Comparative Analysis of Pattern Recognition Methods: An Overview

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Abstract- The identification or interpretation of the pattern in an image can be described effectively with the help of Pattern Recognition (PR). It aims to extract information about the image to classify its contents. Inputs are in the form of digitized binary valued 2D images or textures containing the pattern to be classified. The analysis and recognition of the patterns such as images and textures are becoming more and more complex and multiform. This is because in general the patterns to be analyzed are shifting from simple to complex, and because the patterns of heavy variations and with heavy noise have to be treated. Therefore it is proposed to develop sophisticated strategies of pattern analysis to cope with these difficulties.

Pattern recognition is the research area that studies the operation and design of systems that recognize patterns in data.In this work three basic approaches of pattern recognition are analyzed: statistical pattern recognition, structural pattern recognition and neural pattern recognition. In the statistical approach the recognition is based on the decision boundaries that are established in the feature space by statistical distribution of the patterns. In the structural (syntactic) approach each pattern class is defined by a structural description or representation. The recognition is performed according to the similarity of structures. This is based on the fact that the significant information is not only the features but also the relationships consisting among the features. In the neural network based approach the artificial neural networks are able to form complex decision regions for pattern recognition. The present work involves in the study of Pattern recognition methods on Texture Classifications.

Keywords- Pattern Recognition, Texture, Neural Networks, Classification.

1. Introduction

In machine learning, pattern recognition is the assignment of some sort of output value (or *label*) to a given input value (or *instance*), according to some specific algorithmPattern recognition (PR) as a field of study developed significantly in the 1960s. It was very much an interdisciplinary subject, covering developments in the areas of statistics, engineering, artificial intelligence, computer science, psychology and physiology, among others. Pattern recognition is generally categorized according to the type of learning procedure used to generate the output value. *Supervised learning* assumes that a set of *training data* (the *training set*) has been provided, consisting of a set of instances that have been properly labeled by hand with the correct output[10]. A learning procedure then generates a *model* that attempts to meet two sometimes conflicting objectives: perform as well as possible on the training data, and generalize as well as possible to new data (usually, this means being as simple as possible, for some technical definition of "simple", in accordance with occam's razor). Unsupervised learning, on the other hand, assumes training data that has not been hand-labeled, and attempts to find inherent patterns in the data that can then be used to determine the correct output value for new data instances. A combination of the two that has recently been explored is semi-supervised learning, which uses a combination of labeled and unlabeled data (typically a small set of labeled data combined with a large amount of unlabeled data). Note that in cases of unsupervised learning, there may be no training data at all to speak of; in other words, the data to be labeled *is* the training data [10].

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Texture analysis is important in many applications of computer image analysis for classification or segmentation of images based on local spatial variations of intensity or color. A successful classification or segmentation requires an efficient description of image texture. Important applications include industrial and biomedical surface inspection, for example for defects and disease, ground classification and segmentation of satellite or aerial imagery, segmentation of textured regions in document analysis, and content-based access to image databases. However, despite many potential areas of application for texture analysis in industry there is only a limited number of successful examples. A major problem is that textures in the real world are often not uniform, due to changes in orientation, scale or other visual appearance. In addition, the degree of computational complexity of many of the proposed texture measures is very high.

Texture classification process involves two phases: the learning phase and the recognition phase. In the learning phase, the target is to build a model for the texture content of each texture class present in the training data, which generally comprises of images with known class labels. The texture content of the training images is captured with the chosen texture analysis method, which yields a set of textural features for each image. These features, which can be scalar numbers or discrete histograms or empirical distributions, characterize given textural properties of the images, such as spatial structure, contrast, roughness, orientation, etc. In the recognition phase the texture content of the unknown sample is first described with the same texture analysis method. Then the textural features of the sample are compared to those of the training images with a classification algorithm, and the sample is assigned to the category with the best match. Optionally, if the best match is not sufficiently good according to some predefined criteria, the unknown sample can be rejected instead[11].

