Pattern Recognition

Descriptor concept,

Chain codes, Signatures,

Shape Numbers,

Fourier Descriptors,

Patterns and pattern classes,

Overview of pattern recognition,

Neural Network and Image Processing,

NN based pattern recognition,

Decision-Theoretic Pattern Recognition Methods.

Image recognition (Introduction):

- Image recognition and interpretation, including **understanding, making decision and analysis.**

- Recognition: The process that assigns a label to an object based on the information provided by its descriptors.

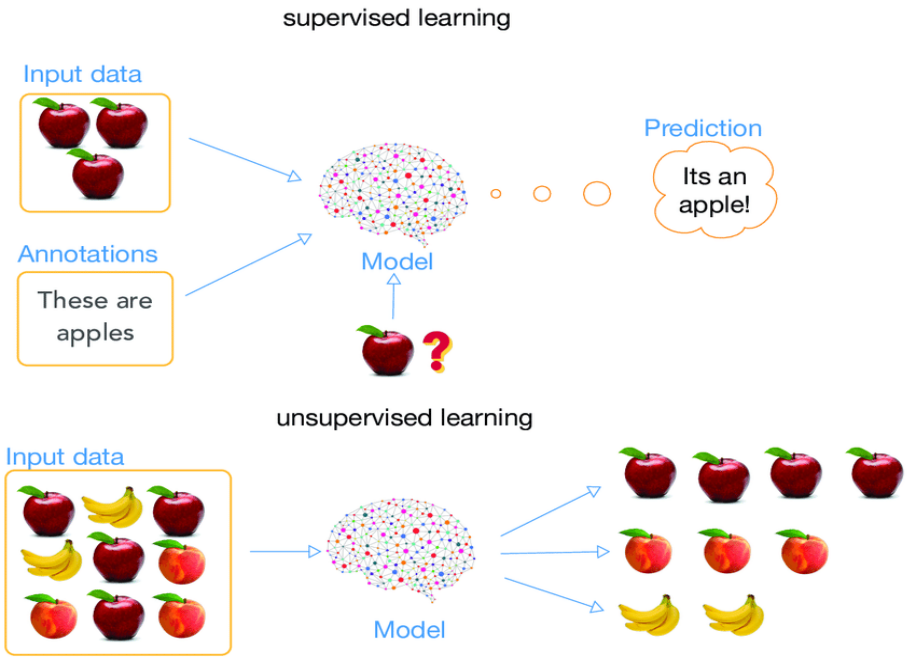
- Pattern recognition is defined as a data analysis process that uses machine learning algorithms to classify input data into objects, classes, or categories based on recognized patterns, features, or regularities in data.

