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Artificial Intelligence Engineering (Level-1)

Module 2

Content

- Module 1: Introduction to AI and Machine Learning
- Module 2: Linear Algebra, Statistics and Probability for AI
- Module 3: Neural Network Architecture
- Module 4: Building Machine Learning Models
- Module 5: Deep Learning Concepts
- Module 6: Python Data Structure
- Module 7: Data Handling with Pandas and NumPy
- Module 8: Python for AI
- Module 9: Classification AI Project
- Module 10: Prediction AI Project

Artificial Intelligence Engineering (Level-1)

Module 2: Linear Algebra, Statistics and Probability for AI

Content

- Introduction to Linear Algebra
- Vector, Matrices, Dot Product and Matrix Multiplication
- Calculatus Basics for Optimization (Derivatives, Gradient Descent)
- Introduction to Statistics
- Types of Statistics
- Measures of Central Tendency (Mean, Median, Mode)
- Measures of Dispersion (Range, Variance, Standard Deviation)
- Data Distributions
- Probability for AI

Learning Outcomes

- Understand Linear Algebra Basics: Grasp the concepts of vectors, matrices, dot products, and matrix multiplication as fundamental tools in AI and machine learning.
- Apply Calculus to Optimization: Learn the basics of derivatives and gradient descent for optimizing functions in AI models.
- Introduction to Statistics: Develop a foundational understanding of statistics to analyze and interpret data effectively.
- Differentiate Types of Statistics: Distinguish between descriptive and inferential statistics and their applications in data analysis.
- Analyze Central Tendencies: Calculate and interpret mean, median, and mode to summarize datasets.

Learning Outcomes

- Understand Measures of Dispersion: Compute range, variance, and standard deviation to evaluate data spread and variability.
- Explore Data Distributions: Identify and understand common data distributions such as normal and skewed distributions.
- Understand Probability Basics: Learn foundational probability concepts to assess uncertainty in AI.
- Develop Problem-Solving Skills: Apply linear algebra, statistics, and calculus to solve real-world AI-related problems.
- Prepare for Advanced AI Concepts: Build the mathematical foundation necessary for deeper exploration into machine learning and AI.

Introduction to Linear Algebra

What is Linear Algebra?

- Linear algebra is the branch of mathematics that deals with vectors, matrices, and linear transformations.
- Essential for data representation and manipulation in AI and machine learning.

Why is it important in AI?

- Used for data analysis, neural networks, optimization, and dimensionality reduction.

Introduction to Linear Algebra

Application of Linear Algebra in AI

- **Neural Networks:**
  - Represent weights as matrices, use matrix multiplication for layer outputs.
- **Computer Vision:**
  - Image data is represented as matrices; transformations like rotation, scaling and translation are matrix operations.
- **Data Dimensionality Reduction:**
  - Techniques like Principal Component Analysis (PCA) use eigenvectors and eigenvalues.

Understanding Vectors

What is a Vector?

- ❑ A vector is a one-dimensional array of numbers (e.g., [3, 5, 7]).
- ❑ Represents quantities with both magnitude and direction.

Common Uses in AI

- ❑ Data points, features in datasets, model weights.

Understanding Vectors

Basic Vector Operations:

- **Addition**: Adds corresponding elements.

  Example: [1,2] + [3,4] = [4,6]

- **Scalar Multiplication**: Multiplies each element by a scalar.

  Example: 3 × [2, 4] = [6, 12]

Understanding Vectors

Notation

- A vector is often written in bold lowercase letters (e.g., **v**).

Example: $$\boldsymbol{v} = \begin{bmatrix} 3 \\ 4 \\ 5 \end{bmatrix}$$

- **Addition**:

$$\boldsymbol{a} + \boldsymbol{b} = \begin{bmatrix} 1 \\ 2 \end{bmatrix} + \begin{bmatrix} 3 \\ 4 \end{bmatrix} = \begin{bmatrix} 4 \\ 6 \end{bmatrix}$$

- **Scalar Multiplication**:

$$3 \times \boldsymbol{v} = 3 \times \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 3 \\ 6 \\ 9 \end{bmatrix}$$

Matrices

What is Matrix?

- **Definition:**
  - A matrix is a two-dimensional array of numbers, arranged in rows and columns.

Example: $$\boldsymbol{A} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

- **Use Cases in Ai:**
  - Represent datasets, image pixels, weights in neural networks, and transformations.

Matrices

❑ Basic Matrix Operations:

- **Matrix Addition:** Adds corresponding elements.

$$A + B = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} + \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} = \begin{bmatrix} 6 & 8 \\ 10 & 12 \end{bmatrix}$$

- **Scalar Multiplication:** Multiplies each element by a scalar.

$$A \times B = \begin{bmatrix} (1 \times 5 + 2 \times 7) & (1 \times 6 + 2 \times 8) \\ (3 \times 5 + 4 \times 7) & (3 \times 6 + 4 \times 8) \end{bmatrix} = \begin{bmatrix} 19 & 22 \\ 43 & 50 \end{bmatrix}$$

Matrices

Matrix Multiplication

- **What is Matrix Multiplication?**
  - Used to transform data, compute weighted sums in neural networks.

