Unit 1.0: Data Science — Detailed Explanation

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1. Definition of Data Science

Data Science is an interdisciplinary field that uses **scientific methods, algorithms, processes, and systems** to extract **useful insights and knowledge from data** (structured, semi-structured, and unstructured).

👉 In simple words:
Data Science = **Data + Analysis + Insights for decision making**

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2. Data Science Life Cycle

Definition

The **Data Science Life Cycle** is a step-by-step process followed by data scientists to solve real-world problems using data.

Steps (Point-wise Explanation)

1. Problem Definition

- Understand the business problem clearly
- Define objectives and goals
- Example: Predict customer churn

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2. Data Collection

- Gather data from different sources
- Sources: databases, APIs, sensors, web scraping
- Data can be:
    - Internal (company data)
    - External (public datasets)

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3. Data Preparation (Cleaning)

- Remove errors, duplicates, missing values
- Convert data into usable format
- Example:
    - Handling null values
    - Removing outliers

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4. Data Exploration (EDA)

- Analyze data using statistics and visualization
- Identify patterns and relationships
- Tools: graphs, charts, summary statistics

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5. Data Modeling

- Apply machine learning algorithms
- Train models using data
- Examples:
    - Regression
    - Classification
    - Clustering

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6. Model Evaluation

- Check model performance
- Metrics:
    - Accuracy
    - Precision
    - Recall
- Improve model if needed

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7. Deployment

- Deploy model into real-world systems
- Example:
    - Recommendation system
    - Fraud detection system

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8. Monitoring & Maintenance

- Monitor model performance over time
- Update model when needed

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3. Types of Data

Definition

Data is classified based on its structure and format.

Types (Point-wise)

1. Structured Data

- Organized in rows and columns
- Stored in databases (SQL tables)
- Easy to process

Examples:

- Excel sheets
- Relational databases

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2. Semi-Structured Data

- Not strictly organized but has some structure
- Uses tags or markers

Examples:

- JSON files
- XML data

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3. Unstructured Data

- No predefined structure
- Difficult to analyze directly

Examples:

- Images
- Videos
- Social media posts
- Emails

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4. Data Science Applications

Definition

Applications of Data Science refer to real-world areas where data-driven solutions are used.

Applications (Point-wise)

1. Healthcare

- Disease prediction
- Medical image analysis
- Drug discovery

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2. Finance

- Fraud detection
- Risk analysis
- Stock market prediction

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3. E-commerce

- Recommendation systems
- Customer segmentation
- Demand forecasting

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4. Social Media

- Sentiment analysis
- Trend detection
- Content recommendation

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5. Transportation

- Route optimization
- Traffic prediction
- Self-driving cars

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6. Education

- Student performance analysis
- Personalized learning

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5. Role of Data Scientist

Definition

A **Data Scientist** is a professional who collects, analyzes, and interprets complex data to help organizations make decisions.

Roles & Responsibilities (Point-wise)

1. Data Collection

- Gather data from multiple sources

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2. Data Cleaning

- Prepare clean and usable data

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3. Data Analysis

- Identify patterns and trends

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4. Model Building

- Develop machine learning models

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5. Data Visualization

- Present insights using charts and dashboards

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6. Decision Support

- Help management make data-driven decisions

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7. Communication

- Explain results to non-technical stakeholders

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6. Data Science Tools and Platforms

Definition

Tools and platforms are software and technologies used to perform data science tasks.