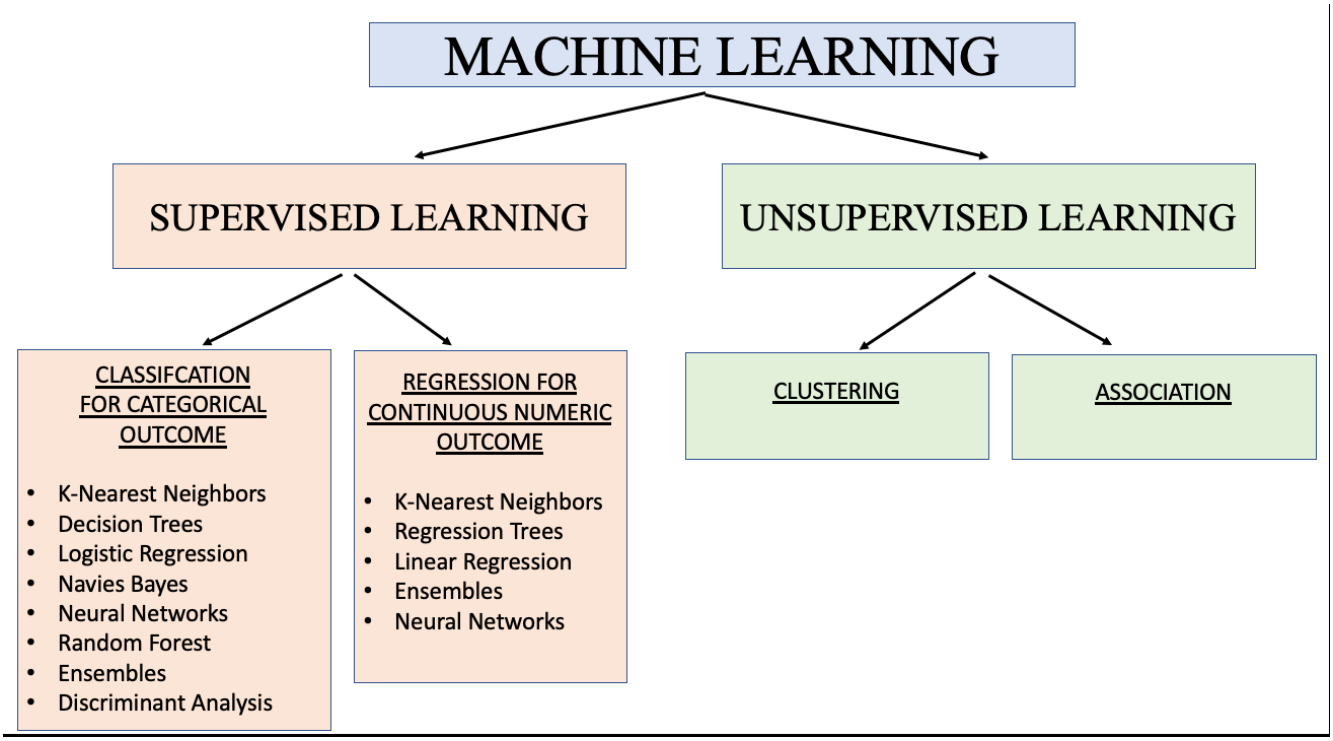
- It has several applications in astronomy, medicine, robotics, and satellite remote sensing, among others.

Pattern recognition involves two primary classification methods:

- **Supervised classification:** In a supervised pattern recognition method, a human train a computer algorithm to recognize patterns based on predefined labeled datasets. Once the pattern is identified, the method subsequently classifies new data.

- **Unsupervised classification:** In unsupervised classification, the model learns independently without any direct guidance from a human. The computer algorithm identifies correlations between multiple data elements (inputs) based on their similarity score and performs data classification.





Objectives of image analysis

- To identify an understanding of image analysis and image improvement techniques
- To identify the steps of image analysis, especially image segmentation.
- To distinguish different approaches of image segmentation techniques, by their names, properties, and principals.
- To tell the right classification of different approaches of image segmentation techniques
- To demonstrate a understanding of image analysis techniques

Uses/ Application of Image recognition

1) **Disease Categorization:** The PR systems have been employed in disease recognition and imaging over a decade.
2) **Natural Language Processing**: The Pattern Recognition algorithms are used in NLPs for building strong software systems that have further applications in the computer and communications industry.
3) **Network Intrusion Detection:** Network intrusion detection is one of the sectors of security. The intrusion is one of the serious threats posed to any data firm. Thus the PR system applications help in intrusion detection by recognizing patterns of intrusion over time. This ensures security systems to be at alarm if the slightest of patterns of intrusion show their traces over the network.

4) **In Image Sensing and Recognition:** Pattern recognition well suits the image processing and its segmentation. The analysis is then performed. This is forwarded to expert reviews. PR algorithms have gradually incorporated intelligence, similar to humans. Machine learning has boosted their recognition powers in medical image sensing and recognizing.
5) **Optical Character Recognition:** Also, commonly known as OCR, they are widely in use these days.
6) **Data Mining and Warehousing Patterns or Knowledge Discovery:** The KDD and other algorithms are used for finding patterns when performing data mining activities.
7) **Acting as Eyes in Computer Vision:** Pattern recognition algorithms are widely used in computer vision. They help in extracting meaningful features from excerpts of images, videos, etc. There are applications in biomedical and medical imaging of diseases.
8) **Prediction of Survival Rates for Patients with Specific Disease:** The probability rates of patients can also be predicted with pattern recognition algorithms.
9) **Seismic Analysis:** PR approaches are used for findings, imaging, and elucidation of sequential patterns of seismic display of recorded data. In this application, we implement Statistical pattern recognition techniques. They are used in variants of seismic analysis and data models.

