

→ Introduction to Patterns and Pattern Recognition

◆ Definition of Pattern:

- Patterns involve identifying trends or sequences, such as predicting missing numbers, alphabets, or completing figures, a common task in school exercises.
- Patterns are everywhere and belong to every aspect of our daily lives.
- Pattern is the most basic thing for anyone to learn anything.

◆ Examples of Pattern-Based Systems:

- Face Recognition System
- Fingerprint identification

◆ Definition of Pattern Recognition:

- The act of taking in raw data & taking an action based on the category of data.
- A process of finding regularities and similarities in data using machine learning, through statistical analysis, historical data, or knowledge gained by the machine.
- Pattern Recognition is the branch of machine learning which deals with the regularities and patterns in the data that can further be used to classify and categorize the data.
- Pattern recognition is not one technique but rather a broad collection of often loosely related knowledge and techniques.

◆ Pattern Recognition System

- System comprises mainly **5 components**.
 1. **Input Data:** Can be words or texts, images, or audio files
 2. **Sensing (& Data Acquisition):** Includes various properties that describe the object, such as its entities and attributes which are captured using a sensing device.

3. **Segmentation:** Data objects are segmented into smaller segments in this step.
 4. **Feature Extraction:** In this step, certain features of data objects such as weight, colors, dimension etc. are extracted.
 5. **Classification:** Based on the extracted features, data objects are classified.
 6. **Post-Processing (& Decision):** Certain refinements and adjustments are done as per the changes in features of the data objects which are used in the process of recognition.
- Thus, decision making can be done once post-processing is completed.
 - **Process Flow:** Input → Sensing → Segmentation → Feature Extraction → Classification → Learning → Cost → Post-Processing → Decision.
 - Systematically processes raw data to recognize and categorize patterns.

◆ Design Principles of Pattern Recognition Systems

- The design of a pattern recognition system usually entails the repetition of a number of different activities.
- **Steps:**
 1. **Data Collection:** Gathering relevant data.
 2. **Feature Choice:** Selecting appropriate features for analysis.
 3. **Model Choice:** Choosing a suitable machine learning model.
 4. **Training:** Training the model with data.
 5. **Evaluation:** Assessing the model's performance.
- **Process Flow:** Start → Collect Data → Choose Features → Choose Model → Train Classifier → Evaluate Classifier → End.
- Iterative design ensures effective system development and performance.

→ Features of Pattern Recognition

◆ Feature Representation and Vectors

- **Terms:**
 1. **Feature:** Each element of vector
 2. **Feature Vector:** Collection of elements
 3. **Feature Space:** Set of Feature Vector
- **Features:**
 1. Features may be represented as continuous, discrete, or discrete binary variables.
 2. A function of one or more measurements, computed so that it quantifies some significant characteristics of the object.
 3. Quantifiable characteristics of objects (e.g., eyes, ears, nose for a face)
- **Feature Vector:**
 1. A set of features that are taken together, forms the features vector.
 2. A d-dimensional column vector combining multiple features (e.g., [eyes, ears, nose]).
- **Vector Representation:**
 1. Objects are represented as n-dimensional vectors, which is a point in (n - D) Euclidean space (e.g., $x=(x_1,x_2,\dots,x_n)^t$)
 2. **Embedding:** Process of finding a feature representation
 - ◆ **Word Embedding** for language processing
 - ◆ **Graph Embedding** for graph/network recognition

→ Training and Learning Models in Pattern Recognition

◆ Learning:

- **Training Set:** Used to build a model.
 1. It consists of the set of images that are used to train the system.
 2. Training rules and algorithms are used to give relevant information on how to associate input data with output decisions.
 3. The system is trained by applying these algorithms to the dataset, all the relevant information is extracted from the data, and results are obtained.
 4. Generally, 80% of the data of the dataset is taken for training data.
- **Testing Set:** Used in testing the model
 1. To check the correctness of the system
 2. It is the set of data that is used to verify whether the system is producing the correct output after being trained or not.
 3. Generally, 20% of the data of the dataset is used for testing.
 4. Testing data is used to measure the accuracy of the system.

◆ Advantages of Pattern Recognition

- Solves classification problems
- Solves the problem of fake biometric detection
- Useful for cloth pattern recognition for visually impaired blind people.
- Helps in speaker diarization.
- We can recognize particular objects from different angles.

◆ Disadvantages of Pattern Recognition

- The syntactic pattern recognition approach is complex to implement and it is a very slow process.
- Sometimes to get better accuracy, a larger dataset is required.
- It cannot explain why a particular object is recognized.

→ Applications of Pattern Recognition

- ◆ Character Recognition
- ◆ Speech Recognition
- ◆ Fingerprint identification
- ◆ Image Processing
- ◆ Manufacturing (3D images)
- ◆ Medical Diagnosis
- ◆ Industry automation (product is defective)