Mallats Wavelet Transform for Human Face Recognition Using Artificial Neural Network

[1]Priti D.Neulkar, [2]Kanchan Dhote
[1]Student of Mtech, [2]Proffessor of Mtech
[1]Electronics and Communication, Electronics and Communication
[1]Tulsiramji Gaiakwad-Patil College of Engineering and Technology, Nagpur, India

***Abstract*— This paper represents face recognition using Mallets Wavelet Transform and Artificial Neural Network. Various methods are implemented for the face recognition system since many years. Improving efficiency and creating a robust face recognition system is the main aim of implementing new single method or combination of methods. This paper represents hybrid method where Artificial Neural Networks (ANN) classifiers is combined with Mallets Wavelet Transform. Developing face recognition includes three stages image acquisition and preprocessing, feature extraction and classification. In the proposed method Mallats Wavelet Transform is implemented for feature extraction method and Artificial Neural Network for classification. ANN is better classifier as compared with other since it can be taught to take decisions as humans can take. It also adapt better with the changes in environment. ANN is also efficient as compared to the other classifiers.**

***keywords* — Hybrid approach for face recognition, Mallets Wavelet Transform, Energy Calculation ,Artificial neural network, Feature extraction, classification**

I. INTRODUCTION

Face Recognition system is one of the biometric among iris recognition, finger recognition, hand recognition, DNA recognition. Advantage of face recognition system is recognition can be done without the consent of the person and without any physical contact of the person. Intensive work is continuously going on in the field of Face Recognition to improve various key factors of it such as efficiency, fault tolerance, robustness, response to the changing background environment etc. It plays an important role in the authentication applications and identification applications. The main important factor to develop any face recognition system is to develop a system which can identify a person as good as a human can recognize even in the case of any facial change for example grown beard, changed hair cut, marks on face etc. Thus various methods are implemented for face recognition to observe and obtain the required output.

Many methods have been proposed for face recognition. Most of these methods are using Artificial Neural Networks (ANN) classifiers approaches combined with appropriate feature extraction for recognition of human faces. ANN is best among the various other methods for classification such as K Nearest Neighbors, Support Vector machines (SVM).ANN is better for the classification since it can take the decisions as the humans can take. It includes training and testing the network. We can train the ANN to reach to the maximum efficiency for face recognition. Rather than working as a mathematical fact it can be made to work for taking logical decisions as humans. It is also better in the terms of fault tolerance, efficiency and robustness.

The principle aim of this project is implement alternative methods to be used for face recognition by using wavelet transform and using wavelets. In this paper wavelet transform is used for the image decomposition which is part of the pre-processing and feature extraction. By decomposing an image using wavelet transform, the resolution of the sub images are reduced. The operating of lower resolution image, make it possible to reduce the computational complexity dramatically.

II. OVERVIEW OF PROBLEM STATEMENT

Some factors needs to be considered while implementing a face recognition system which are not so important in other biometrics used for authentication or recognition. The factors which need to be considered are hair cut, makeup, facial expression while implementing the face recognition system. The recognition system basically divided into three sub parts which are image acquisition and pre- processing, feature extraction and classification[1]. The methods that we have implemented for face recognition are Mallets Wavelet Transform for feature extraction and Artificial Neural Network for classification.

Some of the features extraction methods are Principal component analysis (PCA), Linear Discriminant Analysis (LDA), Wavelet transform etc. In the PCA method faces are represented by a linear combination of weighted eigenvectors, known as eigenfaces. In practice, there are several disadvantages in PCA-based methods. PCA-based methods has lack of discrimination ability and it retains unwanted features because of considering across training samples. [1]The LDA requires two training samples to calculate scatter matrix. The discriminability of PCA can be improved by adding Linear Discriminant Analysis (LDA)[13]. But, to get a precise result, a large number of samples for each class is required. Also the eigenvectors with large eigenvalues are not the best for distinguishing face images. The disadvantage in this is that PCA-based method takes high computational load in finding the eigenvectors.[13] Thus, we proposed a new approach of using Wavelet Transform for feature extraction along with artificial neural network to observe its performance for face recognition.