Approaches/ Applications:

The five major approaches for pattern recognition:

- **Template matching:** Objects are directly compared with a few stored examples or prototypes that are representative of the underlying classes. Because of the large variations often encountered in these examples, the template matching is not the most effective approach to pattern recognition

- **Geometrical classification:** Classes are represented by regions in the representation space (e.g. a feature space as in Figure 1) defined by simple functions. Suppose, the average value of (height, weight) of women is (5’5”, 125 lb) and that of men is (5’11”, 157lb). A simple geometric woman vs. man classifier using (height, weight) as a two-dimensional representation may simplistically divide the representation space into two triangular regions So, a person with (height, weight) = (5’2”, 122lb) will classified by this classifier as a woman.

- **Statistical classification:** Continuing with the foregoing example, a statistical classifier may estimate the statistical distribution of the two features, namely, height and weight of the two classes of interest (women and men) from known samples. At any coordinate or point in the representation space, one could estimate the likelihoods of it being a man or a woman; depending upon which likelihood is higher, one could determine the class of an entity. This method differs from the geometrical method in that the classes are not (pre)defined in terms of any regular shapes in the representation space.

- **Syntactic or structural matching:** In syntactic or structural approach, a complex pattern (e.g., animal) is described in terms of component patterns (e.g., hair and head, or, torso and limbs) and their relationship (e.g., articulated joints). Strategies for learning such a language (defining the structure) from examples are problematic, as it is essentially difficult to compensate for noise. Therefore, pattern classes represented by means of formal structures as grammars, automata, strings, etc.

- **Artificial neural networks:** These networks attempt to apply the models of biological neuralsystems to solve practical pattern recognition problems. This approach has become so popular that the use of neural networks for solving pattern recognition problems has become an area on its own, and is often studied outside the biological context.

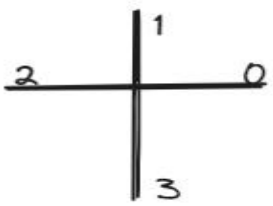
Chain Codes

- Chain codes represent a boundary by a connected sequence of straight-line segments of specified length and direction. This method is widely used for shape representation and analysis.
- **Properties:**
  - *Represents shape efficiently.*
  - *Rotation and scale invariant (with proper normalization).*
  - *Can be used for shape matching and recognition.*

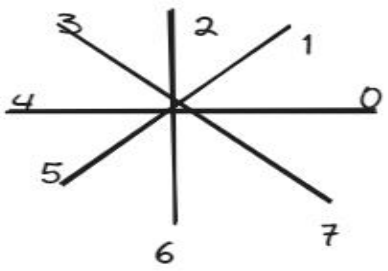
Given an image, "A" represents its pixel position. If A* is the starting pixel, write down the 8-chain code and find the shape number of it.

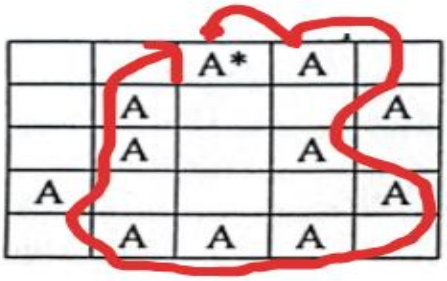
		A*	A	
	A			A
	A		A	
A				A
	A	A	A	

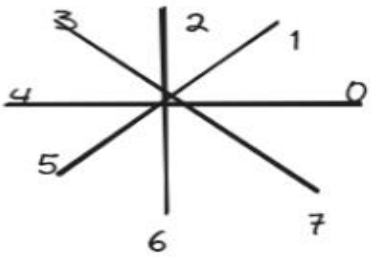
chain code
4chain



8 chain







chain code: 0 7 5 7 5 4 4 3 1 2 1

first difference : 7 7 6 2 6 7 0 7 6 1 7

shape no: 0 7 6 1 7 7 7 6 2 6 7

Signatures

- Signatures are a one-dimensional representation of a two-dimensional boundary. They capture the essence of the shape by plotting the distance from a reference point (typically the centroid) to the boundary as a function of angle.
- Properties:
  - Simplifies the shape representation.
  - Useful for comparing shapes.
  - Rotation invariant but not scale invariant (without normalization).

