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Pattern recognition: Advanced development, techniques and application for Image Retrieval

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ABSTRACT. Objective of our paper is to discuss latest pattern recognition applications, techniques and development. Pattern recognition has been demanding field from many years. We are also discuss driving force behind its swift development, that is pattern recognition is used to give human recognition intelligence to machine which is soul of today's many modern application. It acts as wheel of many techniques and applications in different fields. Pattern Recognition is recognition process which recognizes a pattern using a machine or computer. It 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. The development and demand of pattern recognition technology is very fast and applications of pattern recognition are increase day by day. To fulfill this need, more and more researchers and scientists are evolved new pattern recognition techniques and apply them to many real life applications such as agriculture, robotics, biometrics, medical diagnosis, life form analysis, image processing, process control, information management systems, aerial photo interpretation, weather prediction, sensing of life on remote planets, behavior analysis, , Speech recognition, automatic diseases detection system in the infected plants, cancer detection system etc. with combination of other technology. Particular, in image retrieval system, pattern recognition play important for improving accuracy of image retrieval by using variety of recent techniques and their combination

I. INTRODUCTION

Pattern recognition is a branch of artificial intelligence which study of recognition of patterns and regularities in data. It is closely related machine learning. Pattern recognition techniques widely used in computer vision. Pattern recognition is closely related to machine learning, data mining and knowledge discovery. Pattern recognition is used in many fields, including psychology, psychiatry, ethology, cognitive science, traffic flow and computer science. In simple term, pattern is nothing but description of an object. Depending on nature of pattern, recognition divided into two types, recognition of concrete items and recognition of abstract items. When we decompose word "recognition", we get re + cognition, here, cognition means process of knowing an entity or simply the process of knowing or gaining knowledge about something or knowledge or feeling that the present particular object.

There is threefold motivation behind the swift development of pattern recognition technique as follows; first, we already know that pattern recognition is crucial part of artificial Intelligence that tries to give human intelligence to machine. Second motivation, pattern recognition has capacity to provide high quality and intelligent analysis and classification of measurements, which computer are used to solve problems in science, engineering, and real world problems. Third, pattern recognition techniques presents a unified frame work to support various area such as data mining, knowledge discovery, mathematics, psychiatry, ethologic, cognitive science and computer science.

II. PATTERN RECOGNITION FUNDAMENTALS

In this section, we discuss some fundamental components of pattern recognition, features, patterns and classifiers.

Feature

Feature is any distinctive aspect, quality or characteristic of image data. Features may be figurative like color or numeric like height. The combination of d features is represented as a d-dimensional column vector called a feature vector. The d-dimensional space defined by the feature vector is called feature space. Objects are represented as points in feature space. This representation is called a scatter plot.

Pattern

Pattern is a composite of traits or qualities or features characteristic of an individual object. In classification, a pattern is a pair of variables {x,ω} where **x** is a collection of observations or features and ω is the concept behind the observation.

Classifiers

The aim of a classifier is to partition feature space into classifier labeled decision regions as shown in fig.1. decision boundarie is border between decision region.

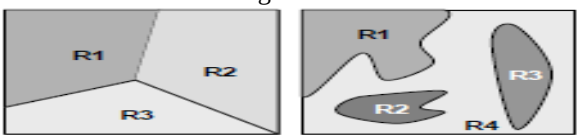

Fig.1. Decision region

III. TYPICAL PATTERN RECOGNITION SYSTEM

A typical pattern recognition system as shown in fig.2, consist of a sensor, preprocessing mechanism, feature extraction mechanism, Classification or description algorithm and a set of examples (training set) already classified or described.

1. Sensor

Sensor is a device used to sense the actual physical object and present output a usually in digital form for processing by machine. Usually, the sensor is selected from existing sensors.

2. Pre-processing

It processes the incoming, generally higher-dimensional data whose variations are reduced and produce a more consistent set of data. Noise filtering, smoothing and normalization are carried out in data preprocessing to proper and precise the image from different errors.