Tools (Point-wise)

1. Programming Languages

- Python (most popular)

- R
- SQL

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2. Data Visualization Tools

- Tableau
- Power BI
- Matplotlib, Seaborn

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3. Machine Learning Libraries

- Scikit-learn
- TensorFlow
- Keras

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4. Big Data Tools

- Hadoop
- Spark

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5. Databases

- MySQL
- MongoDB

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6. Platforms

- Jupyter Notebook
- Google Colab
- Kaggle

Quick Summary

- Data Science = Extracting knowledge from data
- Life Cycle = Step-by-step process from problem to deployment
- Data Types = Structured, Semi-structured, Unstructured
- Applications = Healthcare, Finance, E-commerce, etc.
- Role = Analyze data and support decisions
- Tools = Python, ML libraries, visualization tools

Unit 2.0: Data Collection and Data Preprocessing — Detailed Explanation

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1. Definition of Data Collection and Data Preprocessing

Data Collection is the process of gathering raw data from various sources.
Data Preprocessing is the process of cleaning, transforming, and organizing that data to make it suitable for analysis.

👉 In simple words:
Raw Data → Clean & Organized Data → Ready for Analysis

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2. Data Sources and Data Collection Methods

Definition

Data sources are the origins from where data is collected, and data collection methods are techniques used to gather that data.

Types of Data Sources (Point-wise)

1. Primary Data Sources

- Data collected directly by the user
- First-hand data

Examples:

- Surveys

- Interviews
- Experiments

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2. Secondary Data Sources

- Data already collected by others
- Easily available

Examples:

- Government databases
- Research papers
- Online datasets

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3. Internal Sources

- Data from within an organization

Examples:

- Company databases
- Sales records

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4. External Sources

- Data from outside the organization

Examples:

- Social media
- APIs
- Websites

Data Collection Methods (Point-wise)

- Surveys and questionnaires

- Interviews
- Web scraping
- Sensors and IoT devices
- APIs (Application Programming Interfaces)
- Database extraction

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3. Data Cleaning Techniques

Definition

Data cleaning is the process of removing errors, inconsistencies, and unwanted data.

Techniques (Point-wise)

1. Removing Duplicates

- Eliminate repeated records

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2. Handling Inconsistent Data

- Correct spelling mistakes
- Standardize formats (e.g., date format)

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3. Removing Noise

- Remove irrelevant or incorrect data

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4. Outlier Detection

- Identify abnormal values
- Handle them by removal or adjustment

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5. Data Validation

- Ensure data accuracy and correctness

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4. Handling Missing Data

Definition

Missing data refers to the absence of values in a dataset.

Methods (Point-wise)

1. Deletion Method

- Remove rows with missing values
- Used when missing data is small

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2. Mean/Median/Mode Imputation

- Replace missing values with:
    - Mean (average)
    - Median
    - Mode

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3. Forward/Backward Filling

- Use previous or next value

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4. Predictive Imputation

- Use machine learning models to predict missing values

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5. Constant Value Filling

- Replace with a fixed value (e.g., 0, "Unknown")

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5. Data Integration and Transformation

Definition

- **Data Integration**: Combining data from multiple sources
- **Data Transformation**: Converting data into suitable format

Techniques (Point-wise)

Data Integration

- Merge datasets
- Resolve data conflicts
- Remove redundancy

Data Transformation

1. Normalization

- Scale values to a standard range (0–1)

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2. Standardization

- Convert data to mean = 0 and standard deviation = 1

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3. Encoding

- Convert categorical data into numerical form
    - Example: Male = 0, Female = 1

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4. Aggregation

- Combine data (e.g., daily → monthly data)

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5. Feature Construction

- Create new features from existing data

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6. Data Reduction

Definition

Data reduction reduces the size of data while maintaining its quality and usefulness.

Techniques (Point-wise)

1. Dimensionality Reduction

- Reduce number of features
- Example: PCA (Principal Component Analysis)

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2. Data Compression

- Reduce storage size

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3. Sampling

- Use a subset of data instead of full dataset

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4. Feature Selection

- Select only important variables

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5. Aggregation

- Combine similar data points

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7. Data Preparation for Analysis

Definition

Final step where cleaned and transformed data is made ready for analysis or modeling.