2. Pattern recognition methods

Pattern recognition is a computational algorithm used to classify raw data (sometimes appropriate action choice is included in the definition). The term is from machine learning, but has been adapted by cognitive psychologists to describe various theories for how the brain goes from incoming sensory information to action selection.Pattern recognition undergoes an important developing for many years. Pattern recognition include a lot of methods which impelling the development of numerous applications in different filed. The practicability of these methods is intelligent emulation.

Statistical pattern recognition

Statistical decision and estimation theories have been commonly used in PR for a long time. It is a classical method of PR which was found out during a long developing process, it based on the feature vector distributing which getting from probability and statistical model. The statistical model is defined by a family of class-conditional probability density functions Pr(x|ci)(Probability of feature vector x given class ci) In detail, in SPR, we put the features in some optional order, and then we can regard the set of features as a feature vector. Also statistical pattern recognition deals with features only without consider the relations between features.

Data clustering

Its aim is to find out a few similar clusters in a mass of data which not need any information of the known clusters. It is an unsupervised method. In general, the method of data clustering can be partitioned two classes, one is hierarchical clustering, and the other is partition clustering.

The application of fuzzy sets

The thinking process of human being is often fuzzy and uncertain, and the languages of human are often fuzzy also. And in reality, we can't always give complete answers or classification, so theory of fuzzy sets come into being. Fuzzy sets can describe the extension and intension of a concept effectively. The application of fuzzy sets in pattern recognition started in 1966, where the two basic operations –abstraction and generalization were quite much aimed at by Bellan et al.Two principles proposed by Marr (1982) and (Keller, 1995) which can be think as the general role of fuzzy sets in PR. The PR system based on fuzzy sets theory can imitate thinking process of human being widely and deeply.

Neural networks

Neural networks is developing very fast since the first neural networks model MP was proposed since 1943, especially the Hopfield neural networks and famous BP arithmetic came into being after. It is a data

clustering method based on distance measurement; also this method is model-irrespective. The neural approach applies biological concepts to machines to recognize patterns. The outcome of this effort is the invention of artificial neural networks which is set up by the elicitation of the physiology knowledge of human brain. Neural networks are composed of a series of different， associate unit. In addition, genetic algorithms applied in neural networks is a statistical optimized algorithms proposed by Holland (1975) NeurPR is a very attractive since it requires minimum a priori knowledge, and with enough layers and neurons, an ANN can create any complex decision region.

Structural pattern recognition

The concept of structural pattern recognition was put for the fourth time (Pavilidis, 1977).And structural pattern recognition is not based on a firm theory which relies on segmentation and features extraction. Structural pattern recognition emphases on the description of the structure, namely explain how some simple sub-patterns compose one pattern.

There are two main methods in structural pattern recognition, syntax analysis and structure matching. The basis of syntax analysis is the theory of formal language, the basis of structure matching is some special technique of mathematics based on sub-patterns. When consider the relation among each part of the object, the structural pattern recognition is best. Different from other methods, structural pattern recognition handle with symbol information, and this method can be used in applications with higher level, such as image interpretation. Structural pattern recognition always associates with statistic classification or neural networks through which we can deal with more complex problem of pattern recognition, such as recognition of multidimensional objects.

Syntactic pattern recognition

This method major emphasizes on the rules of composition. And the attractive aspect of syntactic methods is its suitability for dealing with recursion. When finish customizing a series of rules which can describe the relation among the parts of the object, syntactic pattern recognition which is a special kind of structural pattern recognition can be used.(in the middle of 1960's,1978) .

Approximate reasoning approach to pattern recognition

This method which uses two concepts: fuzzy applications and compositional rule of inference can cope with the problem for rule based pattern recognition. (Kumar S.Ray, J.Ghoshal,1996)

A logical combinatorial approach to pattern recognition

This method is presented, and works mainly in Spanish and Russian, which works with the descriptions of the objects. This approach can apply for both supervised pattern recognition and unsupervised pattern recognition.

Applications of Support Vector Machine (SVM) for pattern recognition

SVM is a relative new thing with simple structure; it has been researched widely since it was proposed in the 1990's. SVM base on the statistical theory ,and the method of SVM is an effective tool that can solve the problems of pattern recognition and function estimation, especially can solve classification and regression problem, has been applied to a wide range for pattern recognition such as face detection, verification and recognition, object detection and recognition ,speech recognition etc.

