APPLICATIONS OF WAVELET TRANSFORM AND PSO-MLP BASED FACE RECOGNITION SYSTEM UNDER POSE AND ILLUMINATION VARIATION

S. Meenakshi[1], Dr. D. Murugan[2,] Dr. M. Sivajothi[3]

[1]Research Scholar, Department of Computer Science & Engineering, Manonmaniam Sundaranar University, Abishekapatti,Tirunelveli-627 012,TamilNadu, India

E-mail: hemaharishvarna@gmail.com

[2]Professor and Head, Department of Computer Science & Engineering, Manonmaniam Sundaranar University, Abishekapatti,Tirunelveli-627 012, TamilNadu, India

E-mail: dhanushkodim@yahoo.com

[3]Associate Professor, Department of Computer Science, Sri Parasakthi College for Women, Courtallam, TamilNadu, India E-mail: rksmano@yahoo.com

Abstract

Face recognition system has caught more attention from the researches in computer version over the past decades. Developing an automated face recognition system is a very difficult task due to wide variety of pose, facial expression and illumination. A lot of methods have been developed for face recognition using different strategies like PCA, LDA, ICA and wavelet transform. Recently, face representation using Discrete Wavelet Transform (DWT) has received considerable attention in computer vision and pattern recognition. In this paper, face recognition system using Particle Swarm Optimization (PSO)-Multilayer Perceptron (MLP) where DWT based feature extraction is proposed for the extraction of feature vectors from facial images. Only approximation band of the image is used as input to the PSO-MLP. Parameters of MLP are tuned by PSO algorithm to prevent the limitations of standard MLP, like slow convergence and long training time. Proposed method is validated on ORL database. Performance of the proposed model is analyzed by varying dimension of feature vectors.Results indicate that the DWT-PSO-MLP can achieve high Recognition Rate (RR) than other methods considered for comparison from the literature.

Keywords: Artificial neural network, Face recognition, Multilayer perceptron, Particle swarm optimization algorithm, Pose and illumination variation

I. INTRODUCTION

Biometrics is the exploration of measuring human uniquenesswith the end goal of authenticating thecharacter of a substance. Biometrics concerns with identifyingpeople by their physiological characteristics such as fingerprint, iris, retina, palm print, hand geometry and faceor some behavioral aspects such as voice, signature and gesture.Compared to other biometrics, Face Recognition (FR) is the prominent approach due to the non-expensive implementation and non-obtrusive nature of the image acquisition which may occur without voluntary subject participation [1].FR involves comparing an image with a database of stored faces to identify individual person in the input image.FR is a very active of research and received considerable attention from both researchers and industrial experts.FR has been utilized in may

commercial applications such as security system, criminal identification, multimedia applications and seizure control.

Though FR is being utilized to combat identify missing children, passport fraud and identify fraud, it has some challenges like pose variations, occlusion, variation of illumination and different expressions[2]. Numerous techniques have suggested for FR over the past years. These techniques can be divided into geometry feature based and image feature-based methods. Geometric based feature method considers individual features such as eyes, nose, mouth and a shape of the head and then develop a face model based on the size and the position of these characteristics. Image feature-based method extracts the statistical values and these values are compared with the stored database.Image feature-based method has been of focal importance in pattern recognition and machine vision[3].As a researcher interest in FR recognition continued and many different methods areproposed, like PrincipleComponent Analysis (PCA) [4][5], Linear DiscriminantAnalysis (LDA)[6],Independent Component Analysis (ICA)[7][12], wavelet-based method[8][9] and soft computing-based methods[10][11].

Recent years, hybrid method based on Discrete Wavelet Transform (DWT) and Artificial Neural Network (ANN) have swept a variety of computer vision tasks including face recognition with pose and illumination problem. In this paper, fully automated face recognition system using Particle Swarm Optimized (PSO) tuned Multilayer Perceptron (MLP) is developed. Proposed method consists of two phases: training phase and recognizing phase. At training phase, input image is preprocessed with some image enhancement methods like gamma correction, filtering and histogram equalization in order to compensate the illumination variation. Preprocessed image is decomposed into approximation and detailed sub bands using DWT. Only approximation sub band is extracted and used as input to the PSO-MLP. PSO-MLP carry out the classification task. PSO is a type of swarm intelligence algorithm,is employed to optimize MLP and to overcome the problems like slow convergence and long training time of standard MLP. During recognition phase, query image is preprocessed and feature vectors are extracted. Optimized PSO-ANN is used to recognize the image. Efficiency of the proposed method is measured in terms of Recognition Rate (RR).Performance of the proposed method is analyzed by varying decomposition level.