Steps (Point-wise)

1. Data Formatting

- Ensure correct data types (int, float, string)

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2. Splitting Data

- Divide into:
    - Training set
    - Testing set

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3. Feature Scaling

- Normalize or standardize data

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4. Encoding Categorical Data

- Convert text into numbers

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5. Data Validation

- Check data quality before analysis

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6. Final Dataset Creation

- Ready-to-use dataset for machine learning

Quick Summary

- Data Collection = Gathering data
- Data Cleaning = Fix errors
- Missing Data = Handle null values
- Integration = Combine data
- Transformation = Convert data format
- Reduction = Reduce size
- Preparation = Final step before analysis

Unit 3.0: Exploratory Data Analysis (EDA) and Visualization — Detailed Explanation

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1. Definition of Exploratory Data Analysis (EDA)

Exploratory Data Analysis (EDA) is the process of analyzing and summarizing datasets using statistical techniques and visual methods to understand patterns, relationships, and anomalies.

👉 In simple words:
EDA = **Understanding data before applying models**

Objectives of EDA (Point-wise)

- Understand data structure and features
- Detect missing values and outliers
- Identify patterns and trends
- Check relationships between variables
- Prepare data for modeling

Types of EDA (Point-wise)

1. Univariate Analysis

- Analysis of a single variable
- Example: mean, median, histogram

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2. Bivariate Analysis

- Analysis between two variables
- Example: correlation, scatter plot

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3. Multivariate Analysis

- Analysis of more than two variables

- Example: heatmaps, pair plots

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2. Data Visualization Techniques

Definition

Data visualization is the graphical representation of data to make information easy to understand.

👉 It helps in **better decision making and pattern recognition**

Techniques (Point-wise)

1. Statistical Visualization

- Uses statistical methods
- Example: box plot, histogram

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2. Distribution Visualization

- Shows data distribution
- Example: density plots

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3. Relationship Visualization

- Shows relationship between variables
- Example: scatter plots

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4. Comparison Visualization

- Compare different categories
- Example: bar charts

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5. Composition Visualization

- Show parts of a whole
- Example: pie chart

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3. Charts and Graphs

Definition

Charts and graphs are visual tools used to represent data clearly and effectively.

Types (Point-wise)

1. Bar Chart

- Used for comparing categories

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2. Line Graph

- Shows trends over time

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3. Pie Chart

- Shows percentage distribution

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4. Histogram

- Shows frequency distribution

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5. Scatter Plot

- Shows relationship between two variables

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6. Box Plot

- Displays spread and outliers

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7. Heatmap

- Shows correlation using colors

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4. Data Visualization Tools

Definition

Tools used to create visual representations of data.

Tools (Point-wise)

1. Tableau

- User-friendly
- Drag-and-drop interface
- Used for dashboards

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2. Power BI

- Developed by Microsoft
- Business intelligence tool

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3. Excel

- Basic visualization
- Easy to use

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4. Google Data Studio

- Free online visualization tool

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5. Overview of Tableau

Definition

Tableau is a powerful data visualization tool used for creating interactive and shareable dashboards.

Features (Point-wise)

- Drag-and-drop interface
- Real-time data analysis
- Interactive dashboards
- Supports multiple data sources
- No coding required

Uses (Point-wise)

- Business analytics
- Reporting dashboards
- Data storytelling

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6. Python Libraries for Data Science

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1. NumPy

Definition

NumPy (Numerical Python) is a library used for numerical computations.

Features (Point-wise)

- Supports arrays and matrices
- Fast mathematical operations
- Used for scientific computing

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2. Pandas

Definition

Pandas is used for data manipulation and analysis.

Features (Point-wise)

- Data structures:
    - Series (1D)
    - DataFrame (2D)
- Data cleaning and transformation
- Easy handling of missing data

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3. Matplotlib

Definition

Matplotlib is a plotting library used to create static graphs.

Features (Point-wise)

- Supports various plots
- Customizable graphs
- Widely used for basic visualization

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4. Seaborn

Definition

Seaborn is an advanced visualization library based on Matplotlib.