III. IMAGE ACQUISITION AND ANALYSIS SECTION

This proposed system implements a human-face recognition system using Wavelet transform and Artificial neural network. The principle aim of this research project is to implement alternative methods for face recognition, particularly by using Mallets Wavelet Transform and artificial Neural Network the use of wavelets.

Methodology

The face recognition system is subdivided into three sections which are as follows

- The Image Acquisition and Analysis Section
- The Feature Extraction Section
- The Neural Network Classifier

Facial images of the humans which are required to be recognized later are taken. The facial images should be head posed. The facial image which is to be recognized is subjected for preprocessing and face detection steps. Following are the steps for the face detection of the image needs to be recognized.

A. Image acquisition

Human image which needs to be verified and recognize is taken from a high resolution digital camera. This image is verified against the database of the images of the humans/persons already trained to the face recognizition system. The images should be head posed, should be taken in good surrounding light and should have clear resolution.

B. Image Enhancement

The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for a specific application. In the proposed system fuzzy image enhancement is implemented. Fuzzy image enhancement is based on gray level mapping into fuzzy plane, using a membership transformation function. The aim is to generate an image of higher contrast than the original image by giving a large weight to gray levels that are closer to the mean gray level of image than to those that are further from the mean. An image I of size M x N and L gray level scan be considered as an array of fuzzy singletons, each having a value of membership denoting its degree of brightness relative to some brightness levels. The technique used for image enhancement is Using Fuzzy Sets for Intensity Transformation. This technique is used for the contrast enhancement.

It follows some set of rules such as

IF a pixel is dark, THEN make it *darker*.
IF a pixel is gray, THEN make it *gray*.
IF a pixel is bright, THEN make it brighter.

C. Image Segmentation

Segmentation involves separating an image into regions (or their contours) corresponding to objects. The simplest property that pixels in a region can share is intensity. So, a natural way to segment such regions is through thresholding, the separation of light and dark regions. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero If g(x, y) is a thresholded version of f (x, y) at some global threshold T. g is equal to 1 if f x(, y) ≥ T and zero otherwise. o and all pixels about that threshold to one.

Thresholding is the simplest segmentation method.The pixels are partitioned depending on their intensity value. The proposed method used for image segmentation is Global thresholding, using an appropriate threshold T:

g(x, y) = 1, if f (x, y) > T
0, if f (x, y) ≤ T

Peaks and valleys of the image histogram can help in choosing the appropriate value for the threshold(s).

In the proposed system image segmentation is done by using thresholding. Suppose that the gray-level histogram corresponds to an image f(x,y) composed of dark objects on the light background, in such a way that object and background pixels have gray levels grouped into two dominant modes. One obvious way to extract the objects from the background is to select a threshold 'T' that separates these modes. Then any point (x,y) for which f(x,y) < T is called an object point, otherwise, the point is called a background point.

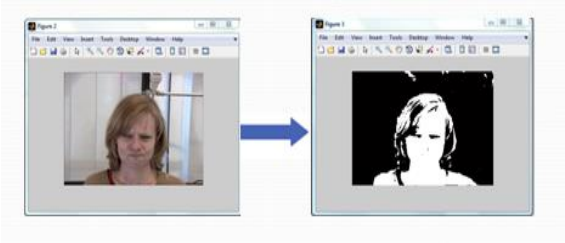

Figure.1: Image segmentation output of enhanced image

D. Face Detection

The properties of image region such as 'Area', 'BoundingBox', 'Centroid', 'FilledArea' etc are used for the face detection of the segmented image With the help of *BoundingBox* property the small rectangle for the face region in the binary image is traced.

With the help of above specified properties boundries of face of an image can be detected. Various tools used for the face detection system provides functions for face detection using above specified properties.

