MATHS for AI (Statistics & Probability)

Importance of Math for AI
Statistics in Real Life
Probability in Real Life

FINDING PATTERNS IN NUMBERS AND IMAGES

Artificial Intelligence (AI) functions by analysing various types of data—such as ***numbers, images, audio, and human interactions***—***to identify patterns that enable tasks like predicting trends or recognizing faces.***

Examples of Patterns in Numbers

In numbers, patterns can involve repeating calculations, consistent differences, or the application of mathematical functions., e.g.,

Consider the sequence of numbers: 2, 4, 6, 8 — The pattern is evident: each number increases by 2. Artificial Intelligence tries to find patterns in similar way.

Consider another sequence: 0, 1, 2, 3, 5, 8, 13, ____ The pattern is that 3rd number onwards, every number is the sum of previous two numbers.

Artificial Intelligence does the same thing but with tons of data, spotting patterns to make predictions or solve problems.

Examples of Patterns in Images

In images, visual patterns may be in the form of **recurring shapes, colours, or actions**. e.g.,

- **AI can identify vehicles in an image by recognizing common features** such as wheels, bonnet, windshield or white screen etc.
- **AI can identify a cat in different images by recognizing common features** such as pointy ears and whiskers. It learns what a cat looks like by studying many cat images.

Importance of Pattern Recognition in AI

A key strength of AI models is their ability to identify patterns and relationships in data, both numerical and image-based.

- In **Numerical Data Analysis**, AI models can **recognize trends, cycles, and correlations** that may not be immediately apparent to humans. For instance, in **Sales forecasting**, AI model can utilize trends in **historical sales data** to predict future sales. AI can also combine pattern recognition with **external data sources**, such as **weather or economic indicators**, to make **more accurate predictions**.
- In **Image Data Analysis**, AI models can identify **patterns and relationships** that humans may overlook or find difficult to discern. For example, **AI models used in medical diagnostics** can detect **patterns in X-ray or MRI images** that are **indicative of a particular condition or disease**.

Note

A ***key strength*** of AI models is their ability to ***identify patterns***, both ***numerical and image-based***, which can be ***used to make predictions, solve problems and discover new insights.***

Given below are a few scenarios showing the use of pattern recognition in AI applications:

- **Spam Detection**: By analyzing the content and structure of emails, AI can identify spam messages and mark them accordingly to protect users from unwanted content.
- **Medical Diagnosis**: AI can analyze X-ray, MRI, CT scan, etc., images to detect pattern indicators of disease like cancer or fractures.
- **Voice Assistants**: With the help of Natural Language Processing (NLP), AI identifies patterns in speech to provide accurate results with a high degree of accuracy.
- **Financial Markets**: AI algorithms employ stock market data to identify patterns that signal buying or selling opportunities for investors.

In each of these examples, math serves as the underlying framework that enables AI to identify and interpret patterns, leading to valuable insights and informed decisions.

1.3 USE OF MATH IN AI

AI is like a super-smart robot that uses math to learn from data by recognizing patterns in numbers and images, helping it make decisions or perform tasks.

Some must-used math tools used in AI are:

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1. **Statistics**

   AI uses statistics to collect, analyze, and interpret data, helping it identify trends and make predictions, **such as recommending movies or products based on past preferences.**

   AI's commonly used statistical techniques include:

- ***Classification, Clustering, Probability distributions, Regression analysis,.***

  AI uses statistics to summarize large datasets, identify trends, and make predictions.

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2. **Linear Algebra**

Linear algebra, the study of vectors and matrices, is essential to AI as it helps machines process and manipulate multi-dimensional data for tasks like **feature extraction, image recognition, and neural networks.**

3. **AI's commonly used linear algebra techniques include:**

- ***Matrix operations, Linear transformations, Vectors, and Scalars.***

AI uses linear algebra for image processing, neural networks, and data transformations.