Features (Point-wise)

- Attractive and informative plots
- Built-in datasets
- Statistical visualizations

- Heatmaps, pairplots, etc.

Quick Summary

- **EDA** = Understanding and analyzing data
- **Visualization** = Graphical representation of data
- **Charts** = Bar, line, pie, histogram, scatter, etc.
- **Tools** = Tableau, Power BI, Excel
- **Libraries**:
    - NumPy → Numerical operations
    - Pandas → Data handling
    - Matplotlib → Basic plots
    - Seaborn → Advanced visualization

Unit 4.0: Statistical Methods for Data Science — Detailed Explanation

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1. Definition of Statistical Methods

Statistical Methods are techniques used to collect, analyze, interpret, and present data for decision-making.

👉 In simple words:
Statistics = **Turning data into meaningful information**

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2. Descriptive Statistics

Definition

Descriptive Statistics summarize and describe the main features of a dataset.

Measures (Point-wise)

1. Measures of Central Tendency

- Describe the center of data

Mean (Average)

$$\bar{x} = \frac{\sum x_i}{n}$$

- Sum of all values divided by total number

Median

- Middle value when data is sorted

Mode

- Most frequent value

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2. Measures of Dispersion

- Show spread of data

Range

- Difference between max and min value

Variance

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

- Measures deviation from mean

Standard Deviation

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

- Square root of variance

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3. Data Distribution

- Shape of data:
    - Normal distribution
    - Skewed distribution

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3. Sampling Methods

Definition

Sampling is the process of selecting a subset of data from a large population.

Types (Point-wise)

1. Random Sampling

- Every element has equal chance

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2. Systematic Sampling

- Select every k-th element

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3. Stratified Sampling

- Divide population into groups and sample from each

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4. Cluster Sampling

- Divide population into clusters and randomly select clusters

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5. Convenience Sampling

- Select easily available data

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4. Hypothesis Testing

Definition

Hypothesis testing is a statistical method used to make decisions using data.

Basic Concepts (Point-wise)

1. Null Hypothesis (H_o)

- No effect or no difference

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2. Alternative Hypothesis (H_1)

- Opposite of null hypothesis

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3. Significance Level (α)

- Probability of rejecting H_o (usually 0.05)

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4. P-value

- Probability of obtaining result

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5. Test Statistic

- Value used to decide hypothesis

Steps (Point-wise)

1. State hypotheses (H_o and H_1)
2. Choose significance level

3. Select test (Z-test, T-test, etc.)
4. Calculate test statistic
5. Compare with critical value
6. Accept or reject H_o

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5. Correlation Analysis

Definition

Correlation measures the strength and direction of relationship between two variables.

Types (Point-wise)

1. Positive Correlation

- Both variables increase together

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2. Negative Correlation

- One increases, other decreases

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3. Zero Correlation

- No relationship

Correlation Coefficient

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

- Range: **-1 to +1**
    - +1 → Strong positive
    - -1 → Strong negative
    - 0 → No relation

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6. Regression Analysis

Definition

Regression analysis is used to predict the relationship between dependent and independent variables.

Types (Point-wise)

1. Linear Regression

- Relationship between two variables

$$y = mx + c$$

$$m$$

$$b$$

-10-8-6-4-2246810-10-5510y-interceptx-intercept

Where:

- y = dependent variable
- x = independent variable
- m = slope
- c = intercept

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2. Multiple Regression

- More than one independent variable

Uses (Point-wise)

- Prediction (e.g., sales forecasting)
- Trend analysis
- Relationship modeling

Quick Summary

- **Descriptive Statistics** → Summarize data (mean, median, variance)
- **Sampling** → Select subset of data
- **Hypothesis Testing** → Decision making
- **Correlation** → Relationship between variables
- **Regression** → Prediction and modeling

Unit 5.0: Machine Learning Techniques — Detailed Explanation

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1. Definition of Machine Learning

Machine Learning (ML) is a branch of Artificial Intelligence that enables systems to **learn from data and improve performance without being explicitly programmed**.