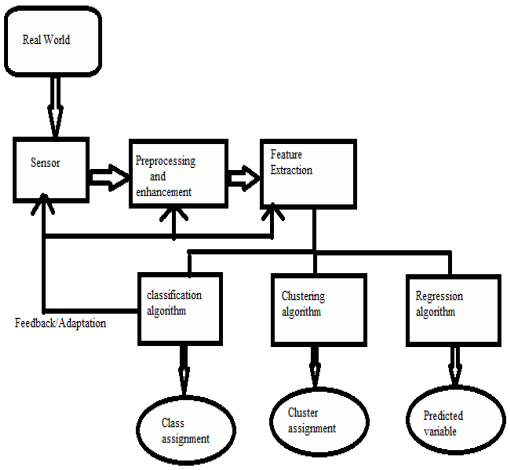

Fig. 2. Typical pattern recognition system

3. Feature Extraction

The feature extractor extracts information relevant to classification from the data input by the sensor. Usually, feature extraction is done in software which can be modified to the sensor hardware on the input side and can develop through research and development to output results highly appropriate to classification.

4. Classification

Classification is a method that present a label to an object depends on some representation of the object's properties. A classifier is a tool or algorithm which uses an object representation as input and provides a class label as output after processing. The classifier uses the features extracted from the sensed object data to assign the object to one of the m designated classes C_1, C_2, ... , C_{m-1}, $C_m = C_r$, where C_r denotes the reject class. An ideal class is a set of objects having some important common properties or by some class label and A reject class is a generic class for objects that is not part of any of the designated known classes.

There are different types of classification such as classification using the nearest mean, classification by maximum a posteriori probability, and classification using a feed-forward artificial neural network, apply according to requirement of application.

IV. BASIC STEPS IN PATTERN RECOGNITION

The basic three components in pattern recognition process are preprocessing, feature extraction, and classification. At first, depending on particular application, database is acquired; it is preprocessed in order to make it appropriate for subsequent sub-processes. After that, features are extracted from the dataset and converted into a set of feature vectors. Feature vector are supposed to be representative of the original data, such representations help in processing and statistical analysis. Then, these features are classified, to separate the data points into different classes based on application domain.

4.1 Pre processing

In pattern recognition process, image processing is first step. Image preprocessing is a advantageous stage in every pattern recognition system to improve its performance. As mention earlier, it is used to reduce variations and produce a more consistent set of data. Preprocessing consist of some noise filtering, smoothing and normalization to correct and accurate the image from different errors, such as strong variations in lighting direction and intensity.

Furthermore, preprocessing perform image segmentation could also be done in this step; it is typically used to locate objects and boundaries such as lines, curves, etc. in images. Basically, segmentation is transforming the representation of the given image into something more meaningful and easier to analyze. In some applications like diseases detection in agriculture applications, segmentation of the interesting pattern of a given image from the background is very important in order to deal with diseases.

4.2 Feature extraction

Feature extraction overcomes the problem of high dimensionality of the input set in pattern recognition. It transformed the input data into feature vector, a reduced representation set of features. Depending on application, simply the relevant information from the input data should be extracted in order to execute the desired task using this reduced representation.

Extracted Features are easily computed, vital, rotationally invariant, and insensitive to various distortions and variations in the images []. Then, most favourable features subset which achieves the highest accuracy results should be selected from the input space. There are many methods for feature extraction such as fourier transform, radon transform, Gabor wavelets transform, and Fuzzy invariant vector.

1. Fourier transform

Fourier transform analyze a signal for its frequency content. Fourier transform has rotation property, translation property. It is abolish the circular shift effect in the resultant feature domain by taking the spectrum magnitude of the Fourier coefficients and then extracted a rotation-invariant feature vector.

2. Radon transform

Radon transform is transform where a mapping from the Cartesian rectangular coordinates (x, y) to a distance and an angle, polar coordinates. Radon transform on an image f(x, y) for a given set of angles is same as computing the projection of the image along the given angles. The resulting projection is the sum of the intensities of the pixels in each direction. This transform can effectively capture the directional features in the pattern image by projecting the pattern onto different orientation slices. The radon transform can be performed in the Fourier domain [ ].

3. Gabor wavelets transform

Gabor wavelet is a wavelet-based transform which is used for feature extraction, provides the optimized resolution in both time and frequency domain for time-frequency analysis. It extracts local features for pattern recognition with optimization and it has three motivations, biological, mathematical, and empirical.

Gabor wavelets give best result in object recognition applications because its biological similarity to the human vision system. An initial parameter selection is done for given a set of Gabor wavelets, a common feature extraction approach construct a feature vector by concatenating the inner product of an image with each wavelet. The relevant Gabor wavelets are selected by boosting algorithms which select a number of very simple weak classifiers and merge them linearly into a single strong classifier.