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \times \begin{bmatrix} i & j \\ k & l \end{bmatrix} = \begin{bmatrix} a.i + b.k & a.j + b.l \\ c.i + d.k & c.j + d.l \end{bmatrix}$$

Linear Equations and System

We are solving the system of equations: $2x + 3y = 8$
$4x + y = 10$

Step 1: Matrix Form

The system can be written in matrix form as: $\begin{bmatrix} 2 & 3 \\ 4 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 8 \\ 10 \end{bmatrix}$

Step 2: Solving Using Substitution or Elimination

Using Substitution:

From the second equation, solve for y in terms of x: $4x + y = 10 \Rightarrow y = 10 - 4x$

Linear Equations and System

Substitute $y = 10 - 4x$ into the first equation:

$$2x + 3(10 - 4x) = 8$$

$$2x + 30 - 12x = 8$$

$$-10x + 30 = 8$$

$$-10x = -22$$

$$x = \frac{22}{10} = 2.2$$

Substitute $x = 2.2$ back into $y = 10 - 4x$:

$$y = 10 - 4(2.2)$$

$$y = 10 - 8.8$$

$$y = 1.2$$

Step 3: Final Solution

$$\boldsymbol{x = 2.2, y = 1.2}$$

Linear Equations and System

Verification

Substitute $x = 2.2, y = 1.2$ into both equation:

1. $2x + 3y = 8$:

$$2(2.2) + 3(1.2) = 4.4 + 3.6 = 8\ (Correct!)$$

2. $4x + y = 10$:

$$4(2.2) + 1.2 = 8.8 + 1.2 = 10\ (Correct!)$$

Thus, the solution is:

$$x = 2.2, y = 1.2$$

Matrices

❑ How to Multiply Matrices:

- For matrices **A** (size $m \times n$) and **B** (size $n \times p$), the result is a matrix of size $m \times p$.

- **Formula:** $\boldsymbol{C} = \boldsymbol{A} \times \boldsymbol{B}$ where $c_{ij} = \sum_{k=1}^{n} a_{ik} \times b_{kj}$

- **Example:**

$$\boldsymbol{A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}, \boldsymbol{B} = \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}$$

$$\boldsymbol{A} \times \boldsymbol{B} = \begin{bmatrix} (1 \times 5 + 2 \times 7) & (1 \times 6 + 2 \times 8) \\ (3 \times 5 + 4 \times 7) & (3 \times 6 + 4 \times 8) \end{bmatrix} = \begin{bmatrix} 19 & 22 \\ 43 & 50 \end{bmatrix}$$

Dot Product and Matrix Multiplication

Dot Product

- The dot product of two vectors **a** and **b** is the sum of the products of their corresponding elements.

$$a \,.\, b = a_1 b_1 + a_2 b_2 + \ldots + a_n b_n$$

- Used in AI to compute weights in neural networks:

$$output = \boldsymbol{w} \,.\, \boldsymbol{x} + \boldsymbol{b}$$

Determinants

For $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$, the determinant is:

$$\det(A) = 1 \cdot 4 - 2 \cdot 3 = 4 - 6 = -2$$

For a 3×3matrix:

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 4 & 5 \\ 1 & 0 & 6 \end{bmatrix}$$

$$def(A) = 1 \cdot \begin{vmatrix} 4 & 5 \\ 0 & 6 \end{vmatrix} - 2 \cdot \begin{vmatrix} 0 & 5 \\ 1 & 6 \end{vmatrix} + 3 \cdot \begin{vmatrix} 0 & 4 \\ 1 & 0 \end{vmatrix}$$

$$= 1 \cdot (4 \cdot 6 - 0 \cdot 5) - 2 \cdot (0 \cdot 6 - 1 \cdot 5) + 3 \cdot (0 \cdot 0 - 1 \cdot 4)$$

$$= 24 + 10 - 12 = 22$$

Eigenvalues & Eigenvectors

For $\boldsymbol{A} = \begin{bmatrix} 4 & 1 \\ 2 & 3 \end{bmatrix}$:

Find eigenvalues (λ) using:

$$\det(\boldsymbol{A} - \lambda \boldsymbol{I}) = 0$$

$$det \begin{bmatrix} 4 - \lambda & 1 \\ 2 & 3 - \lambda \end{bmatrix} = (4 - \lambda)(3 - \lambda) - 2 \cdot 1 = \lambda^2 - 7\lambda + 10 = 0$$

Solve $\lambda^2 - 7\lambda + 10 = 0$ to find $\lambda = 5, 2$.

Linear Transformations

Given transformation $\mathbf{T}(\boldsymbol{x}) = \boldsymbol{A}\boldsymbol{x}$,where:

$$\boldsymbol{A} = \begin{bmatrix} 2 & 0 \\ 0 & 3 \end{bmatrix}, \qquad \boldsymbol{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$\boldsymbol{T}(\boldsymbol{x}) = \begin{bmatrix} 2x_1 \\ 3x_2 \end{bmatrix}$$

Determine how $\boldsymbol{T}$ stretches/compresses vectors.

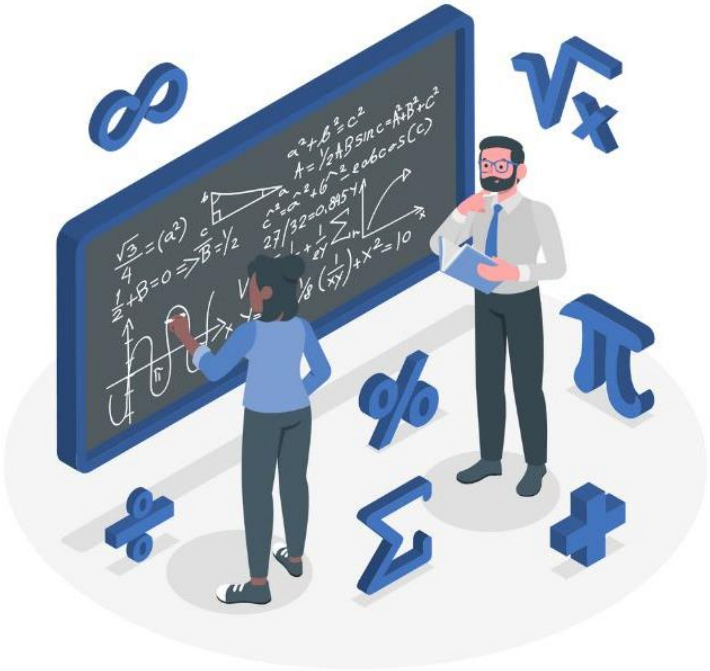
Assignment 1

Assignment 2

Calculus Basics for Optimization

Objectives:

- Understand how calculus is used in AI, particularly for optimization.
- Learn about derivatives, gradients, and their role in training models.