👉 In simple words:
Machine Learning = **Learning from data to make predictions or decisions**

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2. Types of Machine Learning

1. Supervised Learning

Definition

Supervised learning uses **labeled data** (input + output) to train models.

Types (Point-wise)

- **Classification** → Output is category (e.g., spam or not spam)
- **Regression** → Output is continuous value (e.g., price prediction)

Algorithms in Supervised Learning

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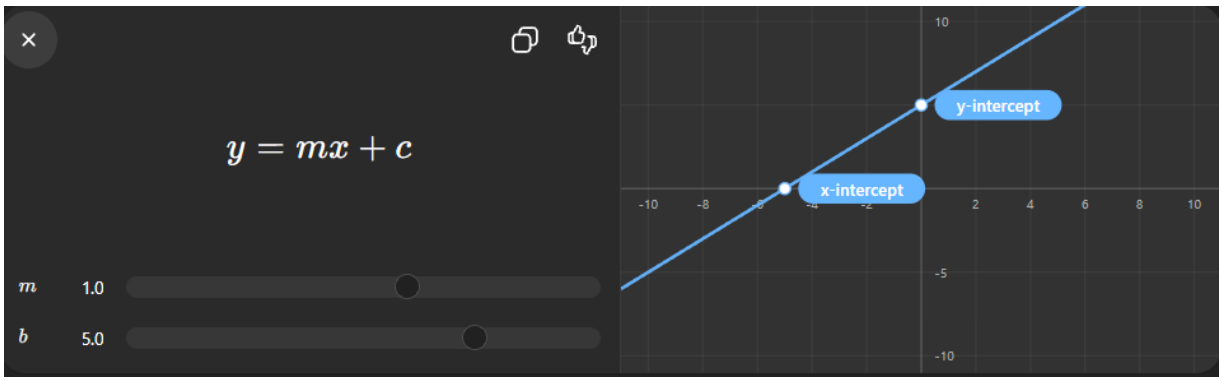
1. Linear Regression

Definition

Used to predict a continuous value based on input variables.



Where:

- y → dependent variable
- x → independent variable
- m → slope
- c → intercept

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2. Decision Trees

Definition

A tree-like model used for classification and regression.

Features (Point-wise)

- Easy to understand
- Uses rules (if-else conditions)
- Splits data based on features

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3. Support Vector Machines (SVM)

Definition

SVM is used to classify data by finding the best boundary (hyperplane).

Features (Point-wise)

- Effective in high-dimensional data
- Maximizes margin between classes
- Can handle linear and non-linear data

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2. Unsupervised Learning

Definition

Unsupervised learning works with **unlabeled data** and finds hidden patterns.

Algorithms in Unsupervised Learning

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1. K-Means Clustering

Definition

Groups data into **K clusters** based on similarity.

Steps (Point-wise)

1. Choose number of clusters (K)
2. Initialize centroids
3. Assign data points to nearest centroid
4. Update centroids
5. Repeat until stable

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2. Hierarchical Clustering

Definition

Creates a hierarchy of clusters (tree-like structure).

Types (Point-wise)

- **Agglomerative** → Bottom-up approach
- **Divisive** → Top-down approach

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3. Model Evaluation Techniques

Definition

Model evaluation measures how well a machine learning model performs.

Techniques (Point-wise)

1. Accuracy

- Ratio of correct predictions

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2. Precision

- Correct positive predictions out of total predicted positives

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3. Recall

- Correct positive predictions out of actual positives

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4. F1-Score

- Balance between precision and recall

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5. Confusion Matrix

- Table showing prediction results

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6. Cross-Validation

- Splitting data into multiple parts to test model

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4. Time Series Forecasting

Definition

Time series forecasting predicts future values based on past time-based data.