4. Fuzzy invariant vector

After extracting an invariant feature vector is extracted, it is converting into a fuzzy invariant vector which increase discrimination and decrease the impacts of low-frequency noise. The fuzzy invariant vector is computed using fuzzy numbers. In a fuzzy-invariant vector, every harmonic of an input pattern has similar distribution. By using fuzzy membership function, the power of each harmonic for an input pattern is mapped identically into fuzzy numbers, 1 or 0 and low-frequency noise will be reduced.

4.3 Classification

The features extracted from each of the patterns in the previous stage are used by system in classification step and recognize them and associate each one to its appropriate class. Two types of learning procedure are supervised learning and unsupervised learning.

In supervised learning, the classifiers have the knowledge of each pattern category and also the criterion or metric to categorize among patterns classes. In unsupervised learning, system parameters are adapted using only the information of the input, and constrained by prespecified internal rules, it find inherent patterns in the data and determine the correct output value for new data instances. Here, we are discussed some classification methods.

1. Fuzzy ART

Adaptive Resonance Theory (ART) is compatible with the human brain in processing information. ART can learn and memorize a large number of new concepts in a manner that does not necessarily cause existing ones to be forgotten. ART classifies input vectors which resemble each other according to the stored patterns and adaptively create a new corresponding to an input pattern, if it is not similar to any existing category.

A fuzzy ART neural network is classifier, based on an unsupervised vector classifier.

2. Neural networks

Neural network is a promising and powerful tool for achieving high performance in pattern recognition which is based on biological concepts to machines to recognize patterns. Artificial neural networks is invention fo neural net, which extract physiology knowledge of human brain.

Classification is a mapping from the feature space to some set of output classes. A neural network consists of a series of different, associate unit. It is mapping device between an input set and an output set. for higher recognition rate, Multiple neural networks can be used, develop N independently trained neural networks with relevant features, and classify a given input pattern by use combination methods.

3. Markov random field

Markov random field (MRF) model is used as classifier for pattern recognition, which combines statistical and structural information. States, Only the best set of states, are used to design model the statistical information, and the relationships between states represents structural information. By using these two statistical and structural, the global likelihood energy function can be rewritten with two parts, structural information model and statistical model. The recognition process is to minimize the likelihood energy function that is the summation of the clique functions.

Neighborhood systems are used to recognize patterns or retrieving images by critical point or feature point matching. The design of neighborhood systems and cliques is based on connectedness and distance, where connectedness representing some patterns by feature points, and many feature points are not connected directly with others.

4. Support Vector Machine

The Support Vector Machine classifier can handle linearly separable data as well as non-linearly separable data using kernel functions. The kernel function such as polynomial, Gaussian radial basis function, exponential radial basis function, spline, wavelet and autocorrelation wavelet kernel, can map the training examples in input space into a feature space. Computation and memory cost in SVM training is depend on dimension of features, hence, feature extraction and selection is an essential step before the SVM classification.

5. Multi-class SVM

Multi-class SVM can be preferred as a meta-level learner. Multi-Classifier system is higher classification accuracy, based on SVM for pattern recognition. This combinational strategy classifier is based on stacked generalization which combine classifiers from different learners, having a two-level structure. a base-level structure consists of N kinds of SVM-based classifiers trained by N features set, and a meta-level structure consists of SVM-based decision classifier trained by meta-feature set that are generated through a data fusion mechanism.

V. ADVANCED TECHNIQUES AND APPLICATION DOMAIN FOR RETRIEVAL

In this section, we discuss some advanced pattern recognition application such as accurate cancer diagnosis and grading system, improved function restoration system for individuals with spinal injury, Gear stiffness degradation system, rice disease detection system etc. with advanced techniques

A novel technique for accurate cancer diagnosis and grading is developed by using structural and statistical pattern recognition methods [1]. Statistical techniques are used for tissue quantification. This effective hybrid model employs both structural and statistical pattern recognition techniques to locate and characterize the biological structures in a tissue image for tissue quantification. This hybrid model defines an attributed graph for a tissue image and a set of query graphs as a reference to the normal biological structure. It then locates key regions that are most similar to a normal biological structure by searching the query graphs over the entire tissue graph. This hybrid model quantifies the located key regions with two different types of features extracted using structural and statistical techniques. A novel myoelectric pattern recognition strategy is applied to restoration of hand function after incomplete cervical spinal cord Injury (SCI) [15]. A series of pattern recognition algorithms with different EMG feature sets and classifiers are identify the intended tasks of each SCI subject. Seven different classes are defined for high degree of accuracy indicating that substantial motor control information can be extracted from partially paralyzed muscles of SCI subjects. Such information can potentially enable volitional control of assistive devices. This method is clinical feasibility and robustness in the concept of using myoelectric pattern recognition techniques toward improved function restoration for individuals with spinal injury.

