Machine Learning
MODULE-1
(Introduction Machine Learning)

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Machine Learning

Class Discussion Topic-1

Textbook: Tom Mitchell, First Edition,McGraw-Hill, 1997.

Chapter : 1

Class Discussion Topic(CDT):

- ✓ Review of Linear Algebra
- ✓ Basic Concepts,
- ✓ Goals and

  Applications of Machine Learning

Lecture Level Learning Outcome

- Student will be able to understand Linear Algebra Concepts and its role in Machine learning Applications
- Student will be able to classify various types of machine learning models

Review of Linear Algebra

- ✓ Machine learning has a strong connection with mathematics. Each machine learning algorithm is based on the concepts of mathematics & also with the help of mathematics, one can choose the correct algorithm by considering training time, complexity, number of features, etc.
- ✓ Linear Algebra is an essential field of mathematics, which defines the study of vectors, matrices, planes, mapping, and lines required for linear transformation.
- ✓ Linear algebra is also used in neural networks and the data science field.

Significance of Linear Algebra in Machine Learning

- ✓ Linear algebra is the backbone of many machine learning algorithms and techniques.
- ✓ Understanding the fundamental operations of linear algebra is crucial for anyone aspiring to delve deep into the world of machine learning.
- ✓ At its core, linear algebra provides a framework for handling and manipulating data, which is often represented as vectors and matrices.
- ✓ These mathematical constructs enable efficient computation and provide insights into the underlying patterns and structures within the data.

Significance of Linear Algebra in Machine Learning

- ✓ In machine learning, linear algebra operations are used extensively in various stages, from data preprocessing to model training and evaluation.
- ✓ For instance, operations such as matrix multiplication, eigen value decomposition, and singular value decomposition are pivotal in dimensionality reduction techniques like Principal Component Analysis (PCA).
- ✓ Similarly, the concepts of vector spaces and linear transformations are integral to understanding neural networks and optimization algorithms.

What is Linear Algebra

- ✓ Linear Algebra is the branch of mathematics that focuses on the study of vectors, vector spaces, and linear transformations. It deals with linear equations, linear functions, and their representations through matrices and determinants

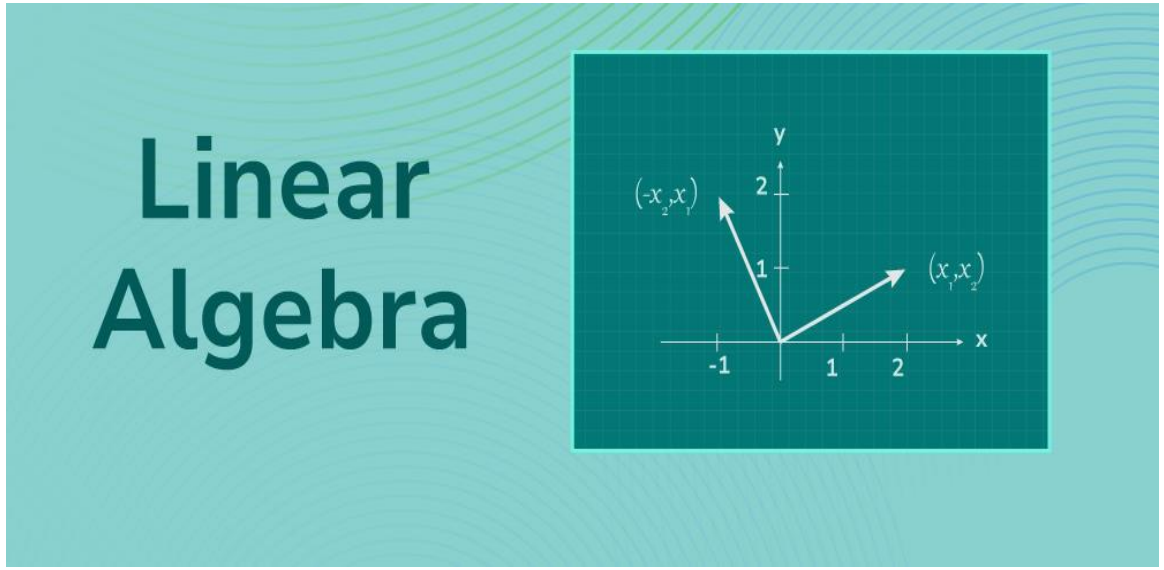
- ✓ It has a wide range of applications in Physics and Mathematics. It is the basic concept for machine learning and data science.