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3. Probability

Probability studies uncertainty, and AI uses it to make decisions under uncertain conditions, **like estimating whether an email is spam.**

4. AI's commonly used probability techniques include:

- ***Bayes' theorem, Conditional probability, Markov models, and Monte Carlo methods.***

AI uses probability theory to analyze and eliminate uncertainties to make decisions in uncertain situations.

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4. Calculus

Calculus, which studies rates of change, helps AI optimize processes and improve over time, such as **ranking web pages in search engines based on relevance.**

AI's commonly used calculus techniques include:

- ***Derivatives and gradients, Gradient descent, Limits and advanced logistic regressions, and more.***

Note

AI uses calculus to optimize processes and make incremental improvements over time, by adjusting parameters to minimize errors.

NUMBER PATTERNS, PICTURE ANALOGY AND AI

AI analyzes patterns in numbers and analogies in images, as summarized in the table showing how AI works with both data types and their applications.

Table 1.1 AI Working with Numbers and Images

	AI Working with Numbers	AI Working with Images
What it looks for	AI identifies patterns, relationships, and rules in	AI detects patterns in images by recognizing similarities,

	AI Working with Numbers	AI Working with Images
	numerical data to discover insights and solve problems.	shapes, orientations, and repetitions.
How it helps	Pattern in numbers help AI make predictions and future analysis.	AI uses classification, clustering, and filtering to distinguish different patterns in images.
Case Study	In a marketing research case study, a company can analyze historical data such as sales, demand etc., to make future predictions.	AI assists doctors in medical imaging by detecting tumours, fractures, or abnormal patterns in CT scans, MRI scans etc.

By finding patterns in number data and analogies in picture data, AI can learn and get better at tasks like:

- **Predicting things** like sales or weather from number patterns
- **Identifying objects, animals, or people** from picture analogies
- **Understanding human speech or text** by recognizing language patterns (*known as natural language processing*)
- **Playing games** by strategizing from data patterns

...and many more

Note

AI learns and improves by identifying patterns in numbers and analogies in images, enhancing the accuracy of its predictions and decisions.

LET US REVISE

✅ *At the core of AI, lies a bedrock of mathematics, through which AI comprehends, learns, and predicts.*

✅ A key strength of AI models is their ability to identify patterns and relationships in data, numerical, textual, and image-related.

✅ AI uses patterns to summarize large datasets, identify trends, and make predictions.

✅ AI uses mathematics to process images, recognize patterns, and even generate realistic images from scratch.

✅ AI uses probability to make decisions under uncertainty.

✅ AI uses calculus to optimize processes and make incremental improvements over time, by adjusting parameters to minimize errors.

Statistics in Real Life

A. What is Statistics?
B. Applications of Statistics

INTRODUCTION

Statistics is a key mathematical tool in AI that helps analyze and interpret large amounts of data. It enables informed decision-making and real-life applications like *predictions, recommendations, and pattern recognition.*

WHAT IS STATISTICS?

Statistics is a branch of mathematics focused on collecting, organizing, and analysing data to identify patterns and make informed decisions. It helps draw conclusions from uncertain or incomplete information in real-life situations.

Statistics

- Statistics is a Math tool that helps AI solve real life problems.
- *The gathering, sorting, analyzing, and interpreting of data is known as Statistics.*
- Statistics is an applied science.

Note:
Statistics helps transform data into meaningful information. Much like how a photo filter highlights certain features in an image, statistics reveals trends and patterns by filtering the noise in raw data.

Why do we need Statistics?

In our daily lives, we often come across a lot of data or information. Statistics helps us:

- make sense of large amounts of data
- understand patterns and trends in the data
- make decisions based on the data

STATISTICS IN REAL LIFE

Statistics help us summarize and describe data in a meaningful way. Following table briefly summarizes some basic statistical concepts and functions.