Using higher-order local autocorrelation coefficients to pattern recognition

In 2004, Vlad Popovici, present an efficient method using higher order autocorrelation functions for pattern recognition. The autocorrelation feature vectors reside in a high dimensional space, which one can avoid their computing easily.

A novel method and system of pattern recognition using data encoded as Fourier series and Fourier space

It was put forward by (Randell. L Mills) in 2006. This novel method anticipate the signal processing of an ensemble of neurons as a unit and intends to simulate aspects of brain which bring capabilities like pattern recognition and reasoning that have not been produced with past approaches as neural networks .

3. Statistical pattern recognition Method

Statistical pattern recognition has been used successfully to design a number of commercial recognition systems. In statistical pattern recognition, a pattern is represented by a set of d features, or attributes, viewed as a d- dimensional feature vector. Well-known concepts from statistical decision theory are utilized to establish decision boundaries between pattern classes. The recognition system is operated in two modes: training (learning) and classification (testing) (see Fig. 1). The role of the preprocessing module is to segment the pattern of interest from the background, remove noise, normalize the pattern, and any other operation which will

contribute in defining a compact representation of the pattern. In the training mode, the feature extraction/selection module finds the appropriate features for representing the input patterns and the classifier is trained to partition the feature space. The feedback path allows a designer to optimize the preprocessing and feature extraction/selection strategies. In the classification mode, the trained classifier assigns the input pattern to one of the pattern classes under consideration based on the measured features.

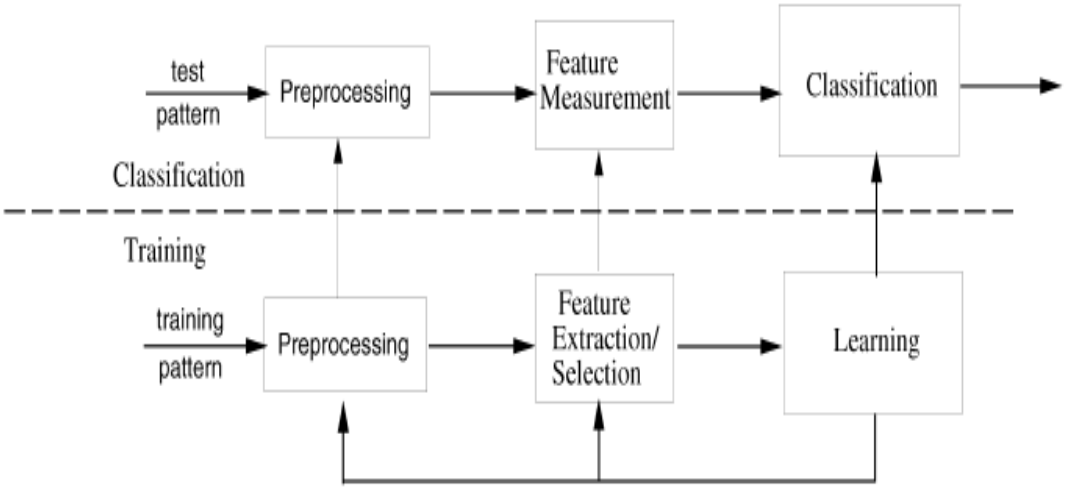

Fig 1 Model for Statistical Pattern Recognition

4. Structural pattern recognition Method

Structural pattern recognition [1][2][3], sometimes referred to as syntactic pattern recognition due to its origins in formal language theory, relies on syntactic grammars to discriminate among data from different groups based upon the morphological interrelationships (or interconnections) present within the data. Structural pattern recognition systems have proven to be effective for data which contain an inherent, identifiable organization such as image data (which is organized by location within a visual rendering) and time series data (which is organized by time). The usefulness of structural pattern recognition systems, however, is limited as a consequence of fundamental complications associated with the implementation of the description and classification tasks.