Linear Equations

- ✓ Linear equations form the basis of linear algebra and are equations of the first order. These equations represent straight lines in geometry and are characterized by constants and variables without exponents or products of variables.

The general linear equation is represented as $u_1x_1 + u_2x_2 + \ldots\ldots u_nx_n = v$

- ✓ Where,
- ✓ u's – represents the coefficients
- ✓ x's – represents the unknowns
- ✓ v – represents the constant



Linear Equations

Example 1:

$2x + 3x = 6$ is a linear equation. If you have two such equations, like $2x + 3y = 6$, and $4x + 6y = 12$, solving them together would give you the point where the two lines intersect.

Linear Algebra Elements mostly used in Machine Learning

- ✓Matrix inverses and determinants
- ✓Linear transformations
- ✓Singular value decomposition
- ✓Solving systems of equations with matrices
- ✓Eigen values & Eigenvectors and Euclidean vector spaces
- ✓Linear Functions
- ✓Vector spaces
- ✓Matrix

An Element in Linear Algebra- Eigen Vector

Eigenvectors

- Eigenvectors are vectors that are associated with a matrix such that when the matrix multiplies the eigenvector, the resulting vector is a scalar multiple of the eigenvector. Eigenvectors are also called characteristic vectors and can only be found for square matrices.

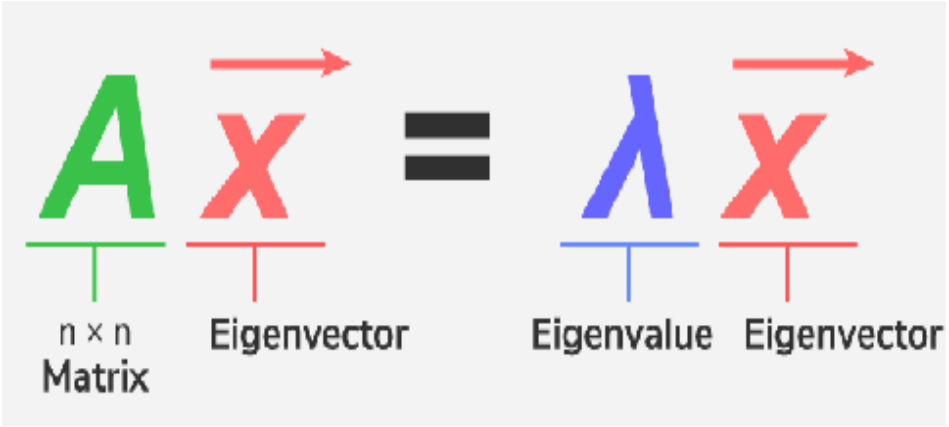
- Eigenvector is given using the equation $Av = \lambda v$, for the identity matrix of order same as the order of A i.e. $n \times n$ we use the following equation:$(A-\lambda I)v = 0$

- λ as $\lambda 1, \lambda 2, \ldots, \lambda n$ these values are called the eigenvalues and we get individual eigenvectors related to each eigenvalue

An Element in Linear Algebra- Eigen Vector

Eigen vectors:

➢Simplifying the above equation we get v which is a column matrix of order n × 1 and v is marix of vectors v1,v2,v3…vn as



An Element in Linear Algebra- Eigen Vector(Example)

Find the eigenvector of the given matrix:
A=[14−4−7]

Solution:

Given:
A=[14−4−7]
$|A-\lambda I| = |1-\lambda 4-4-7-\lambda|$
$(1- \lambda)(-7- \lambda)- 4(-4) = 0$
$(\lambda+3)^2 = 0$
Therefore, $\lambda = -3, -3$
Use the eigenvector equation
$AX = \lambda X$
Now, let's understa

Substitute λ value in the equation:
$AX = -3X$
We know that,
$(A- \lambda I) X = 0$
([14−4−7]+[3003])[xy]=[00]
$4x +4y =0$
Or
$x+y =0$
Assume that $x =k$
So, it becomes
$k +y =0$
$y= -k$
Therefore, the eigenvector is
X=[xy]=k[1−1]

An Element in Linear Algebra- Eigen Vector

- The eigen values of matrix are scalars by which some vectors (eigenvectors) change when the matrix (transformation) is applied to it
- Step-by-step process used to find the eigen values of a square matrix A.