Basic Statistical Concepts

Concept	Function	Purpose	Example
Chart	Organizes data by showing how often each value or category occurs	Helps identify trends or patterns in data	Bar chart, Pie chart, Line graph
Mean	Adds the values and divides by the total number of values	Measures the central value	Mean of (2, 4, 6) = (2+4+6)/3 = 4
Median	Finds the middle value when arranged in order	Measures the central value	Median of (1, 3, 3, 6, 7) = 3
Mode	Finds the value that occurs most often	Measures the most frequent value	Mode of (2, 3, 3, 3, 5, 6) = 3
Range	Subtracts the smallest value from the largest	Measures the spread of values	Range of (2, 4, 6,--, 10) = 10 – 2 = 8

APPLICATIONS OF STATISTICS

Statistics has a wide range of applications in many real-life situations, including disaster management, sports, decision prediction, weather forecast, and many more.

Disaster Management

When a disaster strikes, such as an earthquake or hurricane or flood, we need data to answer the following:

- How many people are affected?
- How many areas are affected?
- How many resources are needed?

For this, statistics are used to analyze data on population density, building structures, location of the disaster, infrastructure availability, and weather conditions.

For example: When an earthquake hits a certain location, statistics are used to collect data from different sources to estimate the number of affected people, areas, and required support.

By analyzing historical data and current trends, emergency workers can:

- understand the risk level
- take immediate action
- make informed decisions (such as where to send help first, how to setup temporary shelters, how many support teams are needed, and so on)
- minimize the impact of disaster

Sports

Statistics play a crucial role in sports. In sports, statistics tell us how well a player or team is performing. Scores, goals, runs – these are all statistics.

Statistics help **sports analysts**, **coaches**, and **players** study these numbers for things like:

- to evaluate player strengths and weaknesses,
- identify key performance indicators,
- giving analytics-based decision parameters
- identify areas of improvement
- and make strategic decisions during matches and for future games.

Whether it's calculating batting averages in cricket or shooting percentages in basketball, statistics provide valuable insights for coaches, players, and fans alike.

Note:
Statistics help in sports, from analysing players' performance to optimizing training.

Disease Prediction

In the field of healthcare, statistics are used to predict: the spread of diseases, assess the effectiveness of treatments, and identify risk factors, and so on. Doctors use statistics to understand diseases and their outbreaks.

- How many people are sick?
- What disease are they experiencing?
- How frequent is the disease occurring?
- Which regions are getting affected?
- Which type of population (e.g., young/old/girls) is getting affected?
- Which type of area (e.g., closed buildings, urban/rural, etc.) is getting affected? and so on.

Epidemiologists analyze data on disease outbreaks, population demographics, and services available. They use statistics to **find and understand the patterns and trends in disease data.**

This helps in:

- creating models that can predict the likelihood of future outbreaks
- making and reviewing public health policies
- using accurate results to prevent the spread of infectious diseases

So, statistics can help predict disease outbreaks by identifying risk factors. It allows planning to contain the spread of disease.

Weather Forecast

Statistics plays an important role in predicting about future weather. Meteorologists rely on **statistical models** to analyze weather data. Weather data is collected from weather stations, satellites, and other sources. Using this data, meteorologists can:

- identify patterns and trends in temperature, precipitation, and atmospheric pressure
- develop mathematical models that simulate the behaviour of the atmosphere
- provide weather forecasts and patterns days or even weeks in advance issue weather forecasts to the public

From planning outdoor activities to preparing for severe weather events, weather forecasts based on statistical analysis help individuals and communities make informed decisions to stay safe and protect their property.

Note:

Weather forecasting uses data like temperature, rainfall, wind speed and more. They are analysed using statistical tools and patterns. This helps people in scheduling their work

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Example Activity on Use of Statistics

Let's look at around and find examples where statistics is used.
Such data (based on statistics) are now easily available in schools.

Sources of statistical data can be:

- In a school (number of textbooks, popular dishes)
- At a shopping mall (number of visitors, best-selling items)
- On the school transport network (bus seat count)
- City road traffic (types of vehicles, which roads have heavy traffic)

and many more.