The rest of the paper is organized as follows: Section 2 briefly review the related works. Proposed face recognition method is presented in Section 3. Numerical results and comparison are provided in Section 4. Section 5 concludes the paper followed by relevant references.

II. REVIEW OF RELATED WORKS

Face recognition is a field of computer vision that uses facial features to identify a person. Chelali and Djeradi [3] developed a face recognition system using ANN. Gabor and wavelet-based features were extracted and fed as input to classification system. Two networks namely MLP and Radial Basis Function (RBF) are used as classifier. Proposed method was tested on ORL and computer vision database. Results showed that good RR of 96 % was achieved using Gabor and wavelet with MLP classifier. Rouhiet al. [4] presented a detailed survey of feature extraction methods for FR. Gumus et al. [5] presented an evaluation of using various methods for face recognition. Wavelet decomposition and Eigenfaces method which is based on PCA used for extracting important features from the facial images. After generating feature vectors, distance classifier and SupportVector Machines (SVMs) are used for classification step.Classification accuracy was analyzed by varying many parameters such as increasing dimension of training set, chosen feature extractor-classifier pairs and chosen

kernelfunction for SVM classifier. Classification accuracy 98.1% was obtained with wavelet-SVM for 240 imagetraining set.An interesting paper using ICA is reported in [12].In this approach, input image was preprocessed with PCA.Feature vectors are extracted using ICA.Query images are recognized by employing Euclidian distance classifier. Many researchers showed improved RR using ANN. However, ANN suffers from many limitations like local minima,slow convergence and long training time. To alleviate these issues, bio inspired algorithms such as Genetic Algorithm (GA) and PSO integrated with ANN in order to improve the classification accuracy.Shieh et al.[13]designed a real time face recognition system by incorporating PCA and PSO-SVM. Feature vectors are extracted using PCA. PSO is used to implement a feature selection, and the SVMs serve as fitness functions of the PSO for classification problems. Experimental results demonstrated that the proposed method simplifies features effectively and obtains higher classification accuracy of 93%. Face recognition method based on ANN and windowing method is proposed by Korkmaz and Yilma [14] .Input images are separated to the different size windows, 4 by 4 and 8 by 8. Then, it is obtained the means of each window and totally sixteen by one and sixty-four by one vectorfeature are obtained, respectively. According to the created features of each images, ANN is trained. Finally, the trained network is tested with test images. Performance of the proposed method is tested by different learning rate and momentum. However, this method needs more time for training.

III. PROPOSED FACE RECOGNITION SYSTEM

Fig. 1 shows the framework of proposed face recognition system. Proposed method consists of two phases.During phase 1, input images are preprocessed, feature vectors are extracted using wavelet transform, based on feature vectors, weights and bias of MLP is optimized with PSO. Recognition model is developed using optimized MLP. At phase 2, query face is preprocessed, features are extracted using DWT and these feature vectors are fed into PSO-MLP for recognition.