The description task of a structural pattern recognition system is difficult to implement because there is no general solution for extracting structural features, commonly called *primitives, from data.*The lack of a general approach for extracting primitives puts designers of structural pattern recognition systems in an awkward position: feature extractors are necessary to identify primitives in the data, and yet there is no established methodology for deciding which primitives to extract. The result is that feature extractors for structural pattern recognition systems are developed to extract either the simplest and most generic primitives possible, or the domain and application specific primitives that best support the subsequent classification task. Some structural pattern recognition systems justify the use of a particular set of feature extractors by claiming that the same set had been used successfully by a previous system developed for a similar application within the same domain; such claims simply shift the burden of feature extractor development onto previously implemented systems.

Simplistic primitives are domain independent, but capture a minimum of structural information and postpone deeper interpretation until the classification step. At the other extreme, domain and application specific primitives can be developed with the assistance of a domain expert, but obtaining and formalizing knowledge from a domain expert, called *knowledge acquisition*, can be problematic.

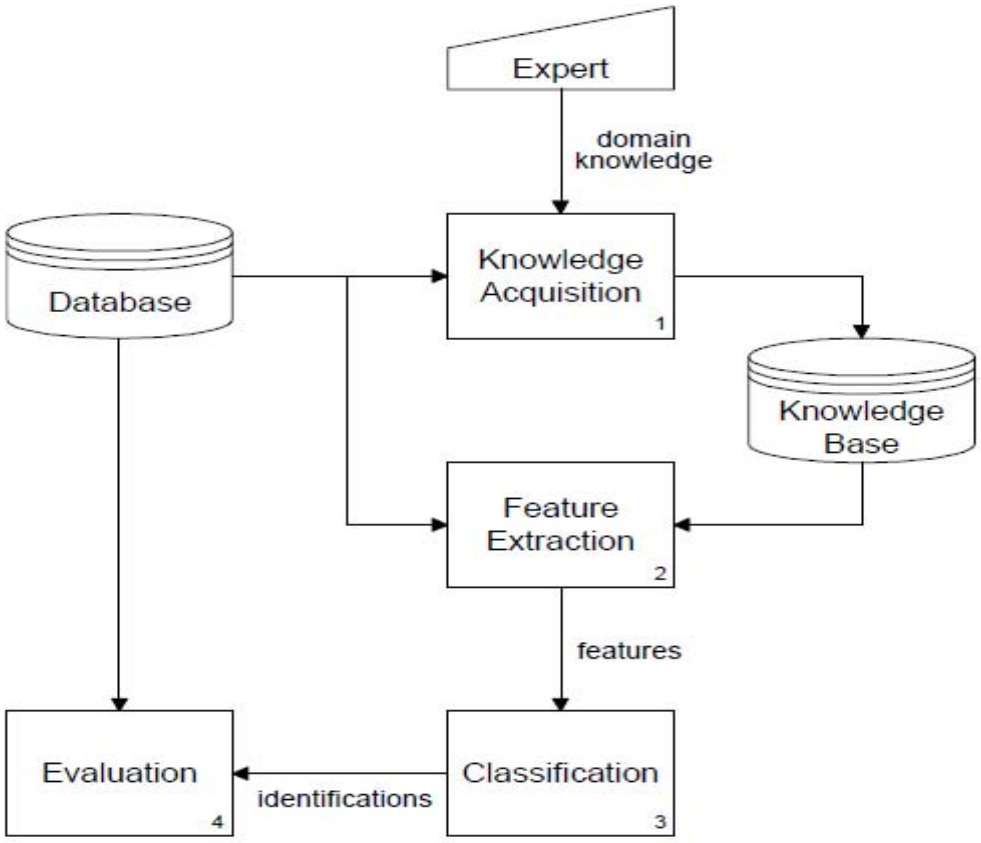

Fig 2 The process of knowledge acquisition for developing domain and Application specific feature extractors for structural pattern recognition.