Examples

- Stock prices
- Weather forecasting
- Sales prediction

Components (Point-wise)

1. Trend

- Long-term increase or decrease

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2. Seasonality

- Repeating patterns over time

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3. Noise

- Random variations

Techniques (Point-wise)

- Moving Average
- ARIMA Model

- Exponential Smoothing

Quick Summary

- **Machine Learning** → Learn from data
- **Supervised Learning** → Labeled data (Regression, Classification)
- **Unsupervised Learning** → Unlabeled data (Clustering)
- **Algorithms**:
    - Linear Regression
    - Decision Tree
    - SVM
    - K-Means
    - Hierarchical Clustering
- **Evaluation** → Accuracy, Precision, Recall
- **Time Series** → Predict future trends

Unit 6.0: Applications of Data Science — Detailed Explanation

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1. Definition of Applications of Data Science

Applications of Data Science refer to **real-world uses of data analysis, machine learning, and statistical techniques** to solve problems and make decisions across different domains.

👉 In simple words:
Data Science Applications = **Using data to solve real-life problems**

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2. Big Data Analytics

Definition

Big Data Analytics is the process of analyzing large and complex datasets (big data) to uncover hidden patterns, trends, and insights.

Characteristics of Big Data (5 V's)

- **Volume** → Huge amount of data
- **Velocity** → Speed of data generation
- **Variety** → Different types of data
- **Veracity** → Data quality
- **Value** → Useful insights

Applications (Point-wise)

- Business decision-making
- Customer behavior analysis
- Social media analytics

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3. Disease Prediction

Definition

Disease prediction uses data science and machine learning to **predict the likelihood of diseases based on patient data**.

How it Works (Point-wise)

- Collect patient data (age, symptoms, history)
- Apply machine learning models
- Predict disease risk

Examples

- Heart disease prediction
- Diabetes prediction
- Cancer detection

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4. Fraud Detection

Definition

Fraud detection identifies **suspicious or illegal activities** using data analysis.

Applications (Point-wise)

- Credit card fraud detection
- Online transaction monitoring
- Insurance fraud detection

Techniques Used

- Machine learning models
- Anomaly detection
- Pattern recognition

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5. Recommendation Systems

Definition

Recommendation systems suggest products or content to users based on their preferences.

Types (Point-wise)

1. Content-Based Filtering

- Recommends based on user's past behavior

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2. Collaborative Filtering

- Recommends based on other users' behavior

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3. Hybrid Systems

- Combination of both

Examples

- Netflix movie recommendations
- Amazon product suggestions
- YouTube video suggestions

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6. Sentiment Analysis

Definition

Sentiment analysis is the process of analyzing text data to determine **emotions or opinions**.

Types (Point-wise)

- Positive
- Negative
- Neutral

Applications

- Social media analysis
- Customer feedback analysis

- Brand monitoring

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7. Intrusion Detection

Definition

Intrusion detection identifies **unauthorized access or attacks in computer networks**.

Types (Point-wise)

1. Signature-Based Detection

- Detects known attack patterns

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2. Anomaly-Based Detection

- Detects unusual behavior

Applications

- Network security
- Cybersecurity systems
- Monitoring unauthorized access

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8. Anomaly Detection

Definition

Anomaly detection identifies **unusual patterns or outliers** that do not match expected behavior.

Applications (Point-wise)

- Fraud detection

- Fault detection in machines
- Network security

Techniques Used

- Statistical methods
- Machine learning models
- Clustering algorithms

Quick Summary

- **Big Data Analytics** → Analyze large datasets
- **Disease Prediction** → Predict health issues
- **Fraud Detection** → Detect illegal activities
- **Recommendation Systems** → Suggest items
- **Sentiment Analysis** → Analyze opinions
- **Intrusion Detection** → Detect cyber attacks
- **Anomaly Detection** → Find unusual patterns