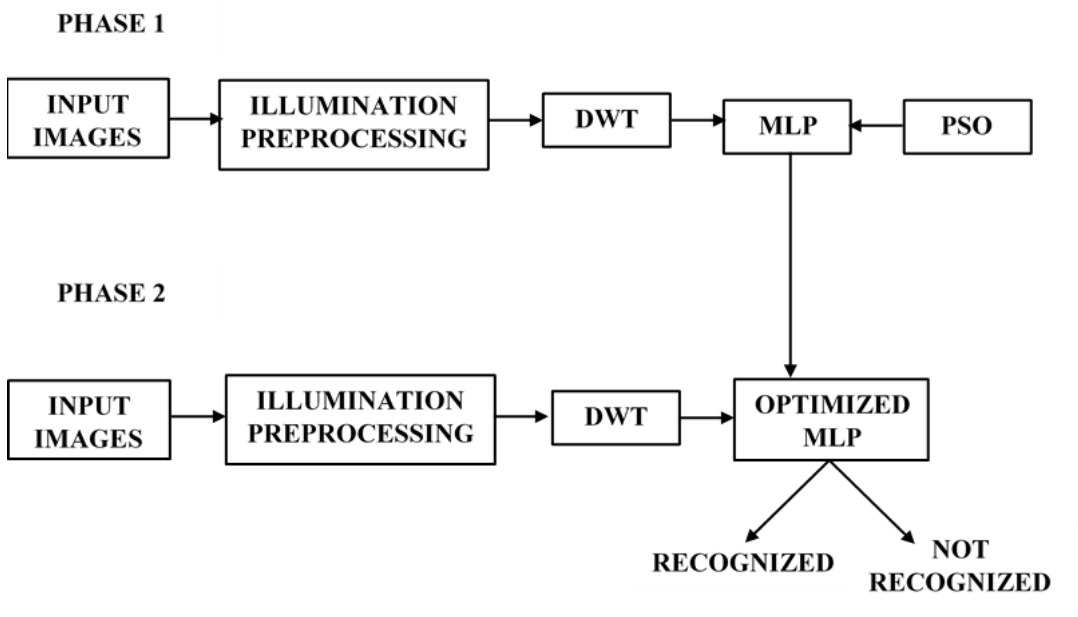

Figure.1 Framework of the proposed face recognition system

Preprocessing

(a) (b)

Figure.2 (a) Before preprocessing (b)After preprocessing

Preprocessing is the first and essential step in image analysis. It is used to improve quality of input image. A major difficulty that FR systems will encounter is the varied illumination conditions. A good preprocessing algorithm may reduce the intra-class difference and improve the performance. Here we choose the processing sequence in [17]. The sequence is made of three stages: gamma correction, difference of Gaussian filtering, and contrast equalization. It is observed from the experimental result that this algorithm can perfectly remove shadows and preserve details on faces, as shown in Fig. 2.

Feature extraction

Wavelet transform is a powerful tool for analysis the image at various resolution. DWT decomposes the signal into a sum of shifted and scaled wavelets. DWT has many advantages live spare representation and non-redundant computation, which make it advantageous to use the DWT over the other transforms Fourier Transform (FT), Gabor transform for feature extraction. DWT has been successfully used for compression, denoising and feature extraction and achieve better results compared to other methods [19].

DWT is suitable method for extracting image features because it allows the analysis of images on multiresolution. Low Pass Filter (LPF)and High Pass Filter (HPF) are utilized for image decomposition. At first level decomposition input image is divided into two components: approximation and detailed sub band. Approximation band is the outcome of LPF. HPF generates detailed sub band. Detailed image contains three sub band namely vertical band, horizontal band and diagonal band. Approximation band can be further split into approximation and detailed image and so on. Level of decomposition depends on the application.

Let the size of an input image is MXN. At first level decomposition in the horizontal direction of down sampling, the size of an input image will be reduced to MX(N/2). After further filtering and down sampling in the vertical direction, four subbands are obtained with the size of (M/2) X (N/2), as shown in Fig. 3. Mathematically, approximation and detailed image can be defined as,