LET US REVISE

- Statistics is a branch of mathematics that deals with collecting, analyzing, interpreting, and presenting data.
- It helps us understand and summarize information by finding patterns and drawing conclusions based on it.
- Statistics have a wide range of applications in many real-life situations, including disaster management, weather forecasting, sports, disease forecasts, and many more.

SESSION 3
Probability in Real Life

- Understanding Probability
- Calculating Probability of an Event
- Events in Probability
- Applications of Probability
- How AI Uses Probability

INTRODUCTION

What would you reply, if I ask you, *"What the chances are of it raining tomorrow?"* You might say, *"No chance"*, or *"50-50"*, or *"100% chance"*. Do you what are we discussing? We are discussing the **probability** of raining tomorrow.

Probability tells us how likely something is to happen. It helps us predict if an event will occur or not.

UNDERSTANDING PROBABILITY

Probability helps us understand how likely an event is to happen. It allows us to predict outcomes, like getting a six when rolling a die (1 out of 6 chances), and supports better decision-making in real-life situations.

Probability is shown or represented as a number between 0 and 1.

- If the probability is ***0***, it means the event ***cannot*** happen.
- If the probability is ***1***, it means the event ***will definitely*** happen.
- If the probability is ***between 0 and 1***, it means the event ***might or might not*** happen.

  The probability of rolling a six on a die is 1/6, while the probability of getting an even number (2, 4, or 6) is 3/6 or 1/2.

CALCULATING PROBABILITY OF AN EVENT

To calculate probability, divide the number of ways an event can happen by the total number of possible outcomes.
That is,

$$\textbf{Probability} = \frac{\textbf{Number of favourable outcomes}}{\textbf{Total number of possible outcomes}}$$

For example, if you have a bag with 3 red balls and 2 blue balls, the probability of picking a red ball is:
Probability = 3 / (3 + 2) = 3 / 5 = 0.6

Thus, the probability of picking a red ball (from the bag with 3 red plus 2 blue balls), is 0.6.
That is, the probability of picking a red ball is 3 out of 5, or 0.6, which can also be written as 60%.

Consider some more examples:

Example 1: You have a box of chocolates with 10 chocolates. Out of these, 4 are milk chocolates, 3 are dark chocolates and 3 are white chocolates. What will be the probability of picking a milk chocolate?

Solution:

$$\text{Probability of picking a milk chocolate} = \frac{\text{Number of milk chocolates}}{\text{Total number of chocolates}}$$

$$= 4 / (4 + 3 + 3) = 4 / 10 = \mathbf{0.4}$$

The probability of picking a milk chocolate is **0.4**, or **40%**.

Example 2: *What is the probability of drawing a red diamond card from a deck of cards?*

Solution: Probability of drawing a red diamond card
= Number of red diamond cards / Total number of cards
= 13 / 52 = **0.25**

The probability of drawing a red diamond card is **0.25**, or **25%**.

Note:
Always remember that the sum of probabilities of all possible outcomes of a given trial is 1 or 100%.

For example, if all possible outcomes of an event (such as drawing a red, blue, or green ball) are equally likely, the probability of picking a single outcome is 0.5 (or 50%), and the total probability is 1.

EVENTS IN PROBABILITY

In probability, an **event** is a possible result of an **experiment**, which is a repeatable process like rolling a die.

The **sample space** is the set of all possible outcomes of an experiment. For example, the sample space for rolling a die is {1, 2, 3, 4, 5, 6}, and events like getting a 1 or 6 are subsets of this space.

In real life, probability helps in predictions—for instance, if a basketball player makes 75 out of 100 free throws, the probability of scoring is 0.75 or 75%.