Calculus Basics for Optimization

Derivatives

- Concept of rate of change and how derivatives are used to optimize functions.
- **Partial Derivatives**: Useful for understanding gradients in multivariable functions.

Example: If $f(x) = x^2$, at $x = 3$, the slope of the tangent (rate of change) is $f'(3) = 2 \cdot 3 = 6$.

The derivative of a function $f(x)$ measures how $f(x)$ changes with respect to x. For instance:

$$f(x) = x^2$$

The derivative $f'(x) = 2x$ tells us the rate of change of $f(x)$ at any point x.

Derivative

- **Definition:** The derivative measures the rate of change of a function with respect to one variable in a single-variable function.
- **Context:** It applies to functions of one variable, such as $f(x)$.
- **Notation:** Represented as $\frac{df}{dx}, f'(x), \; or \; \dot{f}(x)$.
- **Example:** For $f(x) = x^2 + 3x$:

$$\boldsymbol{\frac{df}{dx} = 2x + 3}$$

Partial Derivative

- **Definition:** The partial derivative measures the rate of change of a multivariable function with respect to one variable, keeping all other variables constant.
- **Context:** It applies to functions of multiple variables, such as $f(x, y, z)$.
- **Notation:** Represented as $\frac{\partial f}{\partial x}, \partial_x f \;\; or \; f_x$.
- **Example:** For $f(x, y) = \; x^2y + y^3$:
  - Partial derivative with respect to x:

$$\boldsymbol{\frac{\partial f}{\partial x} = 2xy}$$

  - Partial derivative with respect to y:

$$\boldsymbol{\frac{\partial f}{\partial y} = x^2 + 3y^2}$$

Difference between Derivative & Partial Derivative

Key Differences

Aspect	Derivative	Partial Derivative
Applicability	Single-variable functions $(f(x))$	Multivariable functions $(f(x, y, z))$
Number of Variables	One variable	More than one variable
Notation	$\frac{d}{dx}, f'(x)$	$\frac{\partial}{\partial x}, \partial_x f$
Variables Kept Constant	Not applicable (only one variable)	All other variables are kept constant
Use Cases	Rates of change, Tangents to curves	Multivariable calculus, gradients, and optimization

When to use Derivative & Partial Derivative

When to Use Each

- **Derivative:** When studying functions of a single variable (e.g., $y = f(x)$).
- **Partial Derivative:** When working with functions of multiple variables (e.g., $z = f(x, y)$), especially in physics, engineering, and machine learning.

Basics Derivatives Rules

Basic Derivatives Rules

1. Power Rule:

$$\frac{d}{dx}[x^n] = nx^{n-1}$$

2. Sum/Difference Rule:

$$\frac{d}{dx}[f(x) + g(x)] = f'(x) + g'(x)$$

3. Product Rule:

$$\frac{d}{dx}[f(x)g(x)] = f'(x)g(x) + f(x)g'(x)$$

4. Quotient Rule:

$$\frac{d}{dx}\left[\frac{f(x)}{g(x)}\right] = \frac{f'(x)g(x)-f(x)g\prime(x)}{[g(x)]^2}$$

5. Chain Rule:

$$\frac{d}{dx}f\big(g(x)\big) = f'\big(g(x)\big) \cdot g'(x)$$

6. Exponential and Logarithmic Rules:

$$\frac{d}{dx}e^x = e^x, \ \frac{d}{dx}\ln(x) = \frac{1}{x}$$

Using the Power Rule

Example 1: Using the Power Rule

Find $\frac{d}{dx}\left[3x^4 - 5x^2 + 7x - 10\right]$:

$$\frac{d}{dx}\left[3x^4\right] = 12x^3, \quad \frac{d}{dx}\left[-5x^2\right] = -10x, \quad \frac{d}{dx}\left[7x\right] = 7, \quad \frac{d}{dx}\left[-10\right] = 0$$

$$\frac{d}{dx}\left[3x^4 - 5x^2 + 7x - 10\right] = 12x^3 - 10x + 7$$

Product Rule

Example 2: Product Rule

Find $\frac{d}{dx}\left[x^2 \sin(x)\right]$:

$$f(x) = x^2, \qquad g(x) = \sin(x)$$

$$\frac{d}{dx}\left[x^2 \sin(x)\right] = \frac{d}{dx}\left[x^2\right] \cdot \sin(x) + x^2 \cdot \frac{d}{dx}\left[\sin(x)\right]$$

$$= 2x \sin(x) + x^2 \cos(x)$$

Quotient Rule

Example 3: Quotient Rule

Find $\frac{d}{dx}\left[\frac{x^2}{\cos(x)}\right]$:

$$f(x) = x^2, \qquad g(x) = \cos(x)$$

$$\frac{d}{dx}\left[\frac{x^2}{\cos(x)}\right] = \frac{\frac{d}{dx}[x^2] \cdot \cos(x) - x^2 \cdot \frac{d}{dx}[\cos(x)]}{[\cos(x)]^2}$$

$$= \frac{2x\cos(x) + x^2\sin(x)}{cos^2(x)}$$

Chain Rule

Example 4: Chain Rule

Find $\frac{d}{dx}\left[(3x^2+2)^5\right]$:

$$f(g(x)) = g(x)^5, \qquad g(x) = 3x^2 + 2$$

$$\frac{d}{dx}\left[(3x^2+2)^5\right] = 5(3x^2+2)^4 \cdot \frac{d}{dx}\left[3x^2+2\right]$$

$$= 5(3x^2+2)^4 \cdot 6x$$

$$= 30x(3x^2+2)^4$$

Assignment 3

Calculous Basics for Optimization

Gradient Descent

- An optimization algorithm used to minimize loss functions.
- Understanding how gradients help update weights in machine learning models.

Gradient descent is an optimization algorithm used to minimize a function, typically a cost function $J(\theta)$.

Example:
- Start with an initial guess for the parameters θ.
- Update θ iteratively using:

$$\theta = \theta - \alpha \cdot \frac{\partial J(\theta)}{\partial \theta}$$

where:
- α: Learning rate.
- $\frac{\partial J(\theta)}{\partial \theta}$: Gradient of J with respect to θ.