Shape Numbers

- Shape numbers are derived from chain codes by considering the direction of movement in the boundary representation. It quantizes the boundary information and converts it into a numerical form that can be easily compared.
- Properties:
  - Useful for shape description and comparison.
  - Sensitive to noise.

Fourier Descriptors

- Fourier descriptors use Fourier transformation to represent the shape boundary. The boundary is treated as a periodic function, and the Fourier transform captures its frequency components.
- **Properties**:
  - Compact representation.
  - Rotation, scale, and translation invariant (with proper normalization).
  - Robust to noise.

Patterns and Pattern Classes

- **Patterns**: These are entities to be classified or recognized, such as images, signals, or shapes.
- **Pattern Classes**: These are groups of patterns that share common characteristics and are categorized together based on features.

Neural Network and Image Processing

Neural networks (NN) are computational models inspired by the human brain, used extensively in pattern recognition and image processing due to their ability to learn from data.

Key Aspects:

- **Convolutional Neural Networks (CNNs)**: Specialized for image data, using convolutional layers to capture spatial features.
- **Training**: NNs learn patterns through backpropagation and optimization techniques.
- **Applications**: Image classification, object detection, image segmentation.

NN Based Pattern Recognition

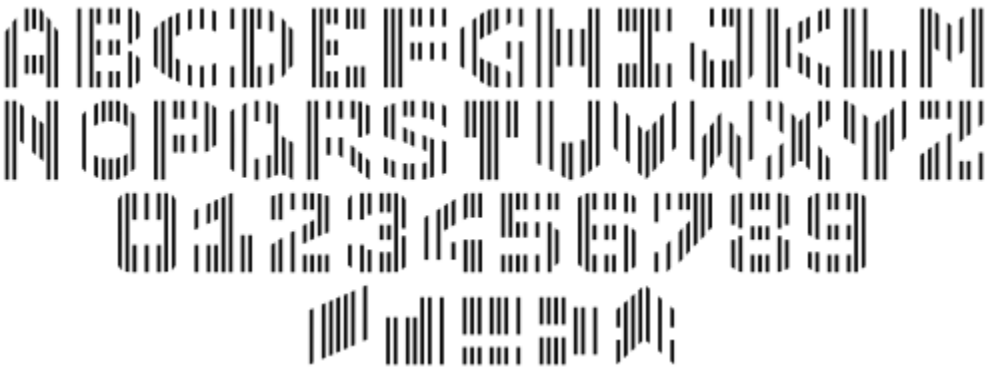
Neural networks can be trained to recognize patterns by learning from labeled data. They are particularly effective in handling high-dimensional data and complex patterns.

Properties:

- High accuracy and robustness.
- Requires a large amount of labeled training data.
- Computationally intensive.

Decision-Theoretic Pattern Recognition Methods

These methods use statistical decision theory to classify patterns. They rely on probability and cost functions to make optimal decisions.



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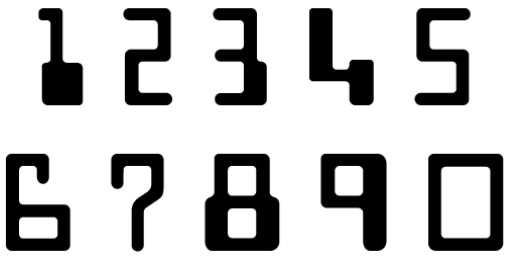
Key Techniques:

- **Bayesian Decision Theory**: Uses prior probabilities and likelihoods to make decisions.
- **Maximum Likelihood Estimation (MLE)**: Estimates parameters that maximize the likelihood of observed data.
- **Minimum Error Rate Classification**: Minimizes the probability of misclassification.



Properties:

- Theoretically sound and optimal under certain conditions.
- Requires knowledge of the probability distributions of the classes.
- Can be computationally complex.