$$A_{j+1}[p] = \sum_{n=-\infty}^{\infty} l[n-2p]a_j[n] \quad (1)$$

$$D_{j+1}[p] = \sum_{n=-\infty}^{\infty} h[n-2p]a_j[n] \quad (2)$$

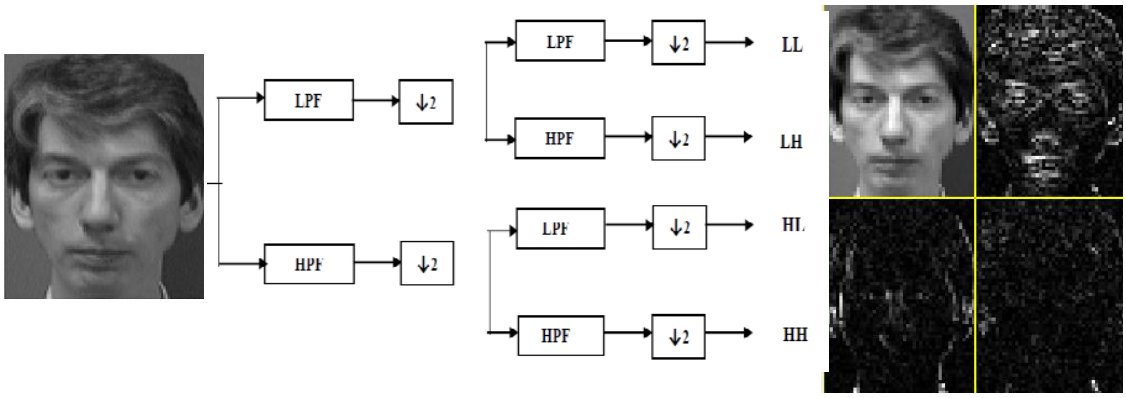

Figure.4 DWT decomposition

There are many wavelet functions are available. The selection of wavelet is very important process in feature extraction.The effectiveness of RR depends on wavelet selection and level of decomposition. In this study, 'Haar' wavelet is employed for extracting features from the facialimage.Performance of the proposed system is analyzed by varying decomposition levels, from 1 to 4. Fig.4depicts the second level decomposition using haar wavelet transform: size of original image is 112x92. The dimension becomes 56x46 with 1st level decomposition. At level 2, the size of image will be reduced to 28 x 23.

Figure.4 Second level decomposition

Approximation band of original image is taken as feature vectors since it contains most important information and discards the redundant information. Furthermore, approximation band keeps the required information and the dimensionality of image is reduced for computation at the next process.

Multilayer perception

MLP is a kind of ANN, feed forward, supervised learning network. It comprises of three layers namely an input layer, multiple layers and an output layer [20]. Input layer receives the input signal. Fig. 5 shows the structure MLP with two hidden layers. Each neuron in the input layer is connected to hidden layer via connection link called weight.

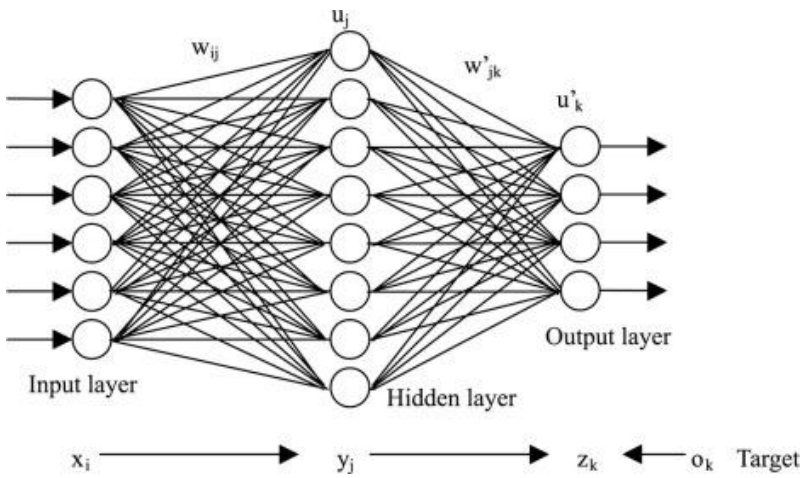

Figure.5MLP with two hidden layers

Input neuron receives the inputs and multiplied with the associated weights. The resultant value is added with bias. By applying activation function, output of neuron would be computed. The output of neuron K is defined as follows:

$$I_K = \sum_{i=1}^{n} X_i W_i \quad (3)$$

$$Y_K = \emptyset(I_K + B_K) \quad (4)$$

Where, X_i is the input, W_i is the weights, I is the input adder, B represents the bias Y is the output and $\emptyset$ denotes the activation function.

In this study, MLP is designed with an input layer, two hidden layers and an output layer. Number of neurons in the input layer depends on the number of feature vectors. Number of hidden layer and its neurons are defined by experimentation. Each hidden layer has 25 hidden neurons. The number of output neurons in the output layer is equal to the number of registered individuals. Tan sigmoidal function is used as an activation function in the hidden layers. Purelin is employed as a transfer function in the output layer.