1. Take the identity matrix I whose order is the same as A.
2. Multiply every element of I by λ to get λI.
3. Subtract λI from A to get A - λI.
4. Find its determinant.
5. Set the determinant to zero and solve for λ..

An Element in Linear Algebra- Eigen Vector(Example)

if λ is an eigenvalue of a square matrix A, then

$A\mathbf{v} = \lambda\mathbf{v}$

If I is the identity matrix of the same order as A, then we can write the above equation as

$A\mathbf{v} = \lambda (I\mathbf{v})$ (because $\mathbf{v} = I\mathbf{v}$)

$A\mathbf{v} - \lambda (I\mathbf{v}) = 0$

Taking **v** as common factor,

$\mathbf{v} (A - \lambda I) = 0$

This represents a homogeneous system of linear equations and it has a non-trivial solution only when the determinant of the coefficient matrix is 0.

i.e., $|\mathbf{A - \lambda I}| = \mathbf{0}$

This equation is called the **characteristic equation** (where $|A - \lambda I|$ is called the characteristic polynomial) and by solving this for λ, we get the eigenvalues.

Benefits of Linear Algebra application in Machine Learning

- Better Graphic experience
- Improved Statistics
- Creating better Machine Learning algorithms
- Estimating the forecast of Machine Learning
- Easy to Learn

Examples of Linear Algebra in Machine Learning

- Datasets and Data Files
- Linear Regression
- Recommender Systems
- One-hot encoding
- Regularization
- Principal Component Analysis
- Images and Photographs
- Singular-Value Decomposition
- Deep Learning
- Latent Semantic Analysis

Machine Learning Introduction

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.

Applications of Machine Learning

1. Image Recognition: Image recognition is one of the most common applications of machine learning. It is used to identify objects, persons, places, digital images, etc. The popular use case is image recognition and face detection .
2. 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.
3. 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.

Applications of Machine Learning

4. Product recommendations:

Machine learning is widely used by various e-commerce and entertainment companies such as Amazon, Flipcart, etc., for product recommendation to the user.

5. 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.

Classification of Learning Systems in Machine Learning

Based on the methods and way of learning, machine learning is divided into mainly four types, which are:

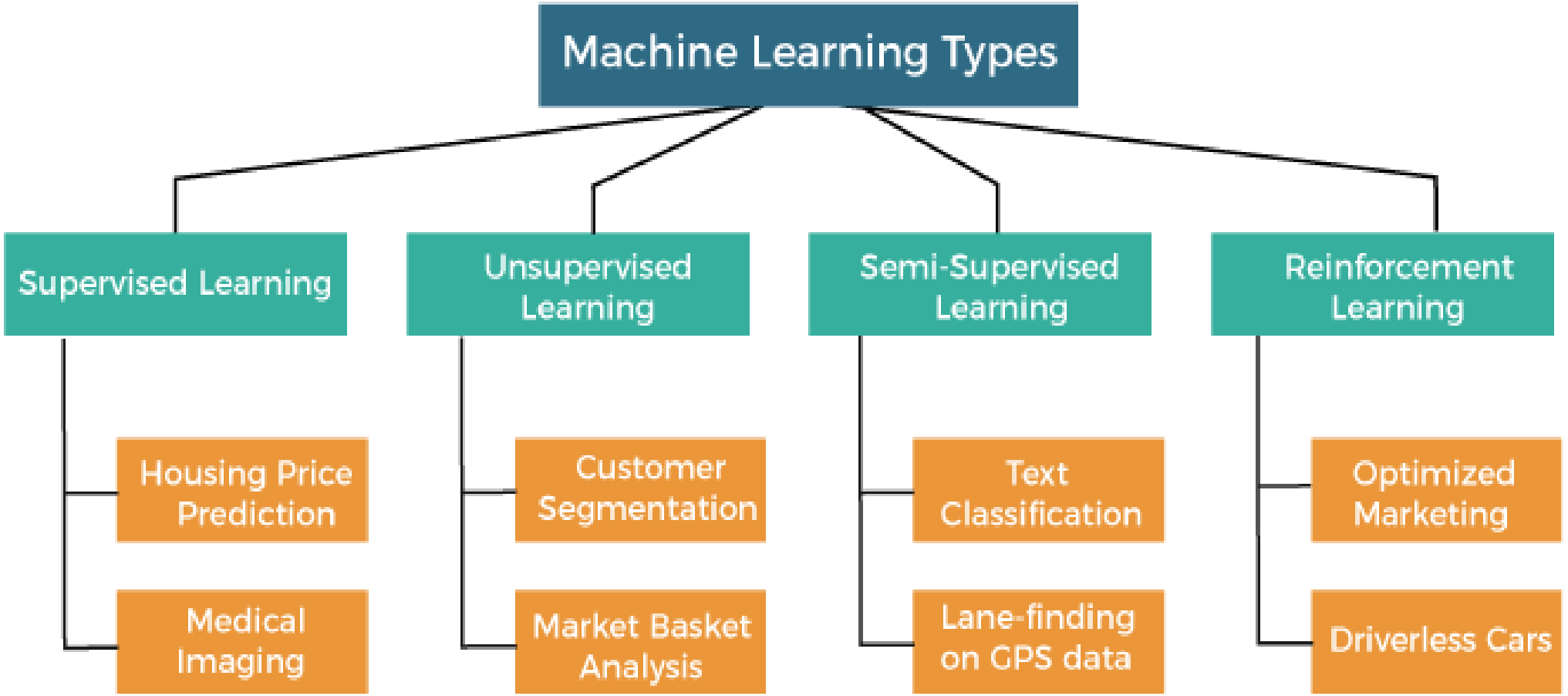
1.Supervised Machine Learning

2.Unsupervised Machine Learning

3.Semi-Supervised Machine Learning

4.Reinforcement Learning

Classification of Learning Systems in Machine Learning



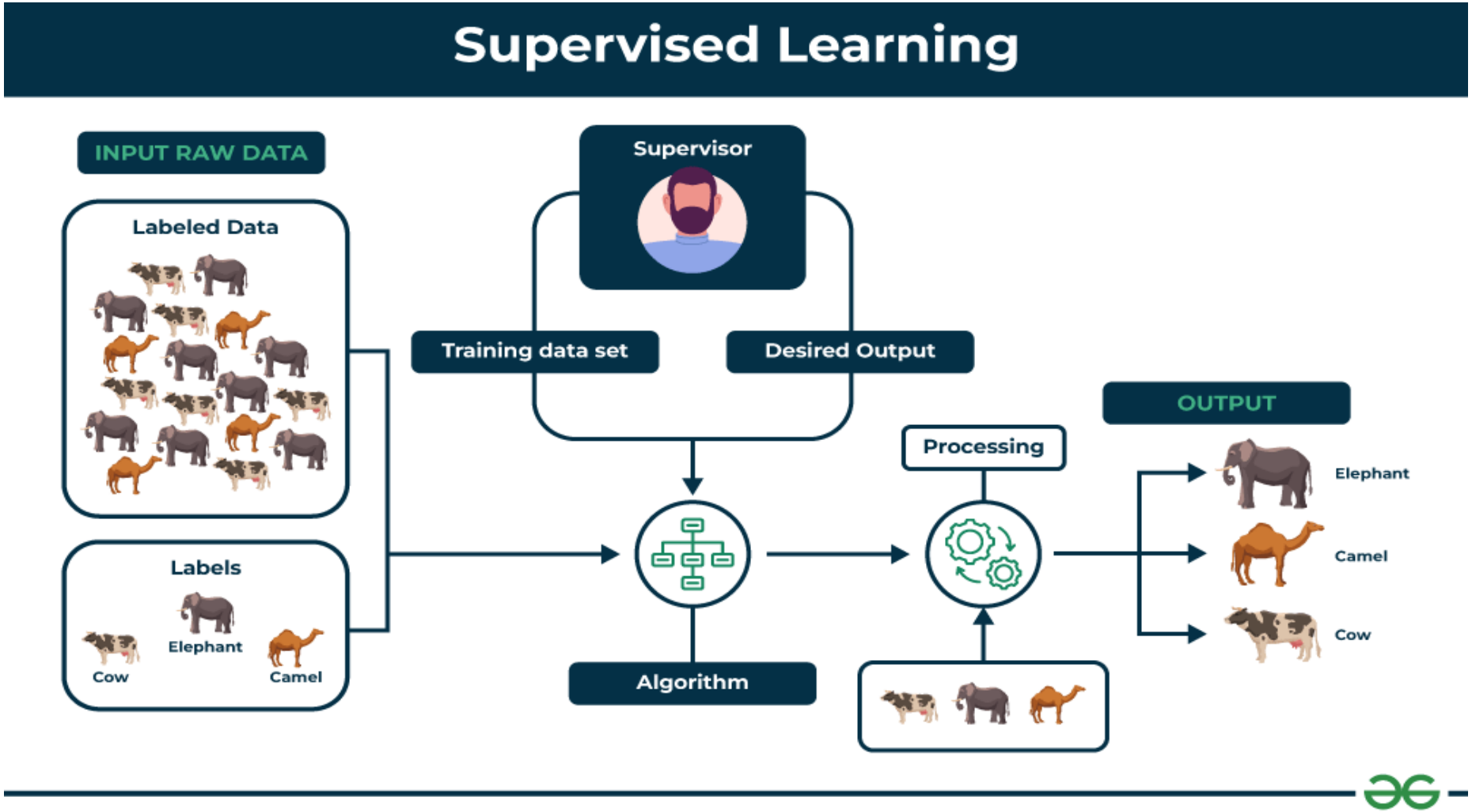
1.Supervised Learning

- Supervised learning is the types of machine learning in which machines are trained using well "labelled" training data, and on basis of that data, machines predict the output. The labelled data means some input data is already tagged with the correct output.
- In supervised learning, the training data provided to the machines work as the supervisor that teaches the machines to predict the output correctly. It applies the same concept as a student learns in the supervision of the teacher.

1.Supervised Learning

- Supervised learning is a process of providing input data as well as correct output data to the machine learning model. The aim of a supervised learning algorithm is to find a mapping function to map the input variable(x) with the output variable(y).
- In the real-world, supervised learning can be used for Risk Assessment, Image classification, Fraud Detection, spam filtering, etc.