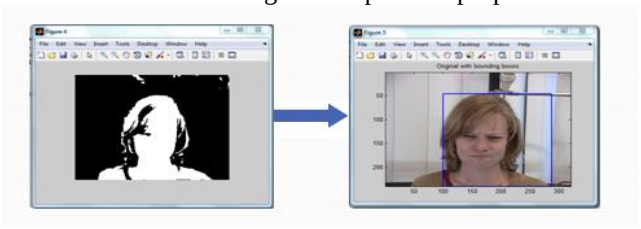

Figure.2: Face Detection

IV. IMAGE ACQUISITION AND ANALYSIS SECTION

Wavelet Transform (WT) is an important method for image analysis. By using the wavelet decomposition the resolution of the sub images can be reduced. It also reduces the computational overhead. In the proposed system, Mallet WT is chosen to be used in image decomposition which is called as wavelet decomposition

A. Mallet Tree Decomposition

The DWT is computed by successive lowpass and highpass filtering of the discrete time-domain signal This is called the Mallat algorithm or Mallat-tree decomposition. The Mallat algorithm for discrete wavelet transform (DWT) is, in fact, a classical scheme in the signal processing community, known as a two-channel subband coder using conjugate quadrature filters or quadrature mirror filters (QMFs). The decomposition algorithm starts with signal *s*, next calculates the coordinates of A_1 and D_1, and then those of A_2 and D_2, and so on. The reconstruction algorithm called the inverse discrete wavelet transform (IDWT) starts from the coordinates of A_J and D_J, next calculates the coordinates of A_{J-1}, and then using the coordinates of A_{J-1} and D_{J-1} calculates those of A_{J-2}, and so on.

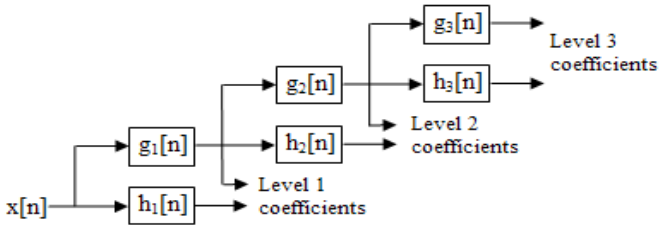

Figure 3: Three Level Wavelet Decomposition Tree.

B. Wavelet Energy Calculation

The user selects a wavelet function from a given set of functions. The selected function is assigned with an identifier for global use. A new class of objects using the selected function are created and displayed. The gray scale version of selected image is subjected to decomposition operation. The book keeping matrix gives the size of approximation coefficients and detail coefficients. By using the decomposition vector as input, energy levels corresponding to approximation and details coefficients are computed.

In the proposed system wavelet energy of 2D wavelet decomposition is calculated. For a two-dimensional wavelet decomposition wavelet energy calculation returns `Ea`, which is the percentage of energy corresponding to the approximation, and vectors Eh, Ev, Ed, which contain the percentages of energy corresponding to the horizontal, vertical, and diagonal details, respectively

For the proposed Face Recognition System 10 images of different persons are captured using high quality digital camera. In the feature extraction section for the unique identification wavelet energy decomposition coefficients are calculated. Figure 4 shows energy calculation of some of the images in the database. The wavelet decomposition of the image is carried out by using the Mallats wavelet decomposition.In the Mallats wavelet decomposition wavelet energy calculation is implemented. These coefficients are unique for each person which uniquely identifies the person.

Table 1: Energy details of some of the images in the database

Input Image	Edetail Value

	EDetail = 0.0588
	EDetail = 0.020324
	EDetail = 0.035323
	EDetail = 0.046452
	EDetail = 0.17339

V. THE NEURAL NETWORK CLASSIFIER

A. Training of Neural Network

Neural networks can be trained for the face recognition. For training the neural network the feature extraction details/coefficients are given as a input data to the neural network. In the proposed system database of the images contains ten images of the persons.Thus, Neural Network basically consists of following stages:

1. Training of neural network
2. Testing of neural network[12]

1. Training of neural network: In the feature extraction section unique coefficients are calculated for each image which is fed to neural network. The neural network is trained with the data of ten images. Table 1 shows the some of the images and its unique energy details value. The feed forward neural neural network is implemented for the proposed system. Feedforward networks consist of a series of layers. The first layer has a connection from the network input. Each subsequent layer has a connection from the previous layer. The final layer produces the network's output. Feedforward networks can be used for any kind of input to output mapping. A feedforward network with one hidden layer and enough neurons in the hidden layers, can fit any finite input-output mapping problem.