Probability Box (Quick Facts):

- **Event**: One or more possible outcomes of an experiment
- **Experiment**: A repeatable action with defined outcomes
- **Sample Space**: All possible outcomes of an experiment

3.4.1 Types of Events

There are different types of events in probability. The most common events are:

1. **Certain Events**: These are events that will definitely happen. For example, the sun rising in the east is a certain event. Certain events have the probability of **1**.
2. **Impossible Events:** These are events that will never happen. For example, rolling a 7 on a standard six-sided die is impossible. Impossible events have the probability of **0**.
3. **Likely Events:** These are events that have a high chance of happening. For example, if you have 10 red marbles and 10 blue marbles in a bag, picking a red marble is a likely event. **Likely events have high probabilities**.
4. **Unlikely Events:** These are events that have a low chance of happening. For example, if a bag contains 19 white marbles and only 1 red marble, drawing the red marble is a low chance event. **Unlikely events have low probability**.
5. **Equally Likely Events:** These are events that have the same chance of happening. For example, when you flip a fair coin, getting heads or tails are equally likely events.

Note

An event is a subset or a grouping of some possible outcomes from the overall sample space.

Example 3: Identify the type of event. Let's do a small exercise to see if you can identify the type of event. We are list some events below. Answer if the given event is **certain**, **impossible**, **likely**, **unlikely**, or **equally likely**?

(i) Flipping a coin and getting heads.
(ii) Rolling a die and getting a number greater than 6.
(iii) Picking a red ball from a bag with 1 red ball and 9 blue balls.
(iv) Choosing a day of the week and it being Monday.
(v) The sun rising tomorrow.

Solution:

(i) *Flipping a coin and getting heads*: **Equally likely** event (because getting heads or tails are equally likely events when flipping a fair coin).

(ii) *Rolling a die and getting a number greater than 6*: **Impossible** event (because a standard die only has numbers 1 to 6).

(iii) *Picking a red ball from a bag with 1 red ball and 9 blue balls*: **Unlikely** event (because there is only 1 red ball and 9 blue balls).

(iv) *Choosing a day of the week and it being Monday*: **Equally likely** event (because any day of the week has the same chance of being chosen).

(v) *The sun rising tomorrow*: **Certain** event (because the sun rises every day).

APPLICATIONS OF PROBABILITY

Probability helps us predict how likely an event will occur. We calculate probabilities and use them in many everyday situations.
Let us have a look at various applications of probability in real life:

Probability in Sports

Sports are full of uncertain events, and probability helps teams and players make better decisions. Probability is applied in Sports for various things. Some of these are:

Predicting Game Outcomes

Sports analysts use probability to predict the outcome of games. They look at past performance, player statistics, and other factors to calculate the probability of a team winning a match.
For example, if a basketball team has won 80 out of their last 100 games, the probability of winning the next game is:
Probability = 80 / 100 = 0.8 or 80%

Player Performance

Coaches use probability to decide which players to put in the game. They look at the players' past performances to see how likely they are to score points, make passes, or block shots.
For example, if a soccer player has scored in 10 out of 20 games, the probability of them scoring in the next game is:
Probability = 10 / 20 = 0.5 or 50%

Game Strategies

Probability helps teams choose the best strategies. For example, in the game of Cricket, a team might use probability to decide if they should put fielders at slips. If the probability of getting a catch at a slip point is high, they might go for it. If it is low, they might not put fielders there.

Probability in Weather Forecasts

Weather forecasts use probability to predict the weather. Meteorologists, the scientists who study the weather, use data from weather stations, satellites, and radars to make these predictions. Probability is applied in weather forecasts for various things.

Some of these are:

1. Chance of Rain

When you hear that there is a 70% chance of rain, it means that in 70 out

of 100 similar situations, it rained. This helps people decide if they should carry an umbrella or plan indoor activities.

2. Temperature Predictions

Meteorologists use probability to predict temperatures. They look at past **data** and current weather patterns to estimate the temperature. **For example**, *if the average temperature on a specific day in the past years was around 25°C, they might predict a similar temperature for this year*.

