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Image Classification Techniques- A Survey

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Abstract

Image classification is the most important process in pattern recognition. In general, this is a final stage of pattern matching. The classification process described the percentage of accuracy in pattern recognition. Feature extraction is another vital stage in pattern matching. These extracted feature are used for classification of the image database, that is pattern matching. The various researchers used different classification techniques for different application,support vector machine used for character recognition. Neural Network Techniques are used for Artificial Intelligent application and soft computing. These paper deals with the study of different classification techniques used for image classification.

Keywords: Classification, Pattern recognition, Support Vector Machine, Neural Network.

1. INTRODUCTION

Image classification is one of the most complex areas in image processing.A machine learning technique is used to assign class label to set of unclassified data. In the classification techniques there are two types of classification techniques, namely Supervised Classification and Unsupervised Classification. In supervised classification, the set of classes is known in advance. However, in unsupervised classification, the set of possible classes are not known. Classification of data can be performed using various methods. An algorithm used to implement classification is known as a classifier. In some cases,“classifier” also refers to a mathematical function, implemented by a classification algorithm to map input data to a particular class. Statistical methods and neural network based methods of classification are discussed in this paper. Image classification systems are based on the one or more methods. One has tofollow proper method to select training dataset by identifying appropriate informational class [1].

2. TECHNIQUES USED FOR IMAGE CLASSIFICATION

The image classification techniques can be broadly classified as Statistical Classification Techniques and Neural Network BasedMethods of ClassificationTechniques.

2.1. Statistical Classification Techniques.

The statistical technique has been most intensively studied and used in practice. Statistics is the study of the collection, organization, analysis, and interpretationof data[2]. Aneural network techniques andmethods imported from statistical learning theory have been receiving increasing attention. The design of a recognition system requires careful attention to the following issues: definition of pattern classes, sensing environment, pattern representation, feature extraction and selection, cluster analysis, classifier design and learning, selection of training and test samples, and performance evaluation. Statistical classifiers are rooted in the Bays’ decision rule and can be divided into parametric ones and non parametric ones. Parametric classifier includes the linear discriminate function (LDF), the quadratic discriminate function (QDF), the Gaussian mixture classifier, etc. An improvement to QDF, named regularized discriminate analysis (RDA), was shown to be effective to overcome inadequate sample size and stabilized the performance of QDF by smoothing the covariance matrices. The modified quadratic discriminate function (MQDF) proposed by Kimura et al. was shown to improve the accuracy, memory, and computation, efficiency of the QDF. The directions are sampled down using Gaussian filter to get 392 dimensional feature-vectors. This feature vector is applied on MQDF classifier. The invariant moments are well known to be invariant under translation, scaling, rotation and reflection [3]. They are measures of the pixel distribution around the Centre of gravity of the character and allow capturing the global character shape information. Traditionally, moment invariants are computed based on the information provided by both the shape boundary and its interior region. The moments used to construct the moment invariants are defined in the continuous but for practical implementation. It is computed in the discrete form [4]. The classifiers under Statistical methods are Bayesian classifier, linear classifiers, Logistic regression, Naïve Byes classifier, Quadratic classifiers, k-nearest neighbor method. Statistical approaches are generally characterized by having a probability model, which provides a probability of being in each class rather than simply a classification. In addition, some human intervention is assumed with regard to variable selection and transformation. One major limitation of the statistical models is that they work well only when the assumptions involved is satisfied. Hence, users must have a good knowledge of both data properties and model capabilities before the models can be successfully applied [1]

2.1.1. Quadratic Discriminate

Quadratic discrimination is similar to linear discrimination, but the boundary between twodiscrimination regions is now allowed to be a quadratic surface. When the assumptionof equal covariance matrices is dropped, then in the maximum likelihood argument withnormal distributions a quadratic surface (for example, ellipsoid, hyperboloid, etc.) isobtained. This type of discrimination can deal with classifications where the set of attributevalues for one class to some extent surrounds that for another. Clarke et al. (1979) findthat the quadratic discriminate procedure is robust to small departures from normalityand that heavy kurtosis (heavier tailed distributions than Gaussian) does not substaticallyreduce accuracy. However, the number of parameters to be estimated becomes,and the difference between the variances would need to be considerable to justifythe use of this method, especially for small or moderate sized datasets (Marks & Dunn, 1974).Occasionally, differences in the covariance are of scale only and some simplification mayoccur (Kendall et al., 1983). Linear discriminate is thought to bestill effective if thedeparture from equality of covariance is small (Gilbert, 1969). Some aspects of quadraticdependence may be included in the linear or logistic form (see below) by adjoining newattributes that are quadratic functions of the given attributes. For example: The quadratic discriminate starts by constructing, for each sample, an ellipse center onthecenter of gravity of the points. In Figure 3.1 it is clear that the distributions are ofdifferent shape and spread, with the distribution of '2's being roughly circular in shapeand the '1's being more elliptical. The line of equal likelihood is now itself an ellipse (in general a conic section) as shown in the Figure. All points within the ellipse are classified[5].

2.2. Neural Network Based Methods of Classification

Image classification is an important task for many aspects of global change studies and environmental applications. Several classification algorithms have been developed from maximum likelihood classifier to neural network classifiers. This studyemphasizes on the analysis and usage of different advanced classification techniques like Artificial Neural Networks, Support Vector Machines, Fuzzy Measures, Genetic algorithms and their combination for digital image classification. Finally the study depicts the comparative analysis of different classification techniques with respect to several parameters. [6] A neural network model which is the branch of artificial intelligence is generally referred to as artificial neural networks (ANNs). ANN teaches the system to execute task, instead ofprogramming computational system to do definite tasks. To perform such tasks, ArtificialIntelligence System (AI) is generated. It is a pragmatic model which can quickly and preciselyfind the patterns buried in data that replicate useful knowledge. One case of these AI models isneural networks. AI systems should discover from data on a constant basis. In the areas ofmedical diagnosis relationships with dissimilar data, the most available techniques are theArtificial Intelligence techniques.An artificial neural network is made up of many artificial neurons which are correlated together in accordance with explicit network architecture. The objective of the neural network is to convert the inputs into significant outputs.The teaching mode can be supervised or unsupervised. Neural Networks learn in the presence of noise[7].

2.2.1. Artificial Neural Networks

ANN is a type of artificial intelligence that limits somefunctions of theperson mind. ANN has a normal tendency for storingexperiential knowledge.An ANN consistsof a sequence oflayer;each layerconsists of a set of neurons. All neurons of every layer are linked by weighted connections to all neurons on the preceding and succeeding layers [2]. ANN is a computational model inspired by the biological neural network. It could be considered as a weighted directed graph in which nodes are neurons and edges with weights are connection among the neurons. Each artificial neuron computes a weighted sum of its input signals and generates an output, based on certain activation functions, such as piecewise linear, sigmoid, Gaussian, etc. It consists of one input layer, one output layer, and depending on the application it may or may not have hidden layers. The number of nodes at the output layer is equal to the number of information classes, whereas the number of nodes at the input is equal to the dimensionality of each pixel. Feed-forward ANN with the back propagation learning algorithm is most commonly used in ANN literature. In the learning phase, the network must learn the connection weights iteratively from a set of training samples. The network gives an output, corresponding to each input. The generated output is compared to the desired output. The error between these two is used to modify the weights of the ANN. The figure 1 shows the architecture of artificial neural network. The training procedure ends when the error becomes less than a predefined threshold. Then, all the testing data are fed into the classifier to perform the classification. [5]

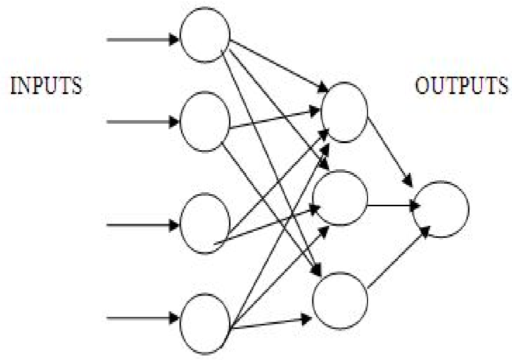

Fig. 1: Artificial Neural Network

2.2.2 Support Vector Machine

A support vector machine builds a hyper plane or set of hyper planes in a high- or infinite dimensional space, used for classification. Good separation is achieved by the hyper plane that has the largest distance to the nearest training data point of any class (functional margin), generally larger the margin lower the generalization error of the classifier [2].Support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns,used for classification and regression analysis[9]. The method is presented with a set of labeled data instances and the SVM training algorithm aims to find a hyper plane that separates the dataset into a discrete predefined number of classes in a fashion consistent with the training examples. The term optimal separation hyper plane is used to refer to the decision boundary that minimizes misclassifications, acquired in the training phase. Learning means to the iterative process of finding a classifier with optimal decision boundary to separate the training patterns (in potentially high-dimensional space) and then to separate simulation data under the same configurations(dimensions)[10]. Support vector machine (SVM) is a learning machine that seeks the best compromise between the complexities of the model and learning ability according to the limited sample information, it is suitable for the machine learning in small samples circumstances, and overcomes the insufficient problem of typical negative type data. Various fuzzy set theories have been used to deal with fuzzy classification problems in remote sensing and image processing as well as land-cover classification[11, 12]. The SVM algorithm provides a choice of four kernel types: (i) Linear, (ii) Polynomial, (iii) Radial Basis Function, and (iv) Sigmoid,

2.2.2.1Kernel Functions

The following theory is based upon Reproducing Kernel Hilbert Spaces (RKHS) (Aronszajn, 1950; Girosi, 1997; Heckman, 1997; Wahba, 1990). An inner product in feature space has an equivalent kernel in input space,

$$K(x, x') = < \phi(x), \phi(x') >,$$

Provided certain conditions hold. If K is a symmetric positive definite function, which satisfies Mercer's Conditions,

$$K(x, x') = \sum_{m}^{\infty} a_m \phi m(x) \phi m(x'), a_m \geq 0$$

$$\iint K(x, x') g(x) g(x') dx dx > 0, g \in L_2,$$

Then the kernel represents a legitimate inner product in feature space. Valid functions that satisfy Mercer's conditions are now given, which unless stated are valid for all real x and x0.

2.2.2.1.1 Polynomial

A polynomial mapping is a popular method for non-linear modeling,

$$K(x, x') = (x, x')^d.$$

$$K(x, x') = (< x, x' > +1)^d$$

The second kernel is usually preferable as it avoids problems with the hessian becoming zero.

2.2.2.1.2 Radial Basis Function

Radial basis functions have received significant attention, most commonly with a Gaussian of the form,

$$K(x, x') = \exp (\| x - x' \|^2)$$

Classical techniques utilizing radial basis functions employ some method of determining a subset of centers. Typically a method of clustering is first employed to select a subset of centers. An attractive feature of the SVM is that this selection is implicit, with each support vectors contributing one local Gaussian function, centered at that data point. By further considerations it is possible to select the global basis function width, s, using the SRM principle. [16]

2.2.3. Fuzzy Measure

In traditional classification methods such as minimum distance method, each pixel or each segment in the image will have an attribute equal to 1 or 0 expressing whether the pixel or segment belongs to a certain class or not, respectively. In fuzzy classification, instead of a binary decision-making, the possibility of each pixel/segment belonging to a specific class is considered, which is defined using membership functions. A membership function offers membership degree values ranging from 0 to 1, where 1 means fully belonging to the class and 0 means not belonging to the class. Implementing fuzzy logic ensures that the borders are not crisp thresholds any more, but membership functions within which each parameter value will have a specific probability to be assigned to a specific class are used. Appending more parameters to this classification, for example, using NIR ratio and NDVI for vegetation classification, better results will be achieved. Using fuzzy logic, classification accuracy is less sensitive to the thresholds [12]. The figure 2 shows architecture of fuzzy logic.

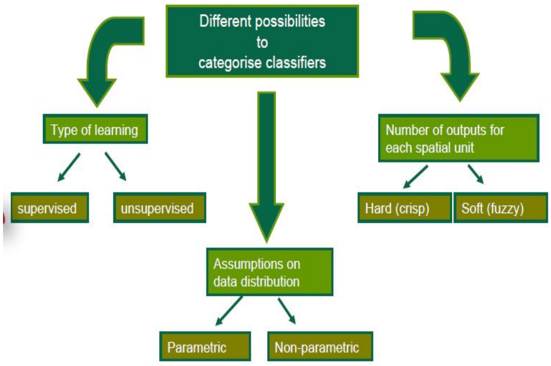

Fig.2: Architecture of Fuzzy Logic

A.Parametric classifier:

The parameters like mean vector and covariance matrix are used. There is an assumption of Gaussian distribution. The parameters like mean vector and covariance matrix are frequently generated from training samples. Example: Maximum likelihood, linear discriminate analysis.

B. Non Parametric classifier

There is no assumption about the data. Non-parametric classifiers do not make use of statistical parameters to calculate class separation. Example: Artificial neural network, support vector machine, decision tree classifier, expert system. [2]

3. CONCLUSION

In this paper we discussed different Image Classification Techniques.Some of the most commonly used techniques are discussed here. We also described supervised and unsupervised classification techniques. Some important approaches such as Parametric and Nonparametric are also useful to categories the images.

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