Automatic Partial discharge (PD) source classification is done by pattern recognition techniques; identify the types of defects causing discharges in high voltage equipment [2]. For designing Automatic PD source classification using pattern classification, three issues are noticed. First, issue is related to feature extraction which is handling by applying stochastic neighbor embedding, principal component analysis, and kernel principal component analysis, discrete wavelet transform, and conventional statistic operators are adopted for feature extraction. Then, second issue is related to identifying various types of PD sources which address by applying pattern recognition algorithm, such as a novel fuzzy support vector machine and a variety of artificial neural networks. For identification of multiple PD sources i.e. is third issue addressed by FSVM.

A software prototype system for rice disease detection is developed by using pattern recognition techniques. Its database consists of based on the infected images of various rice plants [4]. Images of the infected rice plants are processed using image growing, image segmentation techniques to detect infected parts of the plants. Then the infected part of the leaf has been used for the classification purpose using neural network.

Target Differentiation using Infrared Sensor is deal with pattern recognition techniques [5]. T. Aytac et.al. study performances of various statistical pattern recognition techniques for the differentiation of commonly encountered features in indoor environments, possibly with different surface properties, using simple infrared (IR) sensors. The intensity measurement depends on the location, geometry, and surface properties of the reflecting feature. They construct feature vectors based on the parameters of angular IR intensity scans from different targets to determine their geometry type. Mixture of normals classifier with three components correctly differentiates three types of geometries with different surface properties, resulting in the best performance in geometry differentiation.

Gear stiffness degradation is identified using pattern classification techniques that rely on the spectral content of the vibration induced during the operation of the gearbox[6]. This identification system use k-nearest-neighbor algorithm, as well as a novel neural network classifier. The classification process classifies early signs of stiffness degradation. For better and perfect identification, selection of features and clear understanding of the disparity among them is very important with noise attenuation.

Condition monitoring applications are proposed using pattern recognition techniques and impact acoustic techniques on data generated by acoustic emission [9]. In this application, a pattern recognition approach is taken to automate such intuitive human skills for the development of more robust and reliable testing methods. This approach is use in the rail inspection area, within the domain of intelligent transport systems.

Data from impact acoustic tests was made on wooden beams. Features such as magnitude of the signal, natural logarithm of the magnitude and Mel-frequency cepstral coefficients, were extracted from the acoustic emissions of wooden beams used for pattern classification. Then, the extracted feature vectors were used as input to various pattern classifiers such as vector machines and multi-layer perceptron for further pattern recognition task. Experimental result shows that support vector machines provide good detection rates for the classification of impact acoustic signals in the NDT domain.

A circuit power estimation system is proposed using pattern recognition technique [8]. This system utilized Bayesian inference and neural networks used for feature extraction of circuit leakage power and switching. Depending on statistical distribution of circuit leakage power and switching energy, the entire state and transition space of a circuit are classified using neural networks into a limited few classes of different power consumption average values. This technique enables efficient table-lookup of circuit power of the entire state and transition space.

Analyzing differences in handwriting was done by using pattern recognition techniques and computer algorithms for extracting features from scanned images of handwriting [9]. They use handwriting samples of one thousand five hundred individuals, representative of the US population with respect to gender age, ethnic groups, etc. Attributes characteristic of the handwriting were obtained, e.g., line separation, slant, character shapes, etc. These attributes were used to quantitatively establish individuality by using machine learning approaches. Using global attributes of handwriting and very few characters in the writing, the ability to determine the writer with a high degree of confidence was established.

VI. CONCLUSIONS

In this paper, we tries to elaborate all side of pattern recognition in simple language, including the fundamental, component, methodology along with recent techniques and application of pattern recognition. Research on pattern recognition is increasing very swift, the related fields and the applications of pattern recognition have become wider and wider as mention earlier. It appears in various fields like computer vision, agriculture,

robotics, biometrics, automatic detection of diseases in the infected plants.

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