3. Severe Weather Alerts

Probability helps in predicting severe weather like **storms**, **tornadoes**, and **hurricanes**. By analysing weather patterns, meteorologists can estimate the **probability** of these events and issue warnings in time to keep people safe.

For example, *if there is a high probability of a hurricane hitting a coastal area, people can evacuate in time*.

3.5.3 Probability in Traffic Estimation

Traffic estimation uses probability to help manage traffic flow and reduce congestion. Traffic engineers and planners use data from road sensors, cameras, and historical traffic trends to estimate how long travel will take on different roads. Using this data, the probability of delays or traffic jams is estimated, to handle uncertainty, and find patterns to make better transportation decisions.

1. Predicting Traffic Jams

By analysing traffic data, engineers can predict when and where traffic jams are likely to happen. **For example**, *if a road is usually congested during rush hour, they can estimate the probability of a traffic jam at that time*. This helps drivers plan their trips better.

2. Travel Time Estimation

GPS systems use probability to estimate travel times. They look at current traffic conditions and historical data to predict how long it will take to get from one place to another. **For example**, *if it usually takes 30 minutes to travel a certain route but there is a 70% chance of heavy traffic, the GPS might estimate a longer travel time*.

3. Accident Predictions

Traffic planners use probability to predict where accidents are likely to

happen. They look at data on road conditions, weather, and driver behaviour. If they find a high probability of an accident in a certain area, they can make changes to improve safety, like adding traffic lights or speed bumps.

Probability Applications

Probability is vital in many other fields like:

- **Business:** Estimating sales, product demand, investment risks etc.
- **Manufacturing:** Probability of defective products, quality control.
- **Healthcare:** Likelihood of disease, treatment effectiveness etc.
- **Insurance:** Probability of events like accidents, natural disasters etc.

HOW AI USES PROBABILITY?

Artificial Intelligence (AI) relies heavily on probability to make decisions, learn from data, and predict outcomes, especially in uncertain situations.

How probability helps AI.

1. Making Decisions

Artificial Intelligence systems often have to choose the best action from many possible actions to make decisions. AI uses probability to evaluate the likelihood of different outcomes. *For instance, a self-driving car uses probability to decide whether to stop, slow down, or speed up, based on the probability of obstacles on the road.*

2. Learning from Data

Artificial Intelligence learns from data using techniques called **machine learning**. Probability helps AI understand patterns and relationships in data. For example, an AI system may identify objects in camera images (such as cats or dogs) using the probability that a certain image belongs to one category based on the features it detects.

3. Predicting Outcomes

Artificial Intelligence uses probability to predict future events. For

example, in weather forecasting, AI systems analyse historical weather data to predict the probability of rain, snow, or sunshine on a given day. Similarly, in finance, AI predicts stock market trends based on the probability of different economic factors.

4. Handling Uncertainty

Probability helps AI handle uncertainty in the real world. Real-life data is often messy and incomplete, and AI must make decisions based on this imperfect information. Probability allows AI to make the best possible decisions even when there is uncertainty.

5. Improving Accuracy

By using probability, AI systems can improve their accuracy. For example, in medical diagnosis, AI analyses patient data to calculate the probability of different diseases. This helps doctors make more accurate diagnoses and provide better treatment.

6. Learning and Adapting

Probability helps AI systems learn from new data and adapt to changing environments. For instance, a recommendation system continuously updates its probabilities based on new user interactions, improving its recommendations over time.

GLOSSARY

Probability: A measure of the likelihood that an event will occur.

Event: Something that happens or could happen.

Sample Space: Total Possible Outcomes; All the outcomes that could possibly happen.

Certain Event: An event that is sure to happen.

Impossible Event: An event that cannot happen.

Likely Event: An event that has a good chance of happening.

Unlikely Event: An event that has a small chance of happening.

Equally Likely Events: Events that have the same chance of happening.