Particle swarm optimization

PSO is a kind of meta-heuristic optimization algorithms which is motivated by bird flocking and fish schooling. PSO was introduced by Eberhart and Kennedy in 1995 [15].It can be used for nonlinear function optimization. Each member in PSO is called as particle flies through multi-dimensional search space with a velocity and adjusts its position in every phase till it reaches the optimum solution. The position of a particle is influenced by the best position visited by its own experience and the position of the best particle in its neighborhood. Velocity and position of the particle is updated by using Equation (5) and Equation (6) respectively.

$$V^i(t+1) = V^i(t) + c_1 * r_1 * \left[p^i_{best} - p^i(t)\right] + c_2 * r_2 * \left[g_{best} - p^i(t)\right] \quad (5)$$

$$p^i(t+1) = p^i(t) + V^i(t) \quad (6)$$

In this study, PSO is employed for finding optimal weights and bias of MLP.PSO prevents the trapping in a local minimum since it is not based gradient information.Weights and

bias of MLP are optimized by PSO based on the objective function. NMSE is used as objective function. Table 1 summarize the parameters used for optimizing the parameters of MLP.

Table.1 PSO Parameters

Parameters	Value
Swarm size	30
Inertia weight,w	1
c1	1.5
c2	2
Maximum iteration	1000

After optimizingthe weights and bias of MLP, face recognition model is created. query is preprocessed, feature vectors are extracted. Subsequently, optimized PSO-MLP used to recognize the query image.

IV. SIMULATION RESULTS AND DISCUSSION

Several experiments were conducted on ORL database to prove the efficiency of the proposed FR system. ORL database contains 400 images of 40 individuals, and each person has 10 images. All the images are in .pgm format and 8- bit gray scale image of size 112 x 92 pixels [16]. Samples of the ORL database are shown in Fig. 6. From ORL database, we select randomly 200 samples (5 for each person) for building the FR model. 120samples are used for testing the model.

Figure.6 Sample gallery images from ORL database images

Initially, all the images are preprocessed with illumination processing to compensate the illumination variations. We extract the feature vectors from Haar wavelet transform by

decomposing face image in approximation sub bands at first level, second level, 3rd level and fourth level. The size of face image is 112 x 92 pixels. We retain the approximation band of size 56 x 46 at first level, 28 x 23 at second level, 14 x 11 at third level and 7 x 5 at fourth level. The resultant vector is converted into ID signal by using reshape function in MATLAB.The total vector size of features obtained at each level using haar wavelet transform are tabulated in table 2.

Table.2 size of feature vectors

Input image	**1**	**2**	**3**	**4**
112x92	2576	644	168	42

Table.3 optimal MLP topology

Parameters	**Value**
Number of hidden layers	2
Number of hidden neurons	25
Training algorithm	LM
Transfer function	Tansig, purelin
Cost function	MSE

After calculating DWT, feature vectors and targets vectors are normalized between 0 to 1 since MLP is sensitive to input data. Normalized feature vectors are used constructing the FR model. Based on the objective function, PSO is used for optimizing the parameters of MLP. Table 3 lists the optimal MLP architecture found in out experiment to achieve high recognition rate.

Performance analysis

PSO algorithm used for finding optimal values of weights and bias of MLP. Figure .7 illustrates the convergence plot of MSE with respect to number of iterations of PSO for tuning MLP.

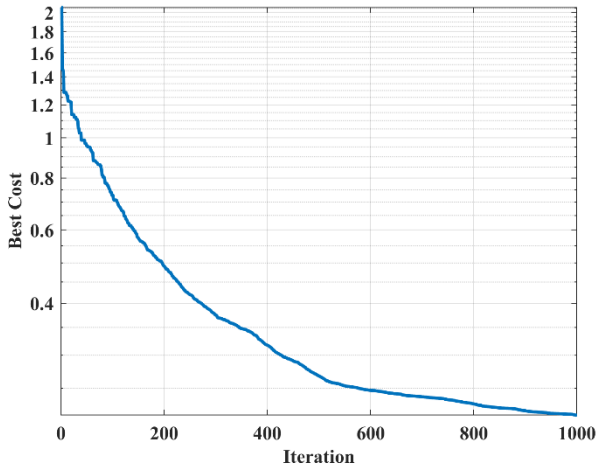

Figure.7 Convergence plot

The performance of DWT-PSO-MLP is evaluated by measuring RR. Mathematically, RR can be expressed as,

$$Recognition\ Rate\ (RR) = \left(\frac{Number\ of\ correctly\ identified\ faces}{Total\ number\ of\ faces}\right) \times 100 \quad (7)$$

