Chapter 8: Probability

Introduction

In the world of Artificial Intelligence and data science, understanding uncertainty is key. **Probability** is the branch of mathematics that deals with **predicting the likelihood of events**. In AI systems, this helps in **decision-making, pattern recognition, and risk analysis**.

In Class 9, you will be introduced to **basic probability concepts**. This chapter will explain what probability is, how it is calculated, and how to interpret results in real-life scenarios, including AI-related applications.

8.1 What is Probability?

Probability is a measure of how likely an event is to occur. The probability of any event lies between **0 and 1**, where:

- **0** means the event is **impossible**,
- **1** means the event is **certain**.

Real-Life Examples:

- Tossing a coin and getting heads.
- Rolling a die and getting a 4.
- Selecting a red ball from a bag of colored balls.

8.2 Key Terms in Probability

1. Experiment:

An action that produces outcomes.

Example: Tossing a coin.

2. Trial:

Each repetition of an experiment.

Tossing a coin once is a trial.

3. Outcome:

A possible result of a trial.

For tossing a coin, outcomes are {Heads, Tails}.

4. Sample Space (S):

The set of all possible outcomes.

For a die: S = {1, 2, 3, 4, 5, 6}

5. Event:

A subset of the sample space.

Getting an even number = {2, 4, 6}

8.3 Classical (Theoretical) Probability

If all outcomes of an experiment are **equally likely**, then the probability of an event is:

$$P(E) = \frac{\text{Number of favourable outcomes}}{\text{Total number of outcomes}}$$

Example 1:

A die is rolled. What is the probability of getting a number less than 5?

- Favourable outcomes = {1, 2, 3, 4} → 4 outcomes
- Total outcomes = 6

$$P(< 5) = \frac{4}{6} = \frac{2}{3}$$

8.4 Probability of Sure and Impossible Events

- **Sure Event:** An event that always happens (Probability = 1)

  Example: Getting a number less than 7 when a die is rolled.

- **Impossible Event:** An event that never happens (Probability = 0)

  Example: Getting a 9 on a standard die.

8.5 Empirical (Experimental) Probability

When the probability is based on actual experiments or observations.

$$P(E) = \frac{\text{Number of times event E occurs}}{\text{Total number of trials}}$$

Example 2:

You toss a coin 100 times and get 52 heads.

$$P(\text{Head}) = \frac{52}{100} = 0.52$$

Note: As the number of trials increases, experimental probability approaches theoretical probability.

8.6 Applications of Probability in AI

Probability plays a major role in:

- **Machine Learning** (e.g., predicting email spam).
- **Robotics** (e.g., estimating object position).
- **Natural Language Processing** (e.g., next-word prediction).
- **Medical Diagnosis** (e.g., predicting disease based on symptoms).

Example: Predicting Weather

An AI system may say:

"There is a **70% chance of rain** tomorrow."

This is a **probabilistic prediction** based on historical data and models.

8.7 Complementary Events

If **A** is an event, then its **complement (A')** is the event that **A does not occur**.

$$P(A') = 1 - P(A)$$

Example:

If the probability of winning a game is 0.3, then the probability of **not winning** is:

$$P(\text{not winning}) = 1 - 0.3 = 0.7$$

8.8 Probability in Daily Life and Ethics in AI

- Probability is used in **recommendation systems** (e.g., YouTube, Netflix).
- It helps AI make **fair and balanced** decisions.
- Misusing probabilistic models can lead to **bias or discrimination**.

- For example, wrongly predicting a person is a threat based on flawed data.

So, understanding probability is **not just a math skill**, but a **foundation for ethical AI**.

Summary

- Probability measures the **likelihood of events**, ranging from 0 (impossible) to 1 (certain).
- Theoretical Probability:

$$P(E) = \frac{\text{Favourable outcomes}}{\text{Total outcomes}}$$

- Experimental Probability is based on trials.
- **Applications in AI** include prediction, diagnosis, and decision-making.
- Understanding probability helps in making **intelligent and fair AI systems**.
