, Julia, Java, …
- **Libraries**: Orange, WEKA, RapidMiner, SAS, Tableau, DL4J, …
- **API**: Scikit-learn, TensorFlow, Keras, PyTorch, …


Data Visualization in Machine Learning

- Data visualization is a crucial aspect of machine learning that enables analysts to understand and make sense of data patterns, relationships, and trends.
- Through data visualization, insights and patterns in data can be easily interpreted and communicated to a wider audience, making it a critical component of machine learning.
- Data visualization is the graphical representation of information and data.
- By using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data.

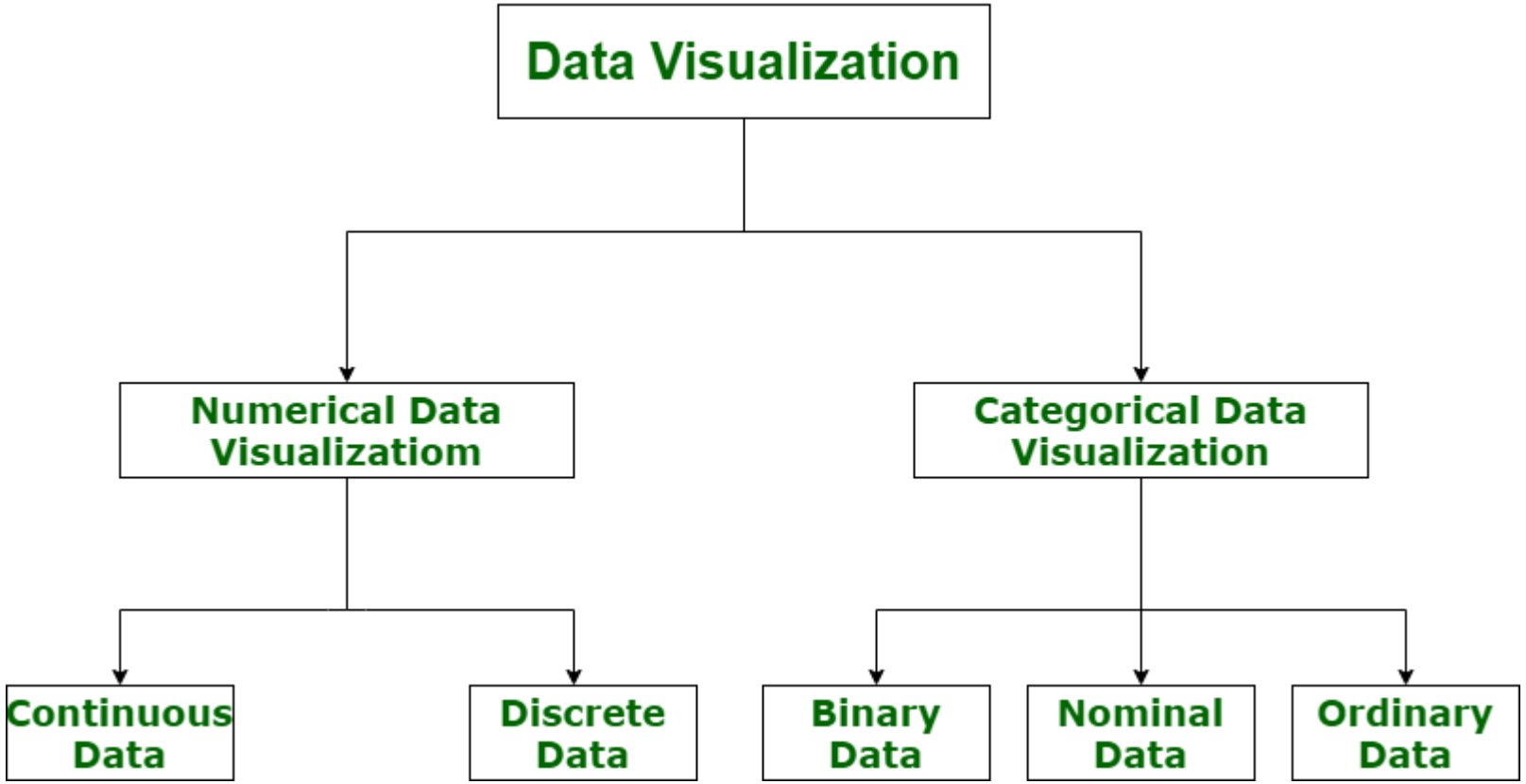
What is Data Visualization?

