Pattern Recognition: An overview

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Summary
Pattern recognition has become more and more popular and important to us since 1960's and it induces attractive attention coming from a wider areas. In this paper Pattern recognition was introduced including concept, method, application and integration. At the same time, ten definitions and more than ten methods of pattern recognition were summarized. On the end, the structure and classification of PR and its related fields and application areas were introduced in detail.

Key words:
Pattern Recognition, Definition, Methods, Application

1. Introduction

Pattern recognition is not unfamiliar with everyone, it has a long history. PR is a subject researching object description and classification method, it is also a collection of mathematical, statistical, heuristic and inductive techniques of fundamental role in executing the tasks like human being on computers. In a sense, PR is figuring out actual problems via mathematical methods.

2. The definition of Pattern recognition

1973(Duda and Hart) defined the pattern recognition is a field concerned with machine recognition of meaning regularities in noisy of complex environments. [1]

1977(Pavlidis) defined pattern recognition in his book: "the word pattern is derived from the same root as the word patron and, in his original use, means something which is set up as a perfect example to be imitated. Thus pattern recognition means the identification of the ideal which a given object was made after." [2]

1978(Gonzalez,Thomas) defined pattern recognition as a classification of input data via extraction important features from a lot of noisy data. [3]

1985(Watanabe) said that pattern recognition can be looked as categorization problem, as inductive process, as structure analysis, as discrimination method and so on. [4]

1990(Fukunaga) defined pattern recognition as" A problem of estimating density functions in a high-dimensional space and dividing the space into the regions of categories of classes."[5]

1992(Schalkoff) defined PR as " The science that concerns the description or classification (recognition) of measurements"[6]

1993(Srihari,Govindaraju) defined pattern recognition as a discipline which learn some theories and methods to design machines that can recognize patterns in noisy data or complex environment. [7]

1996(Ripley) outlined pattern recognition in his book: "Given some examples of complex signals and the correct decisions for them, make decisions automatically for a stream of future examples" [8]

2002 (Robert P.W. Duin) described the nature of pattern recognition is engineering; the final aim of Pattern recognition is to design machines to solve the gap between application and theory. [9]

2003(Sergios Theodoridis,) Pattern recognition is a scientific discipline whose aim is the classification of the objects into a lot of categories or classes. Pattern recognition is also a integral part in most machine intelligence system built for decision making. [10]

3．The research of pattern recognition methods

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.

3.1 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 $Pr(x|c_i)$(Probability of feature vector x given class c_i) 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. [11]Also statistical pattern recognition deals with features only without consider the relations between features.

3.2 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.

3.3 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. [12]Two principles proposed by Marr (1982) and (Keller, 1995) which can be think as the general role of fuzzy sets in PR. [13,14,15,16]The PR system based on fuzzy sets theory can imitate thinking   process of human being widely and deeply.

3.4 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 is 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) [17]

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.

3.5 Structural pattern recognition

The concept of structural pattern recognition was put for the fourth time (Pavilidis, 1977).[18]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.

3.6 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) [19]

3.7 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) [20]

3.8 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. [21]

3.9 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. [22]

3.10 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. [23]

3.11 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 . [24]

4. Pattern recognition system

A pattern recognition system can be regarded as a process that allows it to cope with real and noisy data. Whether the decision made by the system is right or not mainly depending on the decision make by the human expert.

4.1 The structure of pattern recognition system

A pattern recognition system based on any PR method mainly includes three mutual-associate and differentiated processes. One is data building; the other two are pattern analysis and pattern classification .Data building convert original information into vector which can be dealt with by computer. Pattern analysis' task is to process the data (vector), such as feature selection， feature extraction， data-dimension compress and so on. The aim of pattern classification is to utilize the information acquired from pattern analysis to discipline the computer in order to accomplish the classification.

A very common description of the pattern recognition system that includes five steps to accomplish. The step of classification/regression / description showed in fig1 is the kernel of the system.

Classification is a PR problem of assigning an object to a class, The output of the PR system is an integer label, such as classifying a product as "1" or "0" in a quality control test.

