MULTICLASS OBJECT CLASSIFICATION USING NEURAL NETWORK BASED ON WAVELET TRANSFORM

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ABSTRACT

This paper presents a method for object classification based on wavelet features. The object to be classified is first decomposed with wavelet transform. To reduce the computational cost and improve the efficiency the feature set generated by discrete wavelet transform (DWT) is reduce by the application of principal component analysis (PCA). The feature set is processed by neural network classifier to classify it into one of the given classes. The proposed methodology is evaluated using a dataset having five different types of objects. The results demonstrated that proposed methodology has yielded an accuracy of up to 95%. We used two different types of neural network classifiers: backpropagation and radial basis function (RBF). The results demonstrated that backpropagation neural network classifier has performed better than the RBF neural network.

Keywords: Classification, DWT, PCA, neural network.

I. INTRODUCTION

Multiclass object classification is one of the major problems in image processing. Object classification helps in information retrieving by dividing the image into the sub images. The classification processes may include preprocessing, feature extraction, selection of training process, selection of suitable and sufficient number of training samples and accuracy assessment. The multiclass object classification is the set of features, which extracted from the images and processed with neural network. A feature which display some image property numerically. It decreases the size of the dimension of the sample space by extracting the most differentiating information. Discrete Wavelet Transform (DWT) [1]-[4] may reduce the size of feature space. There are two types of classifier: Supervised and Unsupervised. In supervised classification, user is needed to collect the data samples and these data samples are broken into training sample and testing sample. The classification system is trained using training samples. The accuracy of results depends upon how the class of object is determined accurately.

In this paper, supervised classification has been preferred as usually supervised schemes give better results than unsupervised approaches. The rest of the paper is organized as follows. The Section II provides the details of feature extraction, Section III briefly describes the neural network classifier, the proposed methodology is given in Section IV, experimental results are provided in Section V, and finally Section VI concludes the work.

II. FEATURE EXTRACTION

Feature extraction is an important preprocessing step in image classification. Sometimes a large number of features are produced by feature extraction technique and therefore a feature selection scheme is also required to select important features and discarding the rest to improve the accuracy and reducing computation cost. In this work we used DWT for feature extraction and PCA [6] for selecting important features. Both these techniques are briefly described here.

i.) *DWT:* The DWT is one of the most popular technique, which adopted in multiclass object classification. Wavelet transform decomposes a signal into a setoff basis functions. These basic functions are called as wavelets. An image is decomposed into four components LL, LH, HH, HL on applying level one 2-D DWT. LH, HL, and HH are the finest scale horizontal, vertical, and diagonal wavelet coefficients of the image respectively while LL is the approximate image. The DWT is implemented by applying a series of filters. Fig. 1 [2] depicts that input image is filtered through low pass and high pass analysis filters respectively. The output is sub sampled by a factor of 2. The analysis and synthesis process results in the decomposition of the signal into low and high frequency bands.

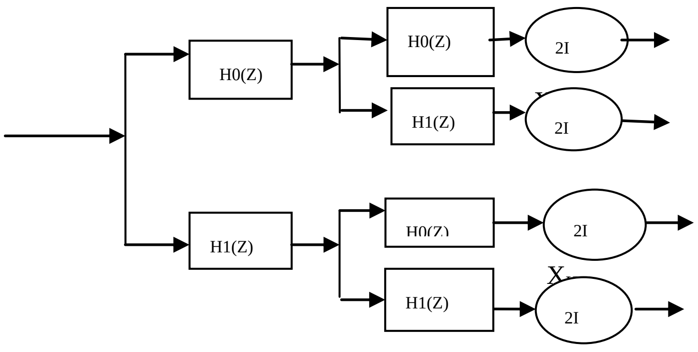

Fig. 1: Wavelet Decomposition of an Image

ii.) *PCA: The* PCA is a widely used statistical techniques used in the signal processing for the information reduction. PCA supports the eigenvector properties for the determination of selected object orientation. The task of feature extraction is to extract most relevant information from the original data and represent it in lower dimensionality space. Extraction of important features is a critical part of the image classification process. The image features can be divided into four categories [5] visual features, statistical features, algebraic features, and transform coefficient features. Visual features include edges, contours, texture etc. Histogram is an example of statistical image features. The algebraic features represent the intrinsic attributes of the image. Principle component analysis (PCA) which is based on Kohenen Leave (KL) transformation is most widely recognized method for algebraic feature extraction. The objective of PCA is to reduce dimensionality preserving the randomness as much as possible [8]. This procedure provides a set of eigenvalues and eigenvectors. Only a few eigenvalues are able to represent the most important characteristics of the image. The PCA approach is widely recognized and used for feature extraction. However if image is large the size of data vector is large and covariance matrix becomes very large making it unfeasible the computation of eigenvectors and Eigen values.

III. NEURAL NETWORKS

In this work the classification is performed using neural network classifier. We used two different type neural networks [7], [8] described as follows.

i.) Backpropagation Neural Network: Back propagation neural network [9] was introduced in 1970 by David Rumelhart, Geoffrey and Ronal Williams. BP neural network now became a solution for different types of problems in many fields. It is inspired by biological neural networks. Back Propagation Neural Network is a multilayered feed forward network trained according to the error [10]. Back Propagation Neural Network can be used to learn and it makes a great deal of mapping relation of input and output model. A neuron has three basic elements. A set of synapses or connecting links each of which is characterized by a weight. It has an adder which performs the weighted sum of the input signals. The third element is the activation function for limiting the amplitude of the output neuron. The backpropagation algorithm uses gradient descent method to minimize the error in weight space.

ii.) RBF Neural Network: A Radial Basis Function (RBF) neural network has an input layer, a hidden layer and an output layer. The neurons in the hidden layer contain Gaussian transfer functions whose outputs are inversely proportional to the distance from the centre of the neuron [9]. For each predictor variable, it consists of one neuron in input layer. Input neuron exists the range of neuron values given by the median. After that input neurons enter the values to each neuron in hidden layer. A set functions given by the hidden layer constitute for input patterns on arbitrary basis. The hidden layers are also called as radial centers and it represented by a vector. The conversion from input space to hidden space is non linear, where as conversion from hidden space to output space is linear. The value provided by the neurons of the hidden layer is multiplied by the weights ($W_1, W_2, \ldots\ldots W_n$) along with the neurons and passed to the summation layer that adds the value of weight and output neuron.

IV. PROPOSED METHODOLOGY

An image classifier using artificial neural network has been developed. The implemented method can automatically detect objects in the given image. The method is tested for the images containing the single object only. Firstly the input image is smoothed to remove the noise contents in it. After smoothing operation the image is decomposed in subband images by applying DWT. The feature vector obtained so is fed to neural network to perform the face recognition. The detailed methodology is given as follows.

i.) Convert the input image to gray scale image
ii.) Normalize the size of the image
iii.) Apply Gaussian filter to smoothen the image to reduce the noise contents in images.
iv.) Apply 2-D DWT to decompose the image into subband images.
v.) Now obtain features from the decomposed images. To extract the most relevant features, PCA is used.
vi.) The features obtained from the images are arranged in a vector called feature vector.
vii.) The feature vector is used as input to artificial neural network.
viii.) Create an artificial neural network with input neurons as per the size of the feature vector.
ix.) The number of neurons in input layer is equal to the number of elements in the feature vector. The number of neurons in the output layer is equal to the number of classes of the objects.

x.) Train the ANN using the training samples.

xi.) When training is over, the system is ready to perform classification. Now test samples are used to evaluate the performance of the ANN based classifier.

V. EXPERIMENTAL RESULTS

The experiments are performed on a dataset consisting of images of five different objects like aero planes, Motorbikes, Cars, Human Faces and Guitars. Out of the available images of each object are used for the training of the network and rest are used for the testing and experimenting process. Some of the images of each object are shown in these figures.

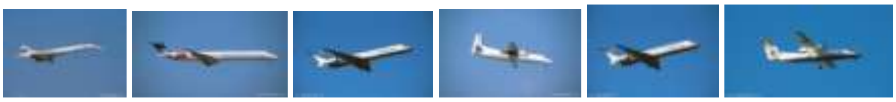

Fig. 2: Airplane dataset

Fig. 3: Motorbike dataset

Fig. 4: Car Dataset

Fig. 5: Guitar Dataset

Fig. 6: Human Face Dataset

The experimental results are derived using the confusion matrix [12]. The proposed object classification technique has been tested on a dataset created that consists of five objects: Airplane, Motorbike, Car, Face, and Guitar. Confusion matrix for the proposed method as obtained by backpropagation neural network is given in Table 1. The accuracy is measured in terms of overall accuracy (OA) and class wise accuracy (CA). It is observed from the results that OA of 91.7% is achieved. Considering class wise accuracy best results was obtained for object “Bike”. The accuracy for object “Face” is not found good as it is less than 85%.

Table 1: Confusion matrix (back propagation)

	Airplane	Bike	Car	Face	Guitar	OA (%)
Airplane	45	0	4	1	0	91.7
Bike	0	47	0	1	2	
Car	1	1	44	0	0	
Face	0	0	0	40	2	
Guitar	2	0	0	6	44	
CA (%)	93.7	97.9	91.7	83.3	91.7	

The confusion matrix for RBF neural network is given in Table 2. The performance of RBF is lower than back propagation neural network. The OA is 87.5%. Similar to previous experiment the best accuracy was achieved for object “Bike” and lowest accuracy was noted for object “Face”. For object “Guitar” comparable results were obtained in the two experiments.

Table 2: Confusion Matrix (RBF)

	Airplane	Bike	Car	Face	Guitar	OA (%)
Airplane	40	1	3	1	0	87.5
Bike	0	46	2	0	0	
Car	2	1	42	2	0	
Face	3	0	0	38	4	
Guitar	3	0	3	7	44	
CA (%)	83.3	95.8	87.5	79.2	91.7	

VI. CONCLUSION

This paper presented a multiclass object classification method based on wavelet features. The proposed method was evaluated for a database containing five different objects using two different types of neural network classifiers. The proposed method produced good accuracy under the tested scenario. The back propagation neural network produced better results than RBF neural network with OA of 91.7% compared to 87.5%.

REFERENCES

[1] X. Wu, and W. Sun, Secretimage sharing scheme with authentication and remedy abilities based on cellular automata and discrete wavelet transform, The Journal of Systems and Software, 86, 2013, 1068–1088.

[2] E. Kofidis1, N. Kolokotronis, A. Vassilarakou, S. Theodoridis, and D. Cavouras, Wavelet-based medical image compression, Future Generation Computer Systems, 15, 1999, 223–243.

[3] W. Zoo, Image Classification Using Wavelet Coefficients in Low-pass Bands, Proc. of International Joint Conference on Neural Networks, Orlando, USA, 2007,12-17.

[4] N. G. Chitaliya, and A. I. Trivedi, Feature Extraction using Wavelet-PCA and Neural network for application of Object Classification & Face Recognition, Proc. IEEE Second International Conference on Computer Engineering and Applications, 2010, 510-514.

[5] Z.-Q. Hong, Algebraic feature extraction of image for recognition, Pattern Recognition, 24(3), 1991, 211-219.

[6] I. Jolliffe, Principal Component Analysis (New York, NY, USA: Springer-Verlag, 2002).

[7] M. Khare, A. K. Singh, R. K. Srivastava, and A. Khare, An Approach towards Wavelet transform based Multiclass object classification, Proc. Contemporary Computing (IC3), 2013, 365-368.

[8] Q. Liu, G. Wu, J. Chen, and G. Zhou, Interpretation Artificial Neural Network in Remote Sensing Image Classification, Proc. International Conference on Remote Sensing, Environment and Transportation Engineering (RSETE), 2012, 365-368.

[9] Z. Caiqing, Q. Ruonan, and Q. Zhiwen, Comparing BP and RBF Neural Network for Forecasting the Resident Consumer Level by MATLAB, Proc. International Conference on Computer and Electrical Engineering, 2012, 169-172.

[10] T. Xie, H.Yu, and B. Wilamowski, Comparison between Traditional Neural Networks and Radial Basis Function Networks, Proc. International Symposium on Industrial Electronics (ISIE), 2011, 1194-1199.

[11] O. Javed, and M. Shah, Tracking and object classification for automated surveillance, Proc. IEEE European Conference on Computer Vision, 2002, 343-357.

[12] M. Farzem, and S. Shirani, A robust multimedia water marking technique using Zernike transform, Proc. Fourth IEEE workshop on Multimedia Signal Processing, 2001, 529-534.