5. Neural pattern recognition Method

In most networks, the principle of learning a network is based on minimizing the gradient of error [4,5]. Therefore it is assumed that a network has a minimum error at the end of learning process [6] but it is not always happened like this. Sometimes because of the largeness of the domain of changes of the input network signal, the activity function of some neurons will be saturated and at last the output of these categories of neurons will be fixed in their border amount. It can make a same situation for the next layers of neurons. With continuing this situation, the network will be in a stable mode. In this case the output of neurons will be fixed and continuing learning is not useful because the network is trapped at a minimum position as a cure we can teach the neurons activity function gradient like links weight. Among neurons activity functions sigmoid function (one directed & two directed) has the most application, therefore for studying the mathematical form of the network

Designing a neural network which is used error back propagation algorithm is not only a science but also an

experimental work. The reason is that many factors are engaged in designing a network which are the results of researcher's experiences however with considering some matters we can lead the back propagation algorithm to better

Performance [7][8][9].

The model of a network comprises analog cells like neuron. Fig. 3 shows an instance of these cells which are used in a network. This multi layer hierarchal network is made of lots of cell layers. In this network there are forward and backward links between cells. If this network is used for recognizing the pattern in this hierarchy, forward signals handle the process of recognizing pattern whereas backward signals handle the process of separating patterns and reminding. We can teach this network to recognize each set of patterns. Even being extra instigators or lack in patterns, this model can recognize it. It is not necessary that the complete reminding recognize manipulated shapes or the shapes that are changed in size or convert the imperfect parts to the main mode.

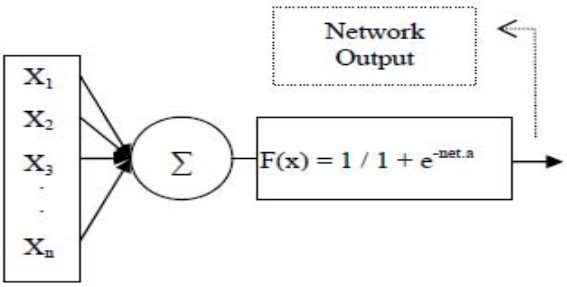

Fig 3 Neuron Model of Pattern Recognition

Conclusion

Pattern recognition is generally categorized according to the type of learning procedure used to generate the output value. In simple sense pattern recognition is the heart of all scientific inquiry, including understanding ourselves and the real-world around us. Now a day the development of pattern recognition is increasing very fast. In this paper we navigate pattern recognition in the round, include the definition of PR, the methods of PR, the composition of PR system and figures related to PR. In addition, it is an important trend to use pattern recognition on engineering applications; one should make efforts on PR.

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References

[1] K. S. Fu. *Syntactic Pattern Recognition and Applications*. PrenticeHall, Englewood Cliffs, New Jersey, 1982.
[2] Rafael C. Gonzalez and Michael G. Thomason. *Syntactic Pattern Recognition: An Introduction*. AddisonWesley, Reading, Massachusetts, 1978.
[3] T. Pavlidis. *Structural Pattern Recognition*. Springer Verlag
[4] K. Economou and D. Lymberopoulos, "A new perspective in learning pattern generation for teaching neural networks", Neural Networks, Volume 12, Issue 4-5, June 1999, Pages 767-775.
[5] Eiji Mizutani and James W. Demmel, "On structure-exploiting trust region regularized nonlinear least squares algorithms for neural-network learning", Neural Networks, Volume 16, Issue 5-6, June-July 2003.
[6] Kamarthi S.V., Pittner S. , Accelerating neural network traning using weight extrapolation, Neural networks, 9, 1999, pp. 1285-1299.
[7] Mirzaaghazadeh, H. Motameni, "Using Neural Network in Pattern Recognition", Proceeding of Iran Computer Conference, 2002.
[8] Burak Goktepe, "Role of Learning Algorithm in Neural Network- Based Back calculation of Flexible Pavements", Journal of Computingin Civil Engineering, Volume 20, Issue 5, pp. 370-373(September/October 2006).
[9] V. Maiorov, "Approximation by neural networks and learning theory", Journal of Complexity, Volume 22, Issue 1, Februery 2006, Pages 102- 117.
[10] http://www.diesel- ebooks.com/item/9780470845134/Webb-Andrew-R.-Statistical-Pattern-Recognition/1.html
[11]]http://media.wiley.com/product_data/excerpt/39/04708451/0470845139.pdf