Machine Learning

Some basic Maths

1) Mean $\frac{\text{Sum of All numbers}}{\text{How Many numbers are there}}$

2) Median Middle value

3) Mode Repeated value

4) Percentage out of 100

5) Ratio part | ~~To~~value

Accuracy :- $\left(\frac{\text{corrected prediction}}{\text{Total prediction}}\right) \times 100$

precision :- $\frac{\text{True positive}}{\text{Total predictive positive}}$

Recall - $\frac{\text{True positive}}{\text{Total Actual positive}}$

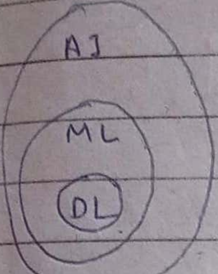
6) Basic Algebra $y = mx + b$

7) plotting x vs y x → independent variable
y → dependent variable
↳ Graphically represents two variable.

8) vectors Quantities with both magnitude and direction.

9) standard deviation :- Measuring the spread of data around the mean.

PHASE-0 ABOUT MACHINE LEARNING



ML :- when a machine or a computer learn from a past data or experience to make smart decision or prediction.

Types :- supervised ML

Input + output

├ ideal for tasks with labeled data where desired output is known.

used :- Linear regression, Logistic, ~~[illegible]~~

unsupervised ML

only input

├ suitable for identifying patterns in unlabeled data without explicit guidance

used :- cluster

Reinforcement ML

├ best for training agents to make decisions through interaction with an environment

(By getting Rewards and penalty)

Date: / /

Week-01

Math + Intuition

Supervised Learning

• When the algorithm is trained on a labeled dataset (both input and output ($x+y$) are known).

• The Model learns a mapping fxn $f: x \to y$ and then predicts y for unseen data.

Types

- Regression: output is continous (eg: Predicting Ho
- Classification: output is categorical (eg: spam vs nospam)

Unsupervised Learning

• When the algorithm is given only input (x) without labels (no y).

• Model tries to find pattern, groups or structures in the data.

Types

Clustering: Grouping similar datapoints (eg. customer
Dimensionality Reduction: Reducing number of features (eg. PCA)

Reinforcement learning

where an agent learns by interacting with a environment, taking actions, and receiving rewards penalties as feedback.

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- The goal is to learn a policy that maximizes cumulative reward over time.
  (Eg:- Games, Robotics, self-driving cars)

- Real world Application: Industrial process optimization, Dynamic pricing in e-commer

Differences

Aspect	Supervised Learning	Unsupervised Learning	Reinforcement Learn
Data type	Labeled Data (x+y available)	unlabeled data (only x available)	state, Action, Rewa tuples from envion
Goal	Learn a mapping fxn $f: x \to y$	Discover hidden structure, patterns	Learn a policy $\pi(s)$ that maximizes long-te reward.
Feedback	Direct	No Direct feedback	Reward signal guides learning
Learning Approach	Minimize error/loss (Eg. MSE, cross-Entropy)	optimizes similarity/dist. between data points	Trial-and-error wi exploration + exploita
Algorithm	Linear/Logistic Reg, SVM, Decision Trees, Neural Nets.	K-Means, Hierarchical clustering, PCA, DBSCAN	Q learning, SARSA, De Q-Network (DQN), Policy Gradient
output	Predictions (continuous or categorical)	clusters, latent features, lower-dimensional space.	sequence of actions (optimal policy)

complexity	Generally lower to moderate	moderate (sometimes high due to lack of labels)	High (requires many iteration and simul
Example	House price pred, spam detection, Disease diagno	customer seq., Market analysis, Anamoly detc.	Game AI, Robot Navig self-driving car
Data requirement	Require large labeled Dataset	Require large dataset but no labeling effort	Requires simulation environment (or real world interaction)
strength	very accurate when enough labeled data available.	Good for discovering unknown patterns	can handle sequential decision-making & delayed rewards.
weekness	Expensive to collect dat labels, prone to overfitting	Hard to evalute results, may form a meaning less clusters	computationally expens needs lots of trials (exploration)

Bias- Variance Tradeoff

Bias

- Bias refers to errors due to overlysimplistic assumptions in the learning algorithm
- Bias always deal with Training data

High-Bias

when model is toosimple, it underfits the data. This means the model does not capture important patterns in the data,

Low Bias

when the model is sufficiently complex and can capture the true relationships b/w input and outpu

variance

refers to errors due to the model's sensitivity to small fluctuations in the training data.

High variance

when the model is too complex, it overfits the data. This means the model performs well on the training set but poorly on new, unseen testing data because it has memorized the training data rather than learning patterns.

Low variance

when the model is general enough to perform consistently across both training and testing data.

Basic probability

Mean

calculated by summing all the values and dividing by the number of values.

$$\text{Mean}(\mu) = \frac{\sum x_i}{n}$$

Ex.

$$\text{Mean} = \frac{10+20+30+40+50}{5} = \frac{150}{5} = 30$$

Variance

variance measures how much the numbers are spread out from the means.

It is the average of the squared differences from mean.

$$\sigma^2 = \frac{\sum (x_i - \mu)^2}{n}$$

Covariance

covariance measures how two variable change together.

- positive covariance :- when one variable increases other tends to increase.
- Negative covariance :- when one variable increases the other tends to decrease.

$$\text{cov}(x, y) = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{n}$$

Distance Metrics (Euclidean, Manhattan)

Distance Metrics are the way to measure how far two points are from each other in space.

(1) Euclidean Distance

is the shortest distance b/w two points, like a straight line you would draw with a ruler.

$$d = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$$

(2) Manhattan Distance

is the distance you would travel along a grid, like moving on streets of Manhattan.

- you only move horizontaly and vertically, not diagonally.

$$d = |x_2 - x_1| + |y_2 - y_1|$$

Linear Algebra

Vectors

A vector is just an ordered list of numbers that represents a quantity with both magnitude and direction.

ex: $\vec{v} = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$

Dot product

The dot product of two vectors measures how similar their directions are.
It gives a single number as output.

$$\vec{a} \cdot \vec{b} = a_1 b_1 + a_2 b_2$$

- If dot product is 0, vectors are perpendicular

Matrix Multiplication

A Matrix is just a table of numbers arranged in rows and columns.
Matrix multiplication combines two matrices to form a new one, following a rule.

Rule

No. of columns in first matrix must equal no. of rows in second matrix.