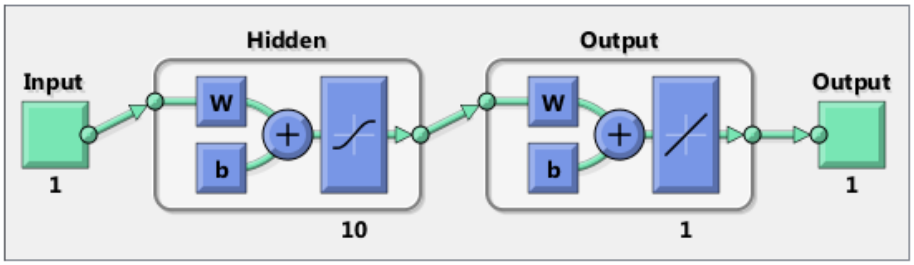

Figure 4: Feed Forward Neural Network

The output *y* of each (non-input) node in the network (for a given pattern *p*) is simply the weighted sum of its inputs, i.e.

$$a_{i,p} = \sum_j w_{ij} y_{j,p} \quad (1)$$

$$y_{i,p} = f\left(a_{i,p}\right) \quad (2)$$

The squashing function *f(x)*, which is required to be both monotonic and differentiable, is typically the *sigmoid* or *logistic function*, given by

$$f(x) = \frac{1}{1+e^{-x}} \quad (3)$$

Feed-forward nets are trained using a set of patterns known as the *training set* for which the desired outputs are known in advance - a process known in the neural network literature as *supervised learning*. Every *pattern* must have the same number of elements as the net has input nodes (excluding the bias unit), and every *target* the same number of elements as the net has output nodes. Taken together, a training pattern and its associated target are known as a *training pair*. Prior to training, the network weights are initialised to small random values. A *training algorithm* is then used to progressively reduce the total network error by iteratively adjusting the weights.

2. Testing of neural network: Testing of the neural network is a image of a person which needs to be recognized is taken as shown in figure 4 and compared with the trained data of the neural network. If the image of a person is recognized then result is shown by showing its correct name as shown in figure 5.

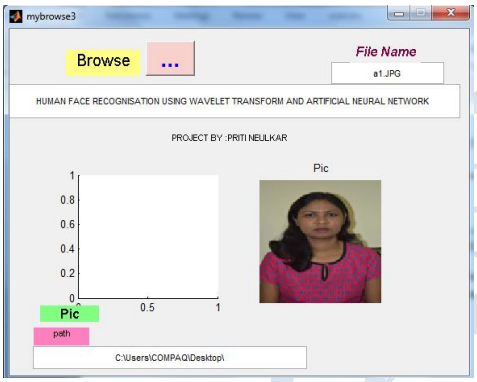

Figure 4: Selection of the Image to be recognized

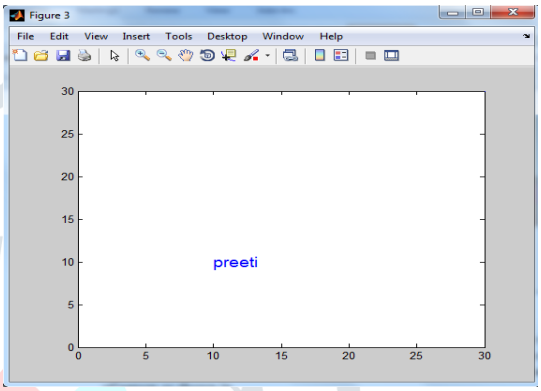

Figure 5: Output Show in the form of name of the Person which is to be recognized

VI. CONCLUSION

The proposed system implements hybrid approach for face recognition by using Mallets Wavelet Transform and Artificial Neural Network. Artificial neural network is proved best among the other classifiers and is most commonly used classifier today. Various feature extraction approaches are used in combination with the Artificial Neural Network system to investigate performance of the combination used for the face recognition. In the proposed face recognition system Mallats Wavelet Transform is used for the feature extraction successfully. Also the Mallats Wavelet Transform in combination with the Artificial Neural Network works efficiently for the proposed system. Further work can be carried out by using combination of Mallats Wavelet Transform with other feature extraction techniques in combination with Artificial Neural Network classifier.

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