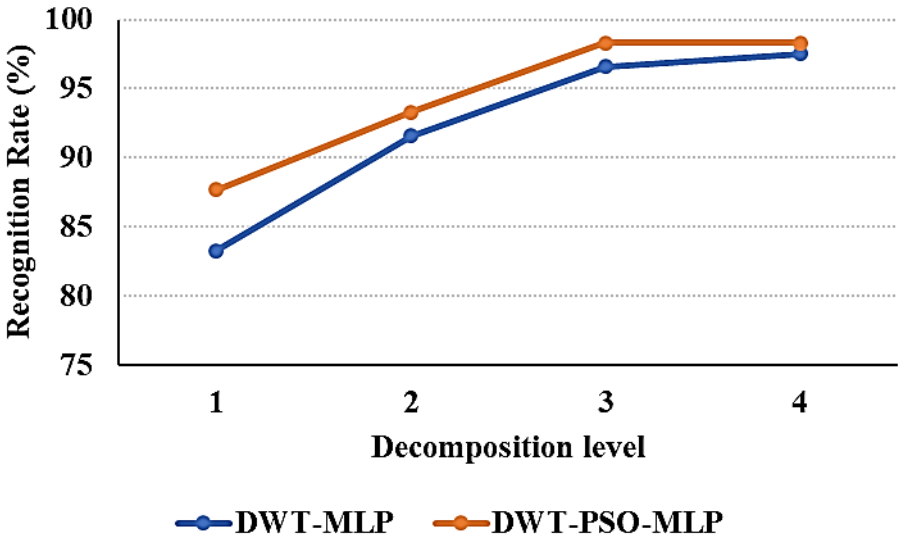

Figure.8 Performance analysis by varying number of feature vectors

Figure.8 shows the comparison of RR obtained using DWT-MLP and DWT-PSO-MLP by varying decomposition level. From the Fig.8, it is observed that the DWT-PSO-MLP achieves high recognition rate using third level approximation band. The results obtained showed the importance of selecting feature vector for achieving high FR.

Comparison with other methods

There are many FR methods are found in the literature. In order to compare RR, we choose some recent methods. The performance of DWT-PSO-MLP in comparison with some existing method for face recognition is presented in Table.4.

Table.4 Comparison between proposed and other existing methods

Contributors	Method	RR(%)
Chelali and Djeradi [3]	Gabor wavelet-MLP	96
Venus et al. [10]	DWT- 2DPCA	92
Gumuset al.[5]	Wavelet-SVM	98.1
Shieh et al.[13]	PCA-PSO-SVM	93
Korkmaz et al.[14]	PCA-BPNN	96
Jain et al.[18]	PCA-ANN	94
Proposed	DWT-PSO-MLP	98.3

Chelali and Djeradiet al.[3] used approximation band of first level decomposition coefficients as a feature vectors and achieved 96% RR. This methodrequires more time for

training the network. Venus et al.[10] used DWT to reduce the high dimensional image into low dimension image. 2D PCA was utilized to find the RR.Gumuset al.[5] extracted the feature vectors using DWT. Images are classified using SVM.Some others used PCA as a feature extraction tool (Korkmaz et al.[14])(Jain et al.[18]).Reduced feature vectors are fed as input to ANN. Standard ANN is good tool for FR. However, it takes more time for training. To overcome such an issue, proposed method used PSO algorithm.From the Table.4, it is proved from the table that our proposed DWT-PSO-MLP achieves high RR compared to other methods considered for comparison from the literature.

V. CONCLUSION AND FUTURE ENHANCEMENT

In this paper, a new face recognition system using soft computing model is presented. DWT based feature extraction method is proposed for the extraction of import features from face images. FR experiments were done by using PSO-MLP. Proposed system is tested on ORL database. Performance of the proposed system is analyzed by varying number of input feature vectors. High recognition rate achieved using third level approximation sub band. The presented DWT-PSO-MLP enhances the FR performance by reducing feature vector dimension compared to other methods considered for comparison. Additionally, proposed also overcome the short comings of standard MLP by using PSