A Review of Pattern Recognition Techniques

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ABSTRACT

Pattern Recognition techniques provide a variety of techniques, in mathematics and computer science, that is individually useful in many different applications. The primary goal of pattern recognition is supervised or unsupervised classification. Statistical approach is most commonly used in practice. More recently, neural network techniques from statistical learning theory have been receiving increasing attention. The pattern recognition process consists of the three stages: segmentation, feature selection and classification. Pattern recognition techniques can be categorized into four parts. These include Statistical Techniques, Structural Techniques, Template Matching, and Neural Network Approach. The aim of this review paper is to summarize and compare some of the well-known techniques of a pattern recognition system and identify research topics and applications which are at the forefront of this exciting and challenging field.

I. INTRODUCTION

PATTERN: Pattern is a set of objects or phenomena or concepts where the elements of the set are similar to one another in certain ways/aspects. The Pattern is described by certain quantities, qualities, traits, notable features and so on. Example: Humans, Radar Signals, insects, Animals, sonar signals. Fossil records, Micro organisms signals, clouds etc. Humans have a pattern which is different from the pattern of animals. Each individual has a pattern which is different from the patterns of others. RECOGNITION: Recognition $\Rightarrow$ Re + Cognition

COGNITION is to become acquainted with, to come to know the act, or the process of knowing an entity (the process of knowing). Recognition is the knowledge or feeling that the present object has been met before (the process of knowing again). Recognition & acquire knowledge through sender perception are very much related.

PATTERN RECOGNITION $\Rightarrow$ Pattern + Recognition. Pattern recognition is the discipline of building machines to perform perceptual tasks which we humans are particularly good at. e.g. recognize faces, voice, identify species of flowers, spot an approaching storm.

Pattern Recognition[3][5] consists of recognizing a pattern using a machine (computer). It can be defined in several ways. Pattern recognition is a study of ideas and algorithms that provide computers with a perceptual capability to put abstract objects, or patterns into categories in a simple and reliable way. Pattern recognition is an ambitious endeavor of mechanization of the most fundamental function of cognition. Pattern Recognition covers a wide spectrum of disciplines such as 1. Cybernetics 2. Computer Science 3. System Science 4. Communication Sciences 5. Electronics 6. Mathematics, 7. Logic, 8. Psychology , 9. Physiology, 10.Philosophy. Application of pattern recognition are Medical diagnosis, Life form analysis, Sonar detection, Radar detection, Image processing, Process control, Information Management systems, Aerial photo interpretation, Weather prediction, Sensing of life on remote planets, Behavior analysis, Character recognition, Speech and Speaker recognition etc.

II. PATTERN RECOGNITION TECHNIQUES

The four best known approaches are i) Template matching ii) Statistical classification iii) Syntactic or structural matching iii) Neural networks

Table 1: Pattern Recognition Techniques

Approach	Representation	Recognition Function	Typical Criterion
Template matching	Samples, pixels, curves	Correlation, distance measure	Classification error
Statistical	Features	Discriminant function	Classification error
Syntactic or structural	Primitives	Rules, grammar	Acceptance error
Neural networks	Samples, pixels, features	Network function	Mean square error

A. Statistical Model[1]

The act of taking in raw data and taking an action based on the "category" of the pattern[9]. A basic attribute of people is categorisation of sensory input. Examples of Pattern Recognition tasks are Reading' facial expressions, Recognising Speech, Reading a Document, Identifying a person by fingerprints, Diagnosis from medical images.

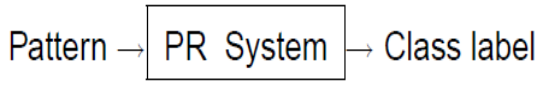

Figure 1: PR System

The data is reduced to vectors of numbers and statistical techniques are used for the tasks to be performed. Classification in Statistical PR[4]:-

- A class is a set of objects having some important properties in common
- A feature extractor is a program that inputs the data (image) and extracts features that can be used in classification.
- A classifier[4][7] is a program that inputs the feature vector and assigns it to one of a set of designated classes or to the "reject" class.

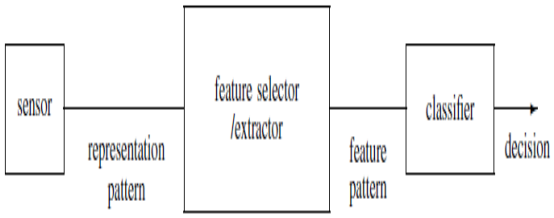

Figure 2: Pattern classifier

Classification in Statistical PR:-

- X=[x1, x2, … , xn], each x_j a real number
- x_j may be an object measurement
- x_j may be count of object parts
- Example: object rep. [#holes, #strokes, moments, …]

A pattern could be a fingerprint images, a handwritten cursive word, a human face, a speech signal.

B. Structural Techniques[1]

The data is converted to a discrete structure (such as a grammar or a graph) and the techniques are related to computer science subjects (such as parsing and graph matching).

In many recognition problems involving complex patterns, it is more appropriate to adopt a hierarchical perspective where a pattern is viewed as being composed of simple subpatterns which are themselves built from yet simpler subpatterns [1]. The simplest/elementary subpatterns to be recognized are called primitives and the given complex pattern is represented in terms of the interrelationships between these primitives. In syntactic pattern recognition, a formal analogy is drawn between the structure of patterns and the syntax of a language. The patterns are viewed as sentences belonging to a language, primitives are viewed as the alphabet of the language, and the sentences are generated according to a grammar. Thus, a large collection of complex patterns can be described by a small number of primitives and grammatical rules. The grammar for each pattern class must be inferred from the available training samples. Structural pattern recognition[6] is intuitively appealing because, in addition to classification, this approach also provides a description of how the given pattern is constructed from the primitives. This paradigm has been used in situations where the patterns have a definite structure which can be captured in terms of a set of rules, such as EKG waveforms, textured images, and shape analysis of contours [2]. The implementation of a syntactic approach, however, leads to many difficulties which primarily have to do with the segmentation of noisy patterns (to detect the primitives) and the inference of the grammar from training data. The syntactic approach may yield a combinatorial explosion of possibilities to be investigated, demanding large training sets and very large computational efforts [3].

C. Template Matching

One of the simplest and earliest approaches to pattern recognition is based on template matching. Matching is a generic operation in pattern recognition which is used to determine the similarity between two entities (points, curves, or shapes) of the same type. In template matching, a template (typically, a 2D shape) or a prototype of the pattern to be recognized is available. The pattern to be recognized is matched against the stored template while taking into account all allowable pose (translation and rotation) and scale changes. The similarity measure, often a correlation, may be optimized based on the available training set. Often, the template itself is learned from the training set. Template matching is computationally demanding, but the availability of faster processors has now made this approach more feasible. The rigid template matching mentioned above, while effective in some application domains, has a number of disadvantages. For instance, it would fail if the patterns are distorted due to the imaging process, viewpoint change, or large intraclass variations among the patterns. Deformable template models [4] can be used to match patterns when the deformation cannot be easily explained or modeled directly.

D. Neural Network Approach[3]:

Artificial Neural Network (ANN)[10] has emerged as a research applications tool including classification and regression. ANN are successfully applied across an range of problem domains in areas as diverge as finance, medicine, engineering, physics and biology. Neural networks[2] can be viewed as massively parallel computing systems and consisting of an extremely large number of simple processors with many interconnections. Neural network models attempt to use some organizational principles (such as learning, generalization, adaptivity, fault tolerance and distributed representation, and computation) in a network of weighted directed graphs in which the nodes are artificial neurons and directed edges (with weights) are connections between neuron outputs and neuron inputs. The main characteristics of neural networks are that they have the ability to learn complex nonlinear input-output relationships, use sequential training procedures, and adapt themselves to the data. The most commonly used family of neural networks for pattern classification tasks [3] is the feed-forward network, which includes multilayer perceptron and Radial-Basis Function (RBF) networks[8]. These networks are organized into layers and have unidirectional connections between the layers. Another popular network is the Self-Organizing Map (SOM)[3][8], or Kohonen-Network , which is mainly used for data clustering and feature mapping. The learning process involves updating network architecture and connection weights so that a network can efficiently perform a specific classification/clustering task. The increasing popularity of neural network models to solve pattern recognition problems has been primarily due to their seemingly low dependence on domain-specific knowledge (relative to model-based and rule-based approaches) and due to the availability of efficient learning algorithms for practitioners to use. Neural networks provide a new suite of nonlinear algorithms for feature extraction (using hidden layers) and classification (e.g., multilayer perceptrons). In addition, existing feature extraction and classification algorithms can also be mapped on neural network architectures for efficient (hardware) implementation. In spite of the seemingly different underlying principles, most of the well known neural network models are implicitly equivalent or similar to classical statistical pattern recognition methods. Anderson et al. point out that [a]neural networks are statistics for amateurs... Most NNs conceal the statistics from the user. Despite these similarities, neural networks do offer several advantages such as, unified approaches for feature extraction and classification and flexible procedures for finding good, moderately nonlinear solutions.

III. PATTERN RECOGNITION APPLICATIONS

The pattern recognition, machine learning, data mining and knowledge discovery in databases (KDD) are hard to separate, as they largely overlap in their scope. Machine learning is the common term for supervised learning methods and originates from artificial intelligence (AI), whereas KDD (Knowledge Discovery in database) and data mining have a larger focus on unsupervised methods and stronger connection to business use.

TABLE 2: Pattern Recognition Applications

Problem Domain	Application	Input Pattern	Pattern Classes
Bioinformatics	Sequence analysis	DNA/Protein sequence	Known types of genes/ patterns
Data mining	Searching for meaningful patterns	Points in multi-dimensional space	Compact and well-separated clusters
Document classification	Internet search	Text document	Semantic categories (e.g., business, sports, etc.)
Document image analysis	Reading machine for the blind	Document image	Alphanumeric characters, words
Industrial automation	Printed circuit board inspection	Intensity or range image	Defective / non-defective nature of product
Multimedia database retrieval	Internet search	Video clip	Video genres (e.g., action, dialogue, etc.)
Biometric recognition	Personal identification	Face, iris, fingerprint	Authorized users for access control
Remote sensing	Forecasting crop yield	Multispectral image	Land use categories, growth pattern of crops
Speech recognition	Telephone directory enquiry without operator assistance	Speech waveform	Spoken words

Table 3: Pattern Recognition Applications

Problem	Input	Output
Speech recognition	Speech waveforms	Spoken words, speaker identity
Non-destructive testing	Ultrasound, eddy current, acoustic emission waveforms	Presence/absence of flaw, type of flaw
Detection and diagnosis of disease	EKG, EEG waveforms	Types of cardiac conditions, classes of brain conditions
Natural resource identification	Multispectral images	Terrain forms, vegetation cover
Aerial reconnaissance	Visual, infrared, radar images	Tanks, airfields
Character recognition (page readers, zip code, license plate)	scanned image	Alphanumeric characters

IV. CONCLUSION

In this paper all the models of pattern recognition system has been compared and analysed. Various models are used in different domain or combinations of models are used. In case of noisy patterns, statistical model is a very good choice. Practical importance of structural model depends upon recognition of simple pattern primitives and their relationships represented by description language. For complex patterns and applications utilizing large number of pattern classes, it is beneficial to describe each pattern in terms of its components. A wise decision regarding the selection of Pattern grammar influences computations efficiency of recognition system. Pattern primitives and pattern grammar to be utilized depends upon the application requirements. Low dependence of neural networks on prior knowledge and availability of efficient learning algorithms have made the neural networks famous in the field of Patten Recognition. Although neural networks and statistical pattern recognition models have different principles most of the neural networks are similar to statistical pattern recognition models. To recognize unknown shapes fuzzy methods are good options. As each model has its own pros and cons, therefore to enhance system performance for complex applications it is beneficial to append two or more recognition models at various stages of recognition process.

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