Pattern Recognition
CS-404

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- ARTIFICIAL NEURAL NETWORKS- by B. YEGNANARAYANA
- Pattern Classification- by David G. Stork, Peter E. Hart, and Richard O. Duda
- Pattern Recognition and Machine Learning- by Christopher M. Bishop

Introduction

- **Pattern Recognition in AI is research area**

  - Studies the operation and design of systems that recognize patterns in data
- Pattern recognition is

  -Study of how machines can observe the environment

  -Learn to distinguish patterns of interest

  -Make sound and reasonable decisions about the categories of the patterns
- Main difference between human and machine intelligence

  -Humans perceive everything as a pattern

  -For a machine everything is data

Pattern: A pattern is a quantitative or structural description of an object.

Pattern Class: A pattern class is a set of patterns that share some common properties.

- Feature can be defined as any distinctive aspect, quality or characteristic which, may be symbolic (i.e., color) or numeric (i.e., height).
- Combination of “d” features is represented as a d-dimensional column vector called a feature vector.
- d-dimensional space defined by the feature vector is called feature space.
- Scatter plot-objects are represented as points in feature space.

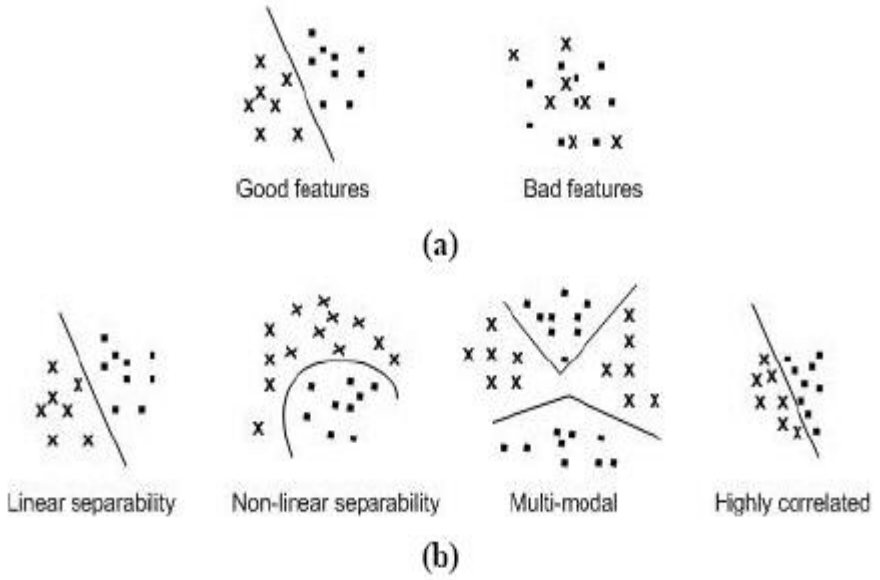


Fig. Characteristic (feature); a. the distinction between good and poor features, and b. feature properties.

- Pattern- composite of features that are characteristic of an individual.
- In classification, a pattern is a pair of variables {x,w} where x is a collection of observations or features (feature vector) and w is the concept behind the observation (label).
- The quality of a feature vector is related to its ability to discriminate examples from different classes (Fig.).
- Examples from the same class should have similar feature values and while examples from different classes having different feature values.
- The goal of a classifier is to partition feature space into class-labeled decision regions. Borders between decision regions are called decision boundaries

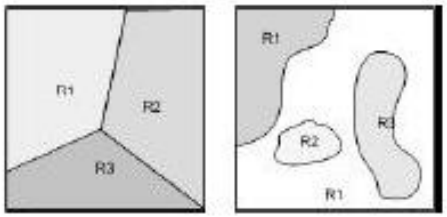
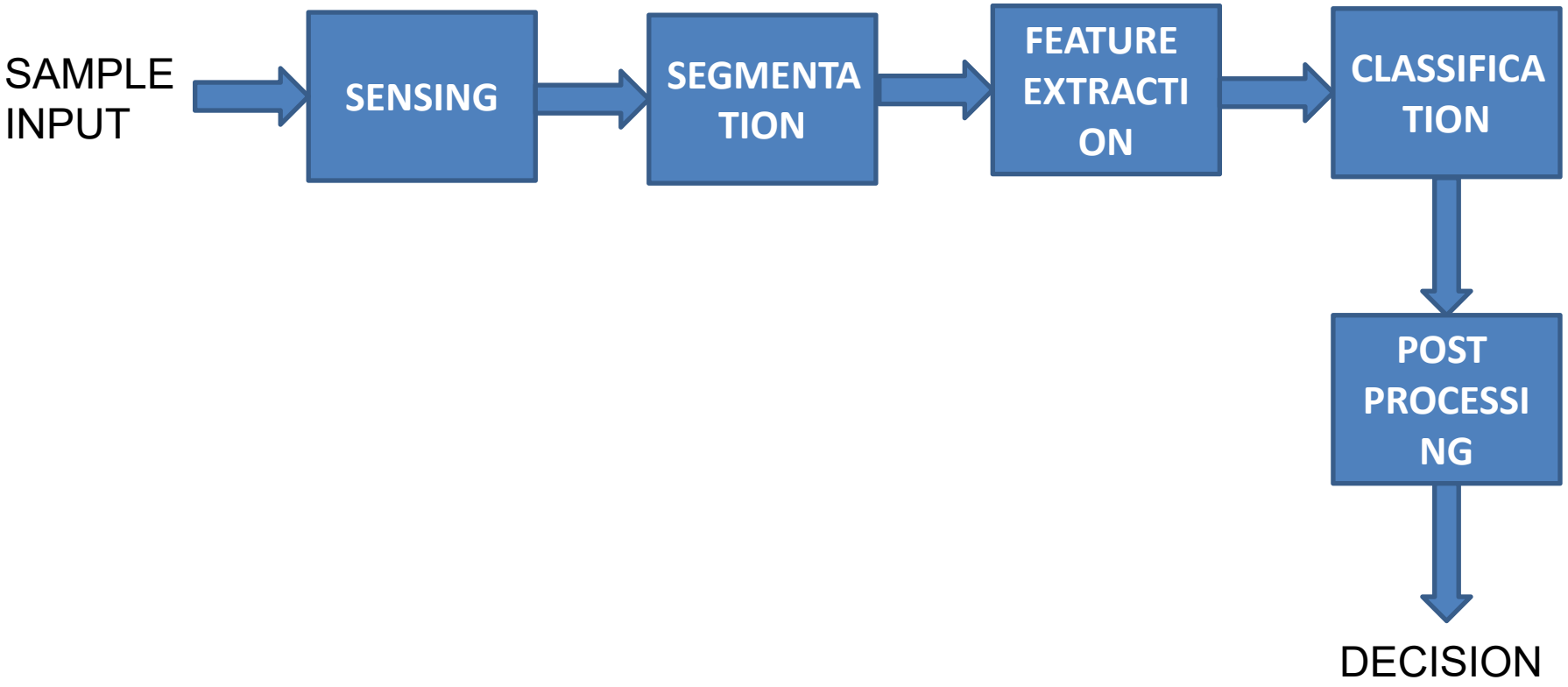


Fig. A pattern recognition system



In general pattern recognition systems can be subdivided into components:

- Sensor-sense the env. & converts images/physical i/p into single data
- Segmentor-isolates stored object from background or other objects
- Feature Extractor-extracts the feature that are sufficient for distinguishing one object from others
- Classifier-uses the feature to assign the sensed object to a predefined label/category
- Post Processor-can take account of other considerations such as cost of errors to decide the appropriate action

Difficulty in classification

Degree of difficulty of the classification problem depends

-variability in the feature values of object in the same category and

This is due to

- Complexity in feature
- Noise

Noise

A noise is the property of the sensed pattern which is not due to the true underlying model

But instead due to

- Randomness in the world
- Randomness in the sensors

Classification Performance: Error Rate

- **Simplest measure of classifier performance**
- Classification Error Rate is the percentage of new patterns that are assigned to the wrong category.
- Total expected cost or risk: It may be better to minimize the total expected cost which is called risk.

The post processor might also be able to exploits context i.e. input dependent information other than the target pattern itself to improve system performance.

Classification

- Construction of a classifier typically requires

  -Select the classification approach whose assumptions best match the characteristics of the problem

  -Use a set of training data that is large enough and representative of the problem

  -Classifier parameters are continuously fine-tuned

  -Assign predefined labels to unknown samples in the testing set

Classifier

- Single classifier
  - Pre-processes raw input
  - Extracts relevant features
  - Classification
  - Only a single decision can be achieved

- Multiple classifier system,
  - Each classifier operates on different aspects of the input
  - Predicts class labels by aggregating predictions

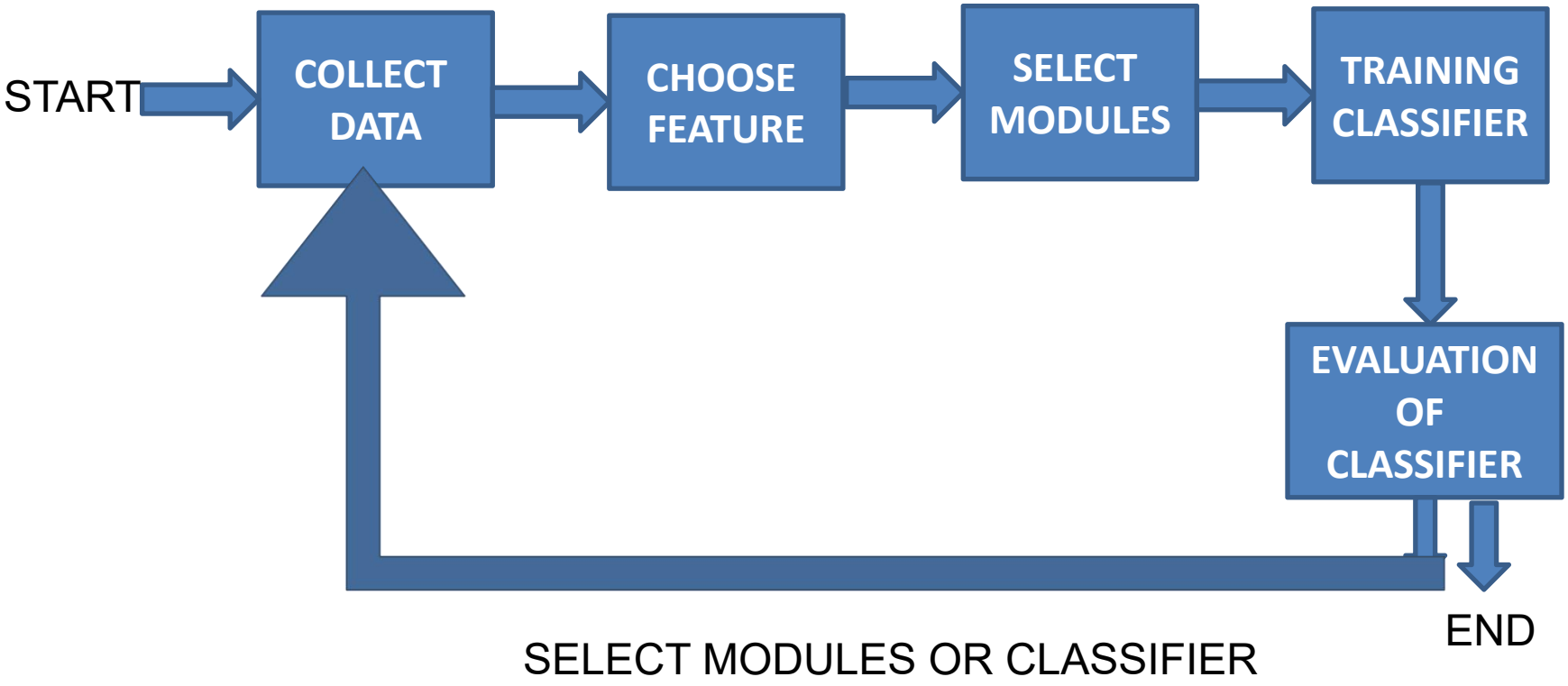
Multiple classifier

- Classifier performance might be improved if multiple classifiers are used.
- Each classifier operates on different aspects of input
- Example: We may combine acoustic recognition (audio) with lip reading (video) to improve the performance of a speech recognizer.

Multiple classifier contd..

- There is no difficulty if all the classifier agree on a particular pattern.
- A super classifier is used which integrates or combines the identifications of different classifiers and produces final decision
- The final decision by super classifier is made on “voting logic” or “weighted voting logic”

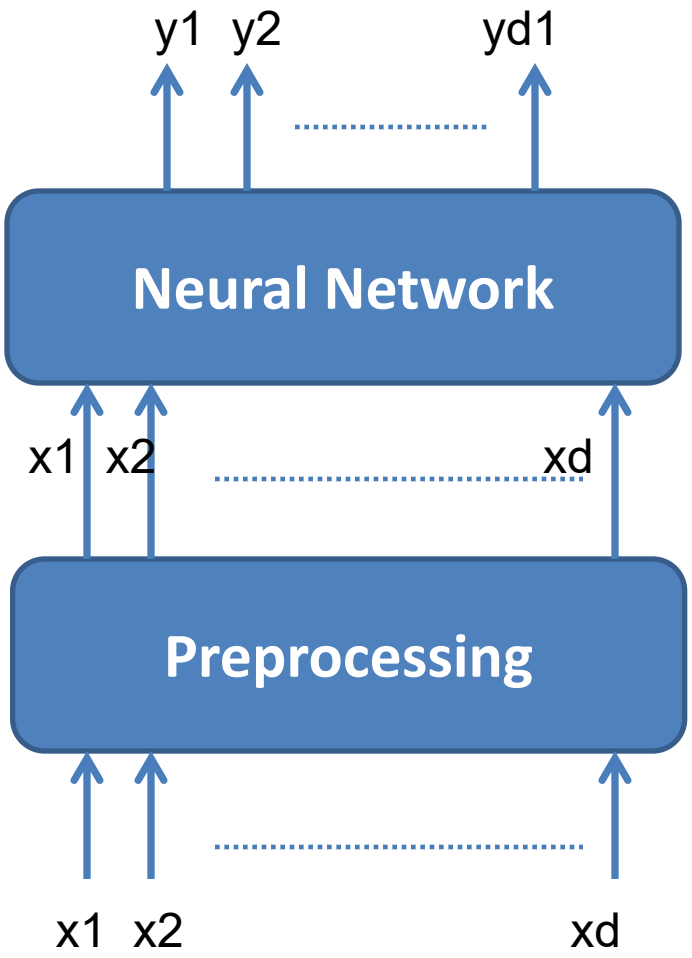
Fig. The design of a pattern recognition system



LEARNING-This carried out during the training of classifier
-Supervised
-Unsupervised
-Reinforcement

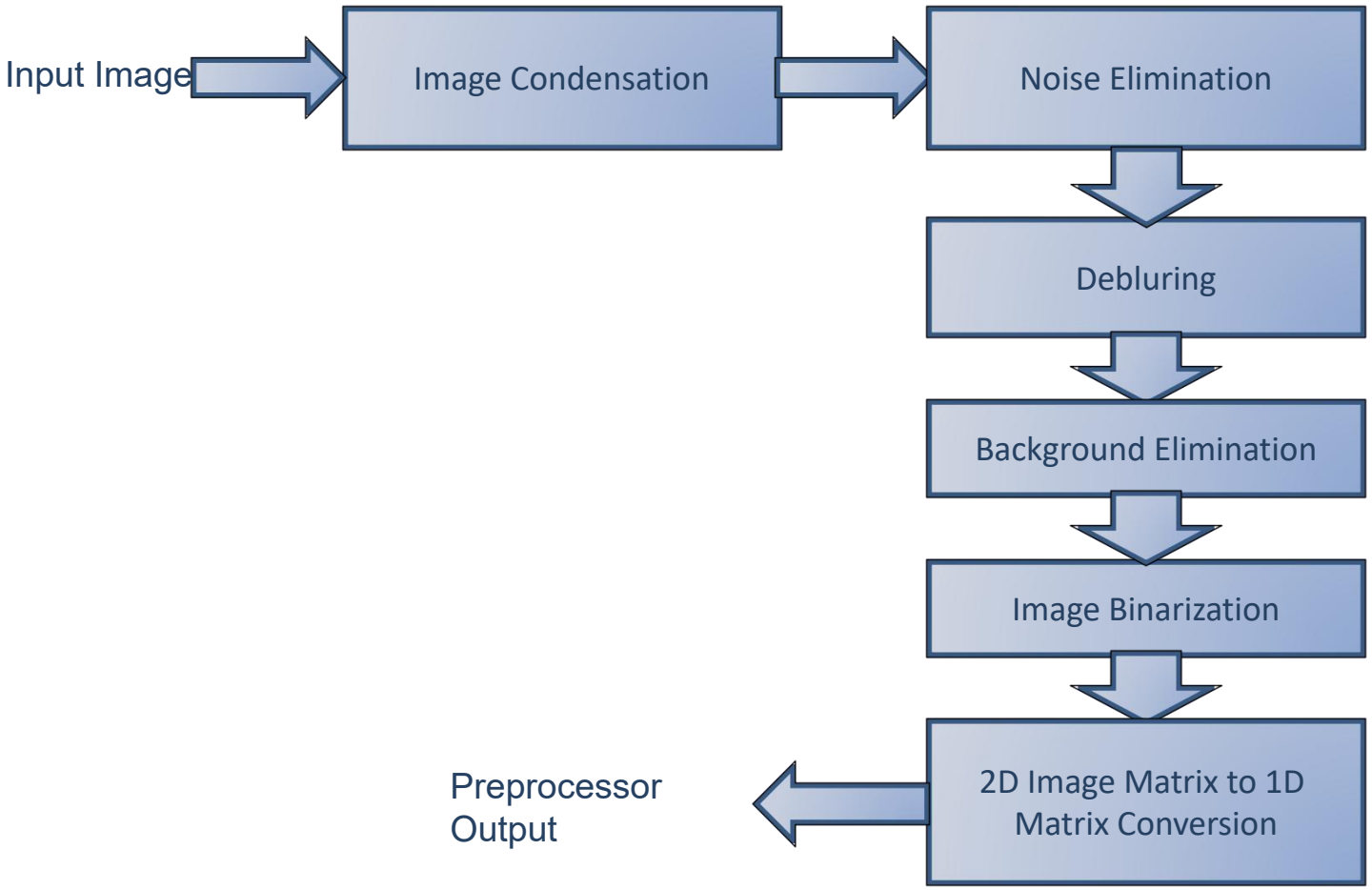
Preprocessing and feature extraction

- Instead of using a single neural network to map each pattern vector into its corresponding output, it is often beneficial to break the mapping into initial preprocessing stage followed by neural network model for identification.
- Here “d” dimensional input pattern vector is converted or mapped into “d1” dimensional pattern vector, where d1 << d



d1 << d

Image Pre-processing



Example:

- Image size = 256*256 pixels
- Image representation in d = 256*256 = 65536 dimensional space.
- Large number of input variables (features or dimensions) creates severe problems for pattern recognition system

- One Solution

  Combine input variables or features together to make a smaller number of new variables or features or dimensions.

  In the previous example, evaluate the ratio of height and width of the character as new input variable or feature.

- Application Area
  - -Automated speech recognition
  - -Speaker identification
  - -Biometrics authentication
  - -Handwritten character recognition
  - -DNA sequence identification and much more