Gradient Descent for Minimization

Problem:

Minimize $f(x) = x^2 - 4x + 4$.

1. **Objective Function**:

$$f(x) = x^2 - 4x + 4$$

2. **Gradient**:

$$\frac{df}{dx} = 2x - 4$$

3. **Update Rule**:

$$x_{t+1} = x_t - \eta \cdot (2x_t - 4)$$

Gradient Descent for Minimization

4. **Iterations**: Start with $x_0 = 0$ and learning rate $\eta = 0.1$:

    - Iteration 1:

$$x_1 = 0 - 0.1(2(0) - 4) = 0 - 0.1(-4) = 0.4$$

    - Iteration 2:

$$x_2 = 0.4 - 0.1(2(0.4) - 4) = 0.4 - 0.1(-3.2) = 0.72$$

    - Iteration 3:

$$x_3 = 0.72 - 0.1(2(0.72) - 4) = 0.72 - 0.1(-2.56) = 0.976$$

The algorithm converges towards $x = 2$, where $f(x)$ has its minimum value.

Assignment 4

Introduction to Statistics

What is Statistics?

- Statistics is the science of collecting, analyzing, and interpreting data.
- Used to draw conclusions and make informed decisions based on data.

Why is Statistics important in AI?

- Helps understand data distributions, relationships, and trends.
- Essential for evaluating model performance, detecting biases, and making predictions.

Types of Statistics

Descriptive Statistics

- Summarizes and describes data.
- Examples: mean, median, mode, range, variance, and standard deviation.

Example: Given a dataset: [10, 20, 20, 40, 50]

- **Mean:** Average value = $\frac{10+20+20+40+50}{5} = 28$
- **Median:** Middle value (sorted) = 20
- **Mode:** Most frequent value = 20
- **Range:** Difference between max and min = $50 - 10 = 40$
- **Variance:** Measure of data spread = $\frac{(10-28)^2 + \cdots + (50-28)^2}{5} = 240$
- **Standard Deviation:** $\sqrt{240} \approx 15.49$

Types of Statistics

Inferential Statistics

- Makes predictions or inferences about a population based on a sample.
- Examples: hypothesis testing, confidence intervals, and regression analysis.

Example:

- A sample of 100 students shows an average height of 5.5 ft.
  - **Confidence Interval:** "We are 95% confident the true mean height of the population is between 5.4 and 5.6 ft.“
  - **Hypothesis Testing:** Test if the mean height of the population is different from 5.5 ft.
  - **Regression Analysis:** Predict a student's weight based on height using a linear regression model.

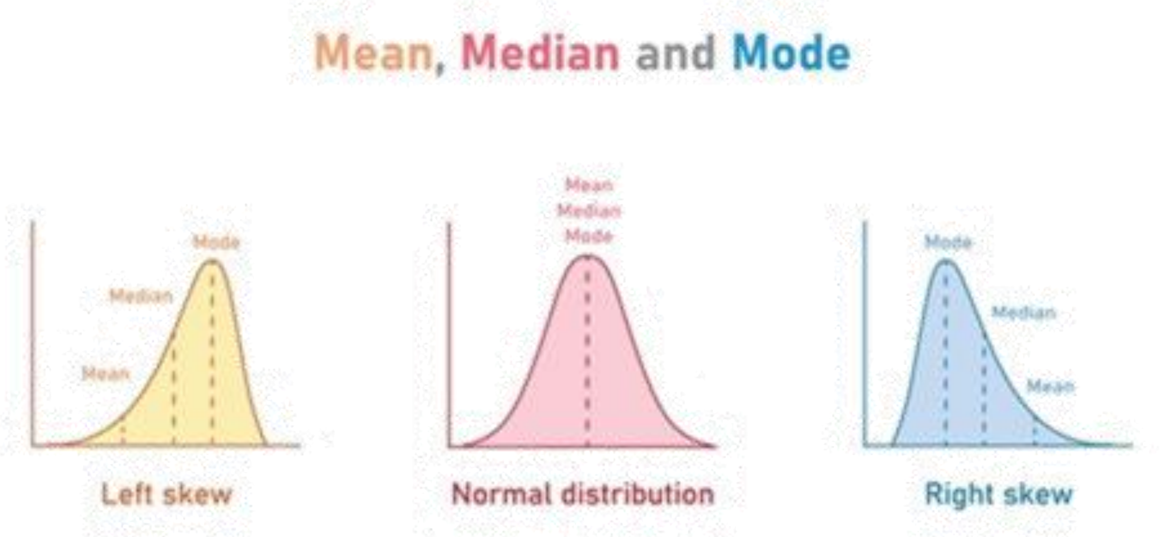
Measures of Central Tendency

- Central Tendency and Summarize datasets
  - Mean
  - Median
  - Mode

Examples:

Dataset: [3, 7 ,5, 5, 10]

Mean = 6, Median = 5, Mode = 5



Mean (Average)

- The sum of all values divided by the number of values.

$$Mean = \frac{\sum x_i}{n}$$

For example:

$$2 + 2 + 5 + 6 + 7 + 8 = \mathbf{30}$$

$$30 \div 6 = \mathbf{5}$$

$$The\ mean\ number\ is\ \mathbf{5}.$$

Median

- The middle value when data is sorted.
- Useful when data has outliers.

For example:

$$2 + 2 + 5 + 6 + 7 + 8 + 9$$

$$The\ median\ number\ is\ \mathbf{6}.$$

Mode

- The most frequently occurring value in the dataset.