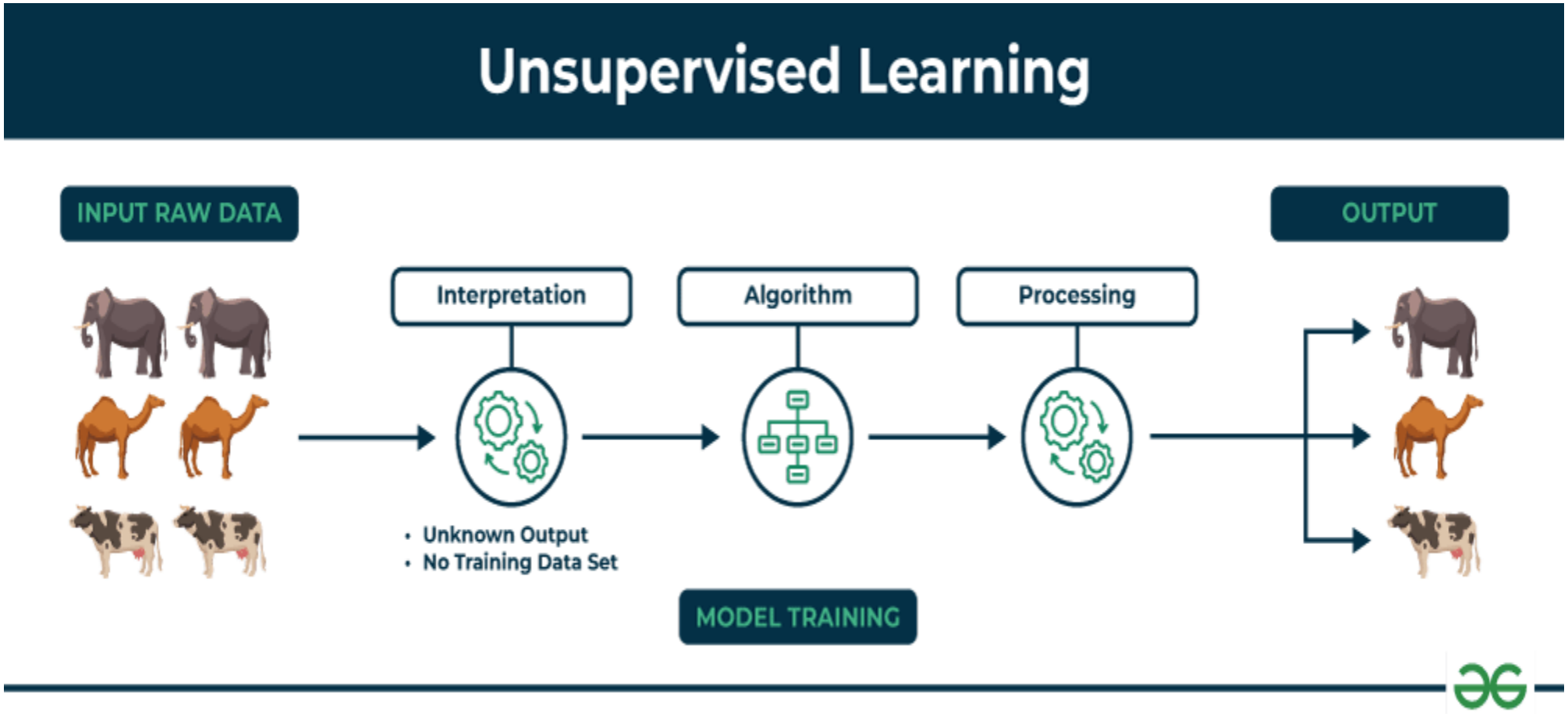
1.Supervised Learning(Example)



2.UnSupervised Learning

- It is different from the Supervised learning technique; as its name suggests, there is no need for supervision. It means, in unsupervised machine learning, the machine is trained using the unlabeled dataset, and the machine predicts the output without any supervision.
- In unsupervised learning, the models are trained with the data that is neither classified nor labelled, and the model acts on that data without any supervision.
- The main aim of the unsupervised learning algorithm is to group or categories the unsorted dataset according to the similarities, patterns, and differences. Machines are instructed to find the hidden patterns from the input dataset.