- Data visualization translates complex data sets into visual formats that are easier for the human brain to comprehend. This can include a variety of visual tools such as:
  - **Charts**: Bar charts, line charts, pie charts, etc.
  - **Graphs**: Scatter plots, histograms, etc.
  - **Maps**: Geographic maps, heat maps, etc.
  - **Dashboards**: Interactive platforms that combine multiple visualizations.

Types of Data for Visualization

- Performing accurate visualization of data is very critical to market research where both numerical and categorical data can be visualized, which helps increase the impact of insights and also helps in reducing the risk of analysis paralysis. So, data visualization is categorized into the following categories:
  - Numerical Data
  - Categorical Data

Types of Data for Visualization



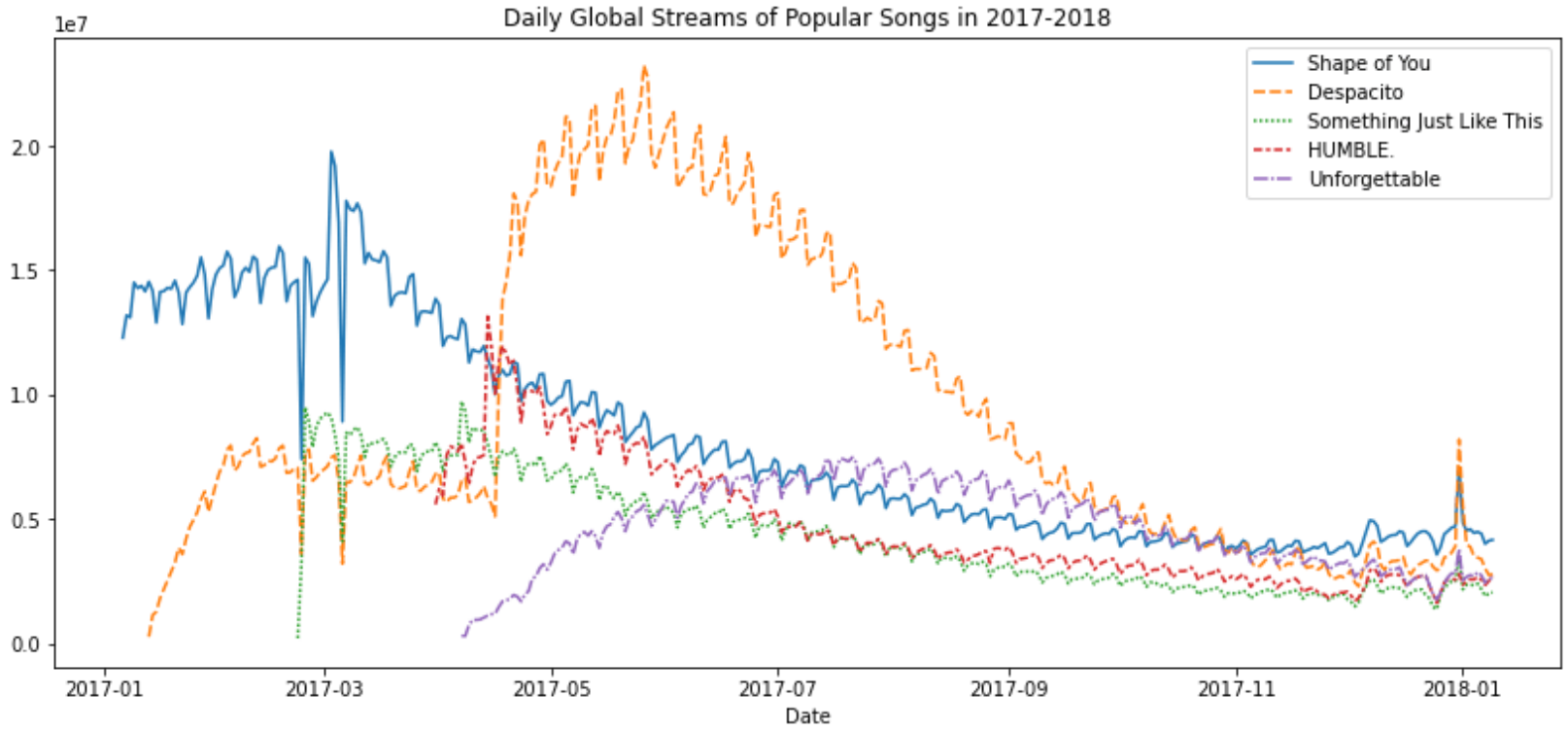
Types of Data Visualization Approaches

Machine learning may make use of a wide variety of data visualization approaches. That include:

- **Line Charts**
- **Scatter Plots**
- **Bar Charts**
- **Heat Maps**
- **Tree Maps**
- **Box Plots**

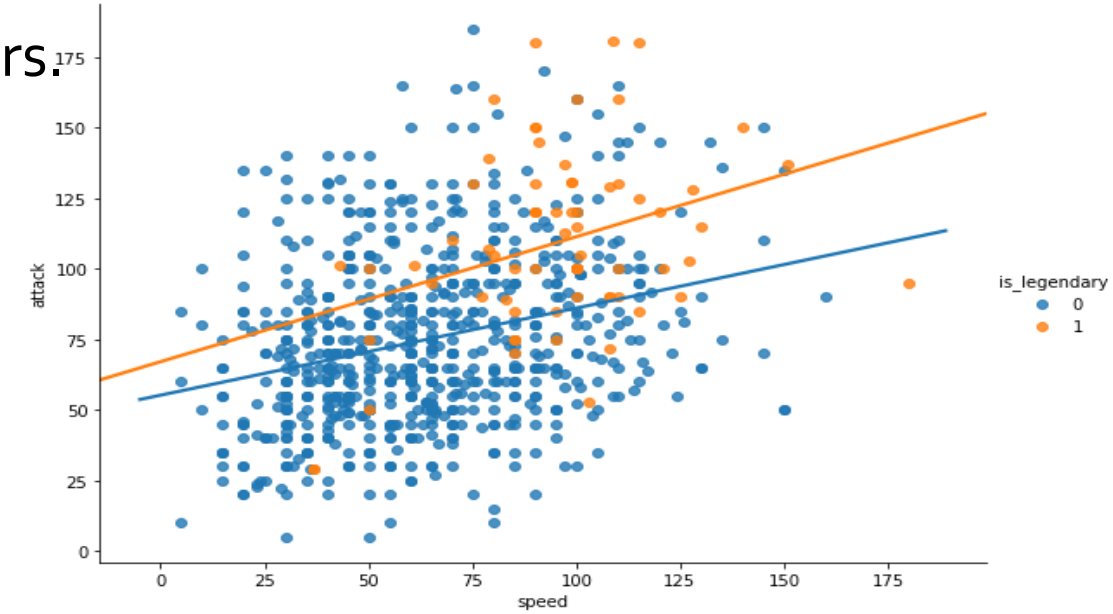
1. Line Charts

- In a line chart, each data point is represented by a point on the graph, and these points are connected by a line. We may find patterns and trends in the data across time by using line charts. Time-series data is frequently displayed using line charts.



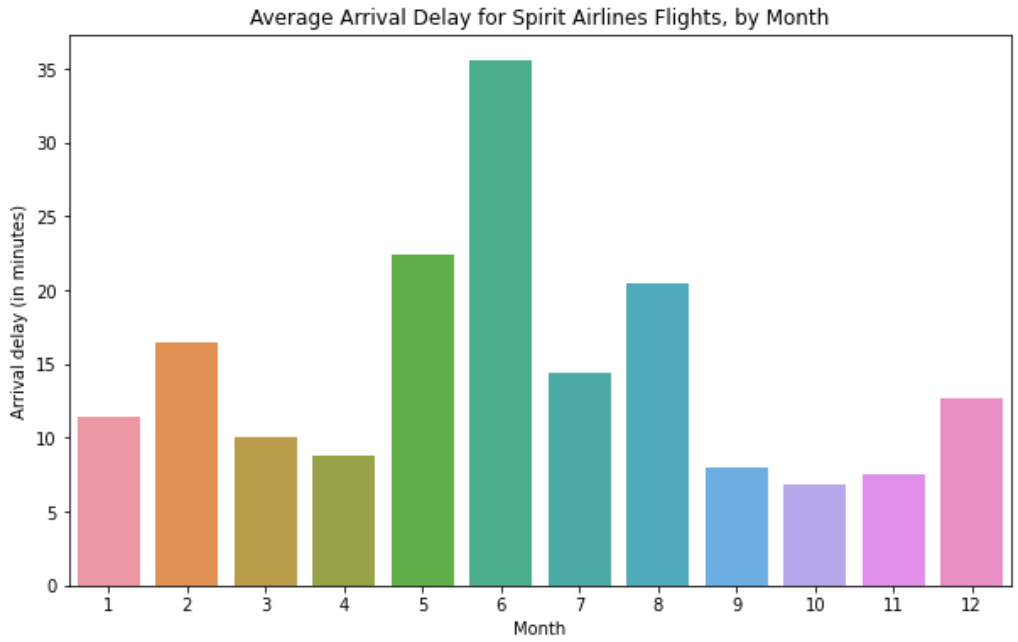
2. Scatter Plots

- A quick and efficient method of displaying the relationship between two variables is to use scatter plots. With one variable plotted on the x-axis and the other variable drawn on the y-axis, each data point in a scatter plot is represented by a point on the graph. We may use scatter plots to visualize data to find patterns, clusters, and outliers.



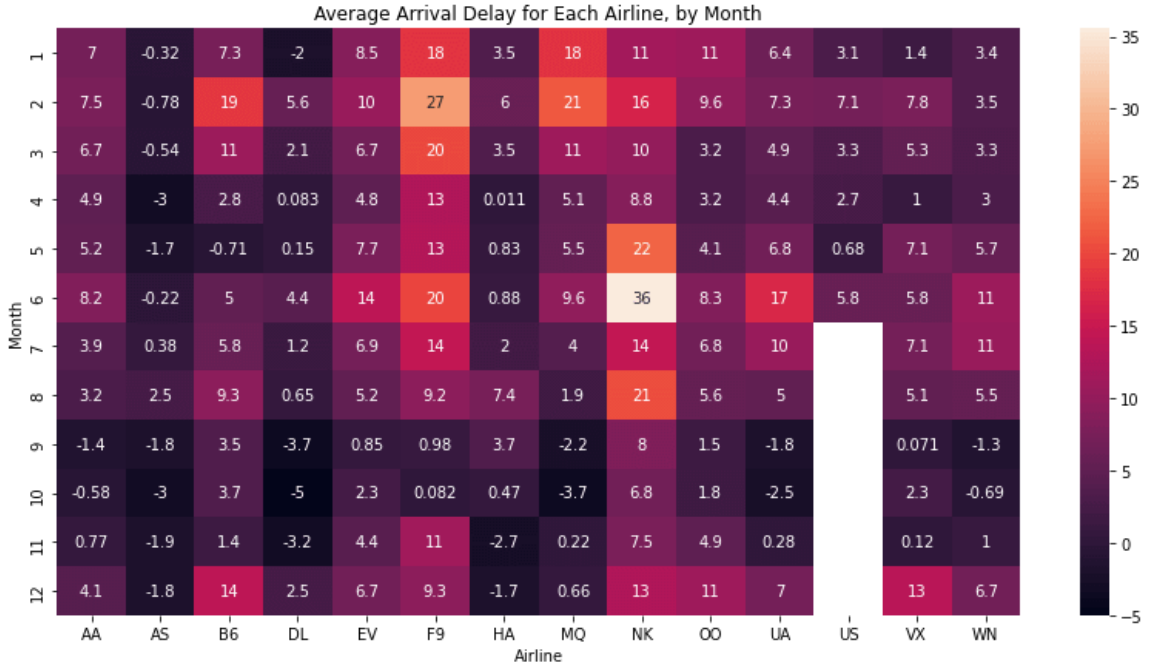
3. Bar Charts

- Bar charts are a common way of displaying categorical data. In a bar chart, each category is represented by a bar, with the height of the bar indicating the frequency or proportion of that category in the data. Bar graphs are useful for comparing several categories and seeing patterns over time.



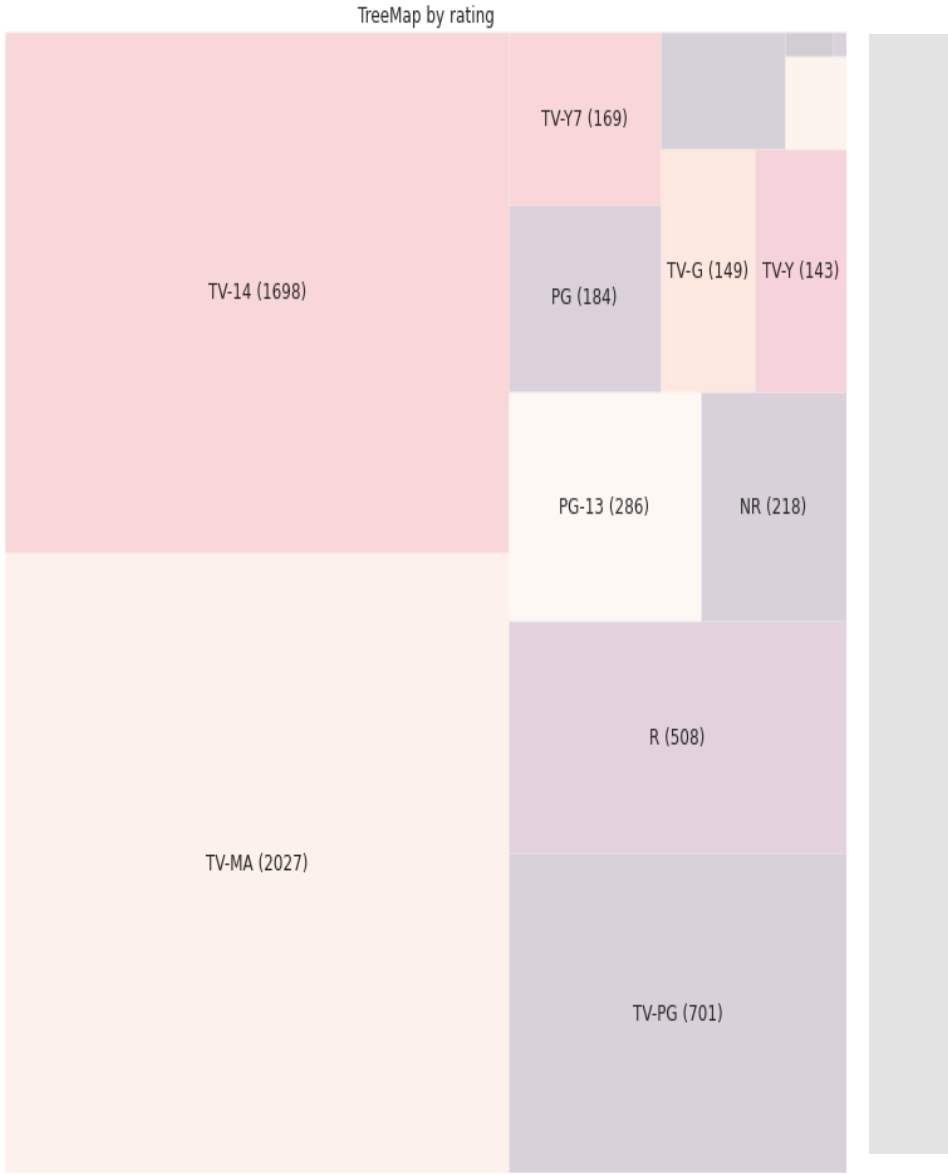
4. Heat Maps

- Heat maps are a type of graphical representation that displays data in a matrix format. The value of the data point that each matrix cell represents determines its hue. Heatmaps are often used to visualize the correlation between variables or to identify patterns in time-series data.



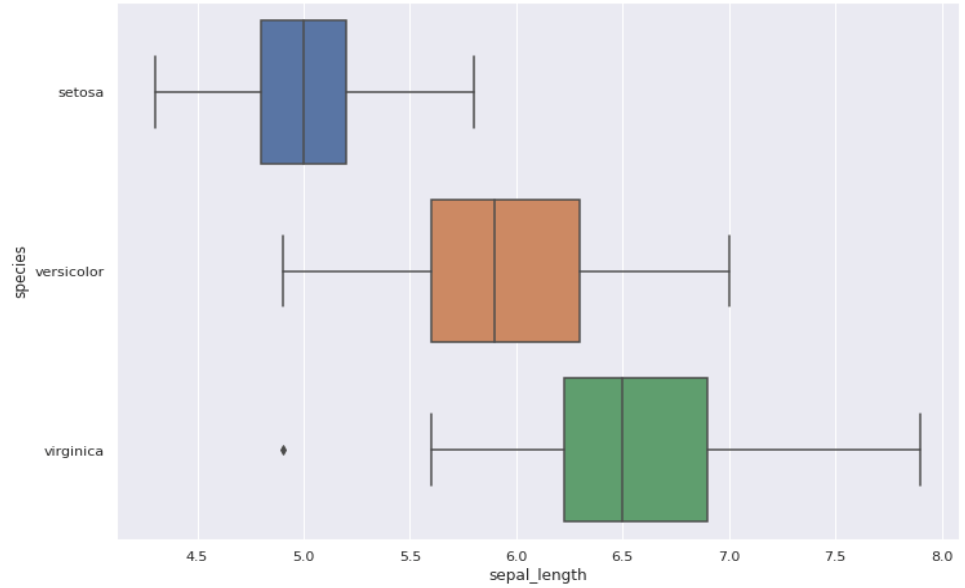
5. Tree Maps

- Tree maps are used to display hierarchical data in a compact format and are useful in showing the relationship between different levels of a hierarchy.



6. Box Plots

- Box plots are a graphical representation of the distribution of a set of data. In a box plot, the median is shown by a line inside the box, while the center box depicts the range of the data. The whiskers extend from the box to the highest and lowest values in the data, excluding outliers. Box plots can help us to identify the spread and skewness of the data.



Uses of Data Visualization in Machine Learning

- **Identify trends and patterns in data:** It may be challenging to spot trends and patterns in data using conventional approaches, but data visualization tools may be utilized to do so.
- **Communicate insights to stakeholders:** Data visualization can be used to communicate insights to stakeholders in a format that is easily understandable and can help to support decision-making processes.
- **Monitor machine learning models:** Data visualization can be used to monitor machine learning models in real time and to identify any issues or anomalies in the data.
- **Improve data quality:** Data visualization can be used to identify outliers and inconsistencies in the data and to improve data quality by removing them.

Any Queries..??

Thank you