For example:

$$2 + 2 + 5 + 6 + 7 + 8$$

$$The\ mode\ number\ is\ \mathbf{2}.$$

Measures of Dispersion

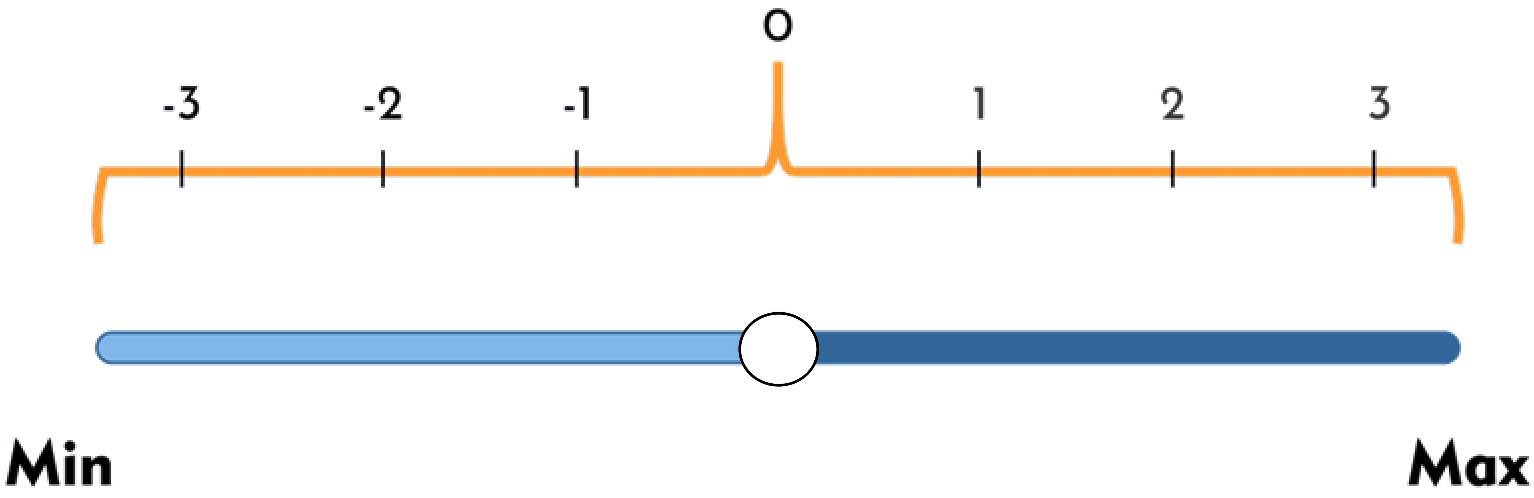
Dispersion + Better Model Training

- **Range**
- **Variance**
- **Standard Deviation**

Range

- The difference between the maximum and minimum values.

$$\boxed{Range = Max - Min}$$



Variance

- Measures how far data points are from the mean.

$$Variance = \frac{\sum(x_i \; - mean)^2}{n}$$

Standard Deviation (SD)

- The square root of variance, showing the average deviation from the mean.

$$\boxed{SD = \sqrt{Variance}}$$

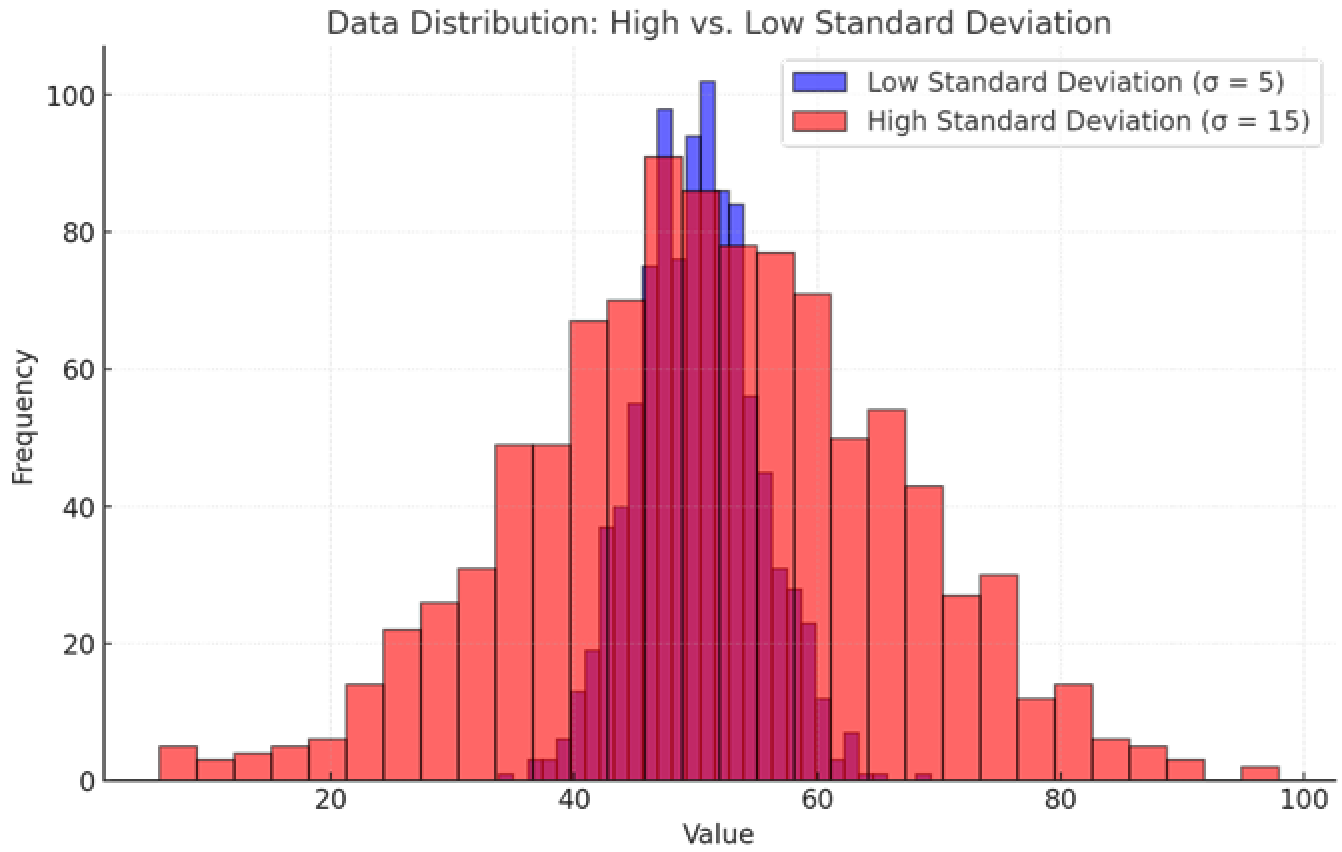
Assignment 5

Assignment 6

Measures of Dispersion

Why it matters in AI?

- Understanding data variability helps in model selection and evaluation.

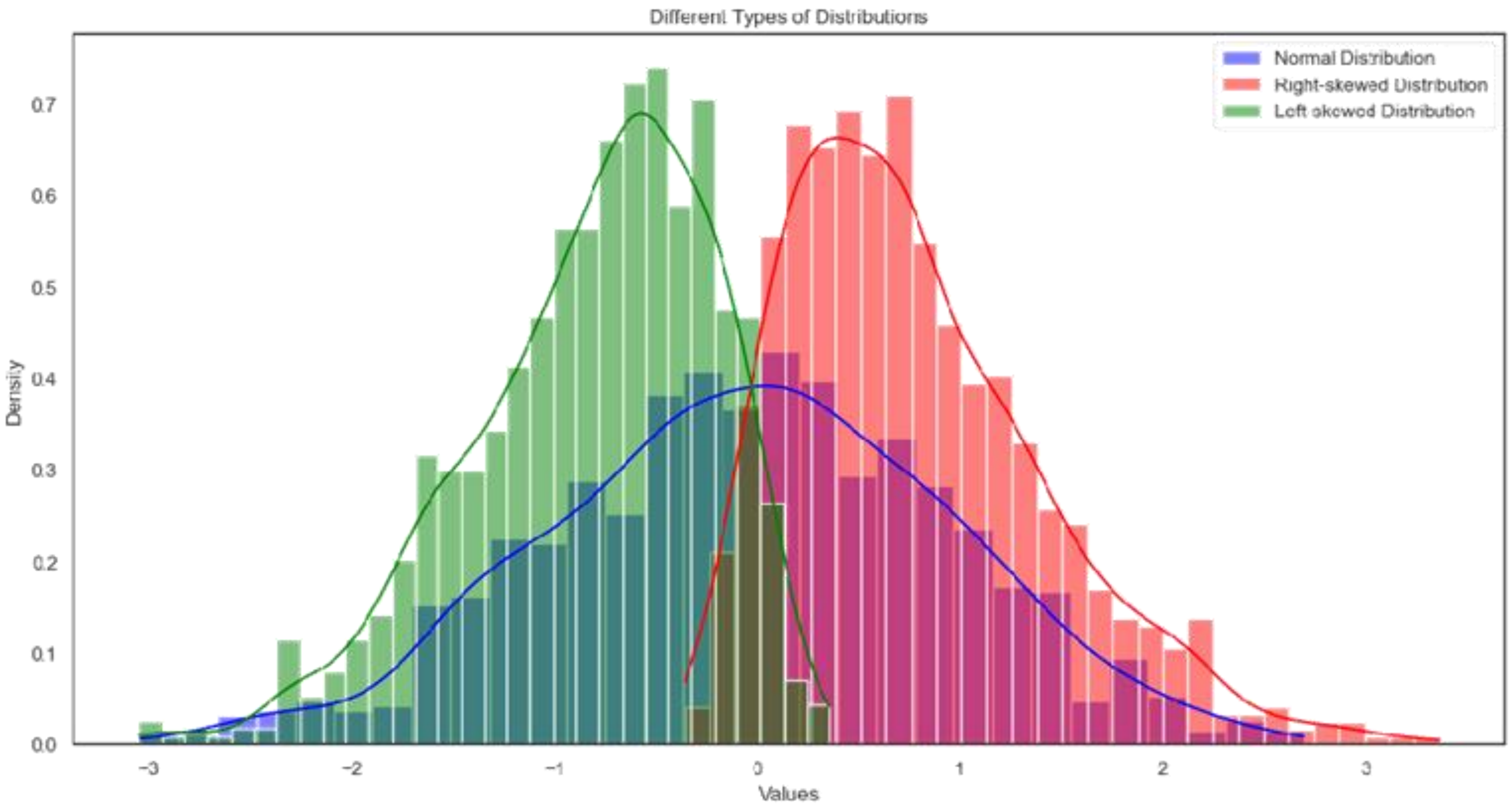


- Graph showing data distribution with a high and low standard deviation.

Data Distributions

What is Data Distributions?

- A distribution shows how often each value in a dataset occurs.



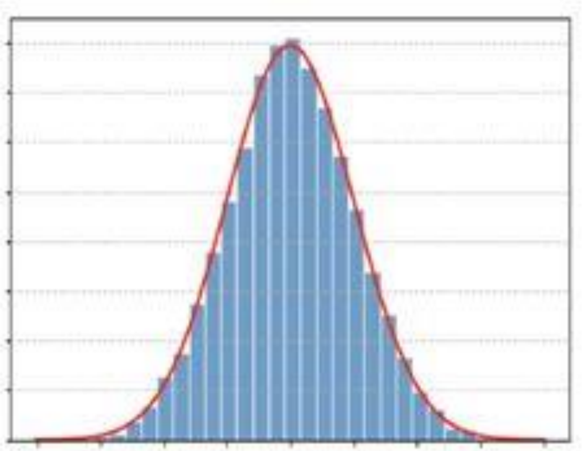
Types of Distributions

Normal Distribution

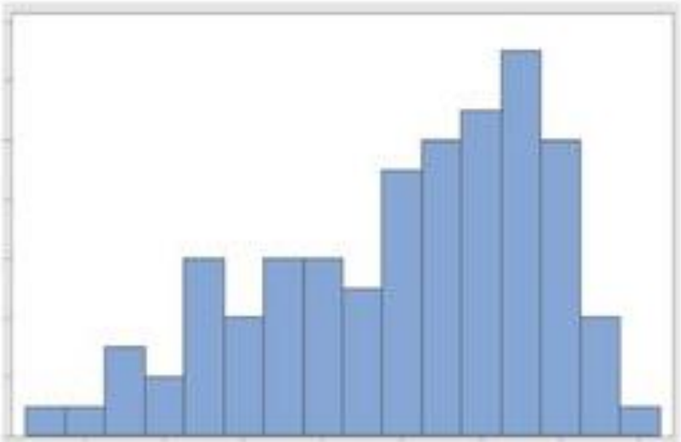
- Symmetrical, bell-shaped curve centered around the mean.
- Properties: 68% of data falls within 1 SD, 95% within 2 SDs