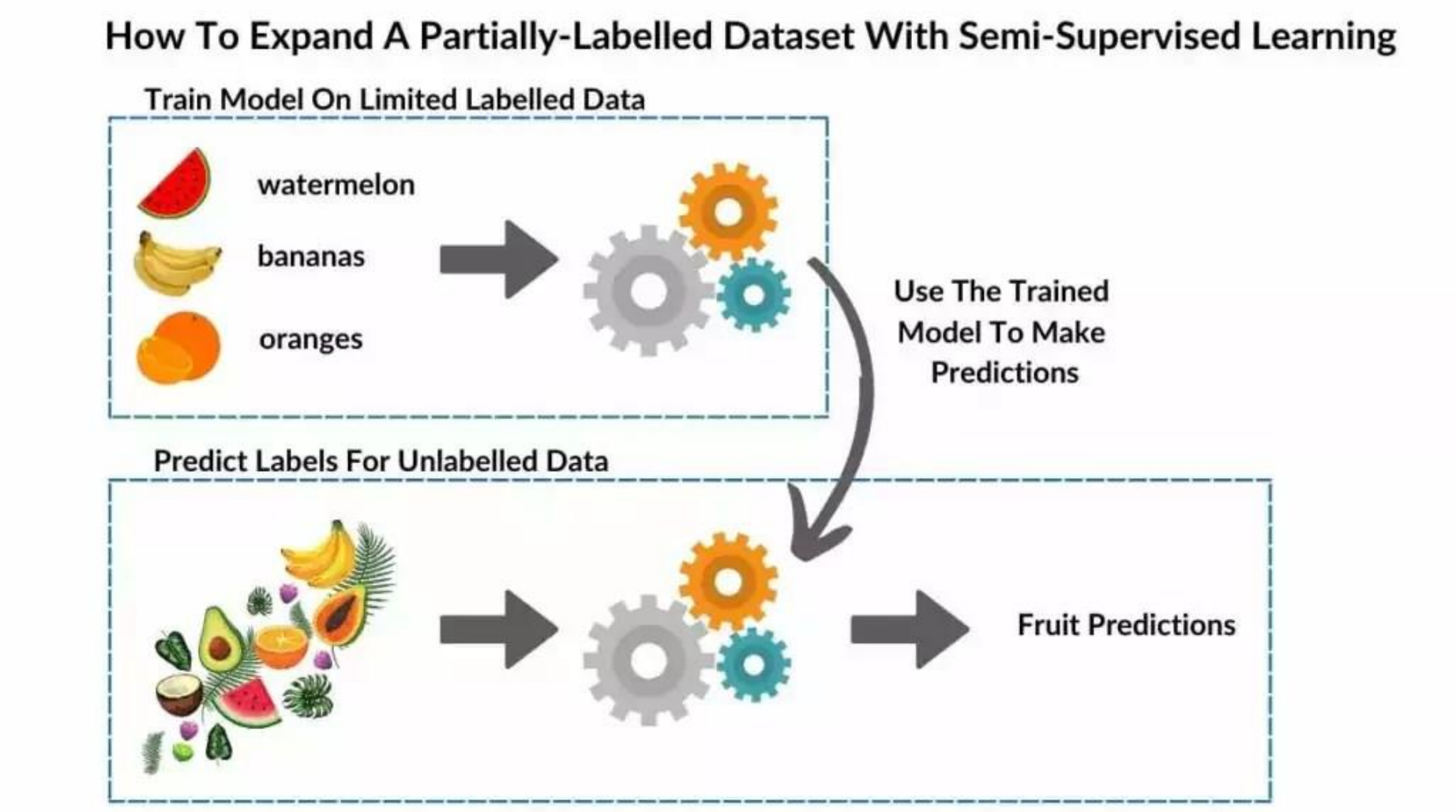
2.UnSupervised Learning



3.SemiSupervised 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.
- The main aim of this is to effectively use all the available data, rather than only labelled data like in supervised learning. Labelled data is a comparatively more expensive acquisition than unlabeled data.

3.SemiSupervised Learning



4.Reinforcement Learning

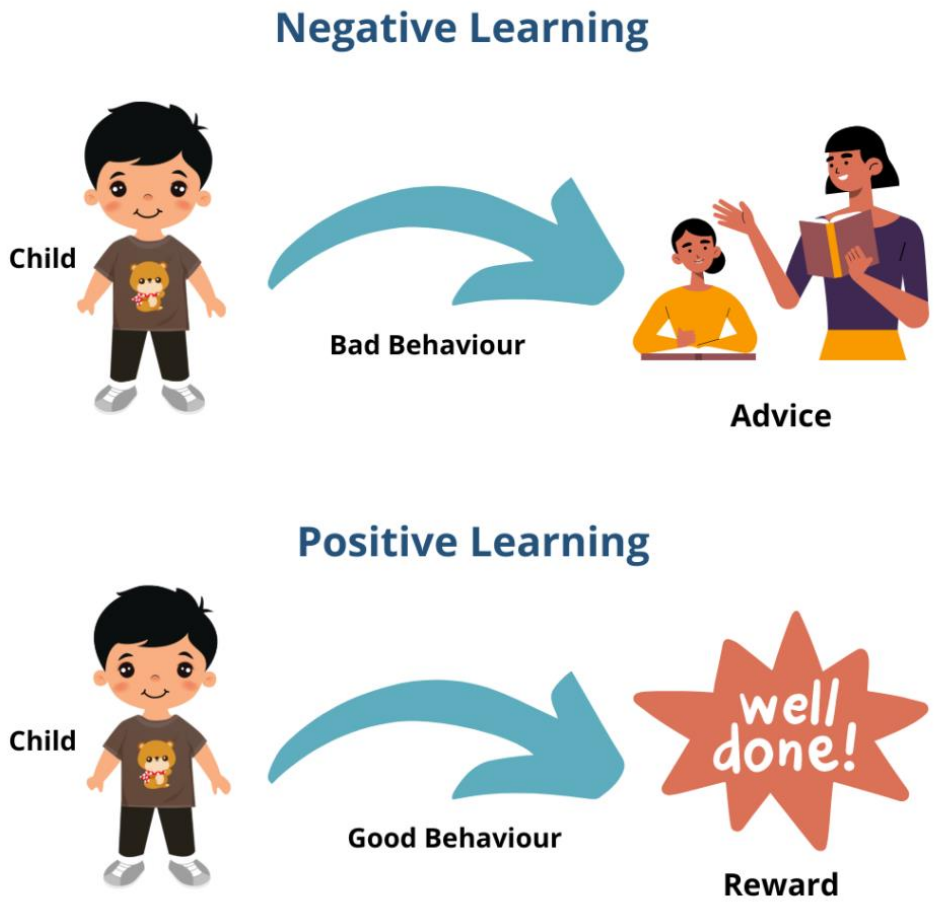
- Reinforcement Learning is a feedback-based Machine learning technique in which an agent learns to behave in an environment by performing the actions and seeing the results of actions. For each good action, the agent gets positive feedback, and for each bad action, the agent gets negative feedback or 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.

4.Reinforcement Learning

Example: self-driving cars

- In Reinforcement Learning (RL), agents are trained on a reward and punishment mechanism. The agent is rewarded for correct moves and punished for the wrong ones. In doing so, the agent tries to minimize wrong moves and maximize the right ones.

4.Reinforcement Learning



Summary

- Linear algebra is also used in neural networks and the data science field.
- Based on the methods and way of learning, machine learning is divided into mainly four types, which are:

1. Supervised Machine Learning
2. Unsupervised Machine Learning
3. Semi-Supervised Machine Learning
4. Reinforcement Learning

Lecture Level Questions

1. What is Machine learning?

a) The selective acquisition of knowledge through the use of computer programs

b) The selective acquisition of knowledge through the use of manual programs

c) The autonomous acquisition of knowledge through the use of computer programs

d) The autonomous acquisition of knowledge through the use of manual programs

Answer: c

Explanation: Machine learning is the autonomous acquisition of knowledge through the use of computer programs.

Lecture Level Questions

2. Which of the following is not a supervised machine learning algorithm?

a) K-means

b) Naïve Bayes

c) SVM for classification problems

d) Decision tree

Answer: a

Explanation: Decision tree, SVM (Support vector machines) for classification problems and Naïve Bayes are the examples of supervised machine learning algorithm. K-means is an example of unsupervised machine learning algorithm.

Lecture Level Questions

3. What is the key difference between supervised and unsupervised learning?

   a) Supervised learning requires labeled data, while unsupervised learning does not.

   b) Supervised learning predicts labels, while unsupervised learning discovers patterns.

   c) Supervised learning is used for classification, while unsupervised learning is used for regression.

   d) Supervised learning is always more accurate than unsupervised learning.

Answer: a

Explanation: The presence or absence of labeled data in the training set distinguishes supervised and unsupervised learning approaches.

Lecture Level Questions

4. Which type of machine learning algorithm falls under the category of “unsupervised learning”?

   a) Linear Regression

   b) K-means Clustering

   c) Decision Trees

   d) Random Forest

Answer: b

Explanation: K-means Clustering is an example of unsupervised learning used for clustering unlabeled data based on similarities.

Lecture Level Questions

5. Which type of machine learning algorithm falls under the category of “unsupervised learning”?

   a) Linear Regression

   b) K-means Clustering

   c) Decision Trees

   d) Random Forest

- Answer: b

  Explanation: K-means Clustering is an example of unsupervised learning used for clustering unlabeled data based on similarities.

References

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