Regression is a generalization of a classification task, and the output of the PR system is a real-valued number, such as predicting the share value of a firm based on past performance and stock market indicators.

Description is the problem of representing an object in terms of a series of primitives, and the PR system produces a structural or linguistic description.

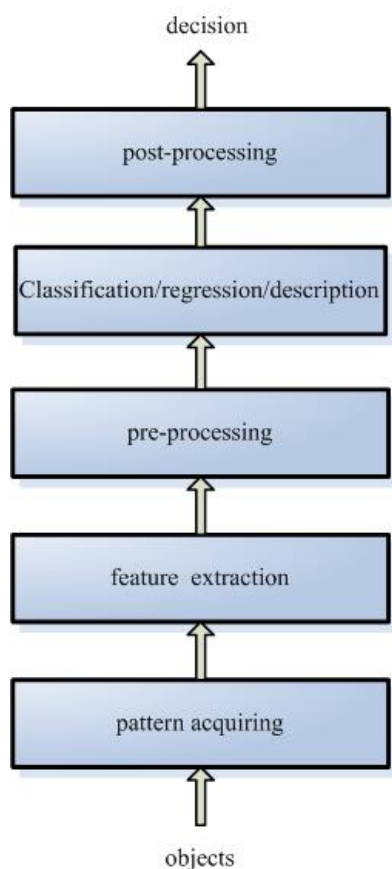A general composition of a PR system is given below.

Fig.1   the composition of a PR system

4.2 The classification of pattern recognition system
Rule based system
Classical fuzzy system
Bayesian system
Neural networks system
Fuzzy neural networks systems

These are mainly classification of PR system, whether the system is successful mainly depends on his decision like an expert or not. [25]

5. Applications

It is true that application was one of the most important elements for PR theory. Pattern Recognition has been developed for many years ,and the technology of PR has been applied   in many fields such as artificial intelligence ，computer engineering ，nerve biology，medicine image analysis，archaeology，geologic reconnoitering，space navigation ，armament technology and so on. Detailed applications, such as below:

•Computer vision
The first vision system presented was supposing the objects with geometric shapes and optimized edges extracted from images. [26，27，28]
•Computer aided diagnosis
Medical imaging, EEG, EEG signal analysis
Designed to assist physicians, such as: X-ray mammography
Highlighting potential tambours on a mammogram
•Character recognition
Automated mail sorting, processing bank checks;
Scanner captures an image of the text;
Image is converted into constituent characters
•Speech recognition
Human computer interaction, Universal access;
Microphone records acoustic signal;
Speech signal is classified into phonemes and words
•Safety
Face recognition
Identifying fingerprints
•Astronomy:
Classifying galaxies by shape
Astronomical telescope image analysis
Automatic spectroscopy
•Bioinformatics
DNA sequences analysis
DNA micro array data analysis [29]
Research of heredity
•Agriculture
Output analysis
Soil evaluating
Extraction mineral characterization in coffee and sugar [30]
•Geography
Earthquake analysis
Rocks classification
•Engineering
Fault diagnosis for vehicle system
Recognition of automobile Type
Improve the safety performance of automobile
•Military affairs
Aviation photography analysis
Automatism Aim recognition

6. Related fields

Machine learning	Formal languages
Adaptive signal processing	Cognitive sciences
Artificial Neural networks	Biological cybernetics
Exploratory data analysis	Structural Modeling
Fuzzy and genetic systems	Mathematical statistics
Detection and estimation theory	Nonlinear optimization
Robotics and vision	Computational Neuroscience

Table 1   the related fields of PR

7. Conclusion

In its broadest sense pattern recognition is the heart of all scientific inquiry, including understanding ourselves and the real-world around us. And the developing of pattern recognition is increasing very fast, the related fields and the application of pattern recognition became wider and wider.

In this paper we expatiate pattern recognition in the round, include the definition of PR, the methods of PR, the composition of PR system, the related fields of PR and the application of pattern recognition.

In addition, it is an important trend to use pattern recognition on engineering; we should make efforts on this. And pattern recognition scientists should pay attention to new technique of PR, and enlarge the application areas of PR.

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