Skewed Distribution

- **Left-Skewed**: Tail on the left, mean < median.
- **Right-Skewed**: Tail on the right, mean > median.



Normal Distribution



Skewed Distribution

Probability for AI

What is Probability?

- ❑ The likelihood of an event occurring, ranging from 0 (impossible) to 1 (certain).

Why Probability is important in AI?

- ❑ Used in algorithms for classification, regression, and prediction.

Descriptive Statistics

- ❑ Measures of central tendency (mean, median, mode).
- ❑ Measures of dispersion (variance, standard deviation).

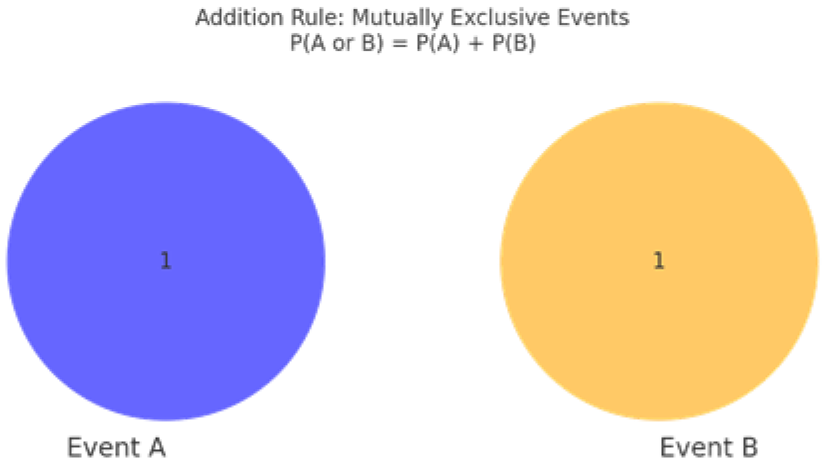
Inferential Statistics

- ❑ Hypothesis testing, p-values, confidence intervals.
- ❑ Correlation and causation.

Basic Probability Rules

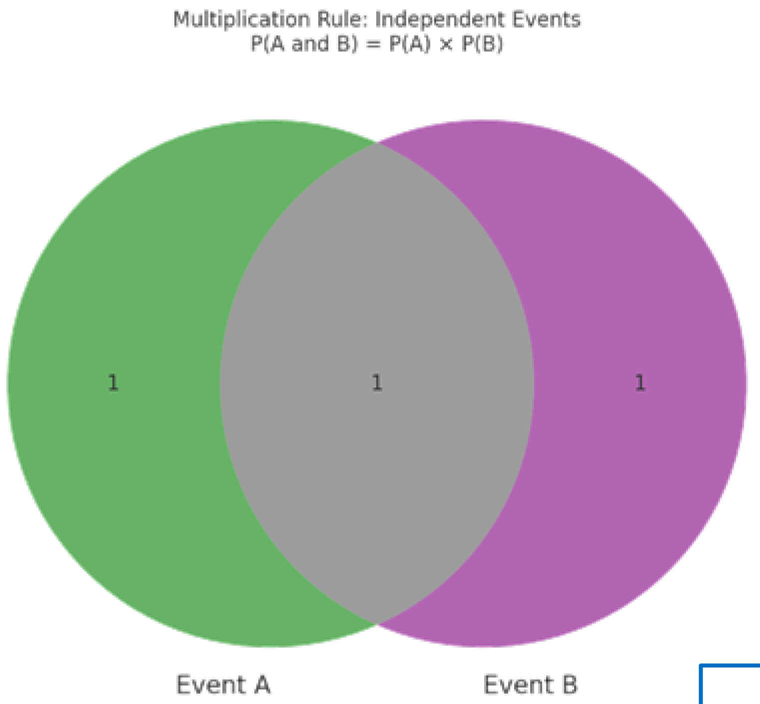
- **Addition Rule:** For mutually exclusive events:

$$P(\,A \text{ or } B) = P(A) + P(B)$$



- **Multiplication Rule:** For independent events:

$$P(\,A \text{ and } B) = P(A) \times P(B)$$

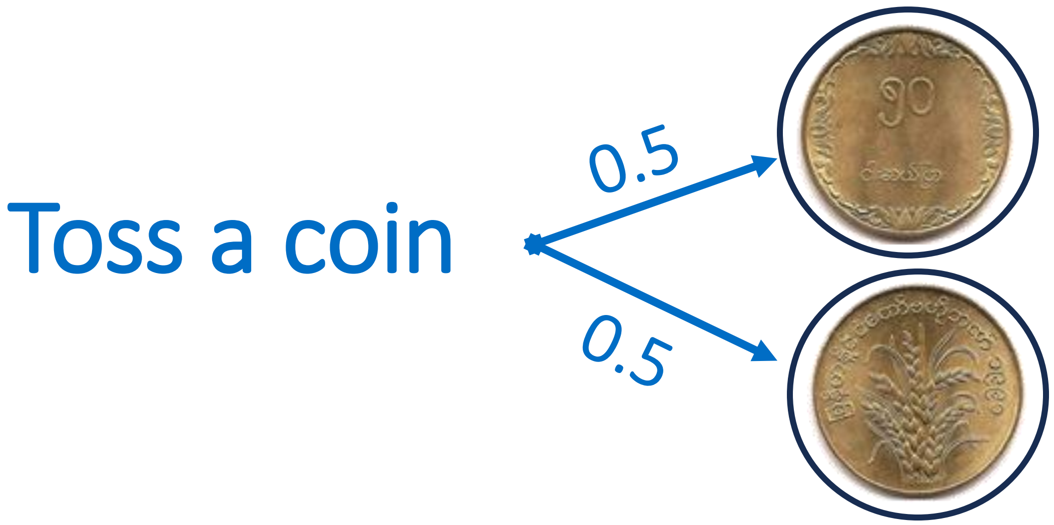


Venn diagrams illustrating addition and multiplication rules.

Basic Probability Rules

Example: What is the probability of getting heads when flipping a coin?

- When flipping a coin, the probability of getting heads is 0.5 since there are two equally likely outcomes (heads or tails).



Prior Probability

- $P(Spam)$: The Proportion of emails labeled as spam.
- $P(Not\ Spam)$: The Proportion of emails not labeled as spam.

Example: Suppose you have an email dataset where:

- 40% of the emails are labeled as **Spam**.
- 60% of the emails are labeled as **Not Spam**.

Prior Probability:

- $P(Spam) = 0.4$ (Proportion of emails labeled as spam)
- $P(Not\ Spam) = 0.6$ (Proportion of emails not labeled as spam)

Conditional Probability

- Calculate the likelihood of certain words appearing in spam vs. non-spam emails.

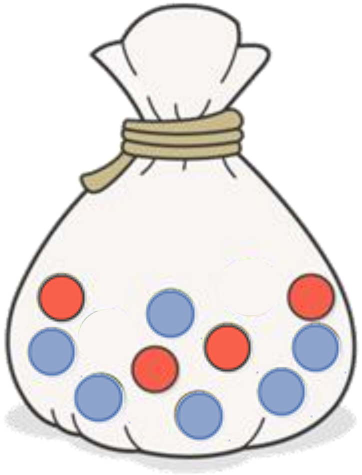
$$\boxed{P(Word|Spam)}$$

Conditional Probability

Scenario: You have a bag of 10 marbles:

- 4 are **red**.
- 6 are **blue**.

Now, suppose you randomly pick a marble, and you are told it's **blue**. What's the probability that this blue marble came from the bag?



Conditional Probability: The probability of picking a **blue marble** is:

$$P(Blue) = \frac{Number\ of\ blue\ marbles}{Total\ marbles} = \frac{6}{10} = 0.6$$

If we are given the condition that the marble is **blue**, the probability stays the same, since we're directly working with the blue marbles. This illustrates:

$$P(Blue\ |Condition: Bag) = 0.6$$

Assignment 7

Bayesian Approach

- Use Bayes' Theorem to classify a new email:

$$P(Spam|Words) = \frac{P(Words|Spam) \times P(Spam)}{P(Words)}$$

Scenario: You have two bowls of candies

- **Bowl A**: 30% chocolate candies, 70% fruit candies.
- **Bowl B**: 80% chocolate candies, 20% fruit candies.

You randomly pick a bowl, and from that bowl, you pick a **chocolate candy**. What’s the probability it came from **Bowl B**?

Bayesian Approach

Given:
- $P(Bowl\ B) = 0.5$
- $P(Chocolate \mid Bowl\ B) = 0.8$
- $P(Chocolate \mid Bowl\ A) = 0.3$

Formula to use:

$$\boxed{P(Bowl\ B \mid Chocolate) = \frac{P(Chocolate \mid Bowl\ B)\ \cdot P(Bowl\ B)}{P(Chocolate)}}$$

1. Calculate $\boldsymbol{P(Chocolate)}$:

$$P(Chocolate) = P(Chocolate \mid Bowl\ A)\ \cdot P(Bowl\ A) + P(Chocolate \mid Bowl\ B)\ \cdot P(Bowl\ B)$$
$$P(Chocolate) = (0.3\ \cdot 0.5) + (0.8\ \cdot 0.5) = 0.15 + 0.4 = \mathbf{0.55}$$

2. Calculate $\boldsymbol{P(Bowl\ B \mid Chocolate)}$:

$$P(Bowl\ B \mid Chocolate) = \frac{0.8\ \cdot 0.5}{0.55} = \frac{0.4}{0.55} \approx \mathbf{0.727}$$

Assignment 8 (Python Assignment)

Assignment: Predicting Loan

- **Problem Statement:**
  - Build a model to predict whether a customer will default on a loan based on past data.

Applying Probability:

- **Prior Probability**:

  The historical rate of loan defaults: $P(Default)$

- **Conditional Probability:**

  Probability of default given income level: $P(Default \mid Income\ Level)$

  Probability of default given credit score: $P(Default \mid Credit\ Score)$

- **Using Bayesian Networks:**

  Model relationships between variables like income, credit score, and loan default risk.

Assignment: Predicting Loan

```
import pandas as pd
from sklearn.model_selection
import train_test_split

from sklearn.naive_bayes
import GaussianNB from sklearn.metrics
import confusion_matrix, accuracy_score
# Load dataset (simulated example)
data = pd.DataFrame({ "income": [50, 100, 150, 30, 120], "credit_score": [700, 850, 650, 600,
720], "default": [0, 0, 1, 1, 0] })
# Feature matrix and target variable
X = data[['income', 'credit_score']] y = data['default']
# Train-test split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)
# Train a Gaussian Naive Bayes classifier
model = GaussianNB() model.fit(X_train, y_train)
# Make predictions
predictions = model.predict(X_test)
accuracy = accuracy_score(y_test, predictions)
print("Accuracy:", accuracy)
```

RIG

Realistic Infotech Group

Realistic Infotech Group
IT Training & Services
No.79/A, First Floor
Corner of Insein Road and
Damaryon Street
Quarter (9), Hlaing Township
Near Thukha Bus Station
09256675642, 09953933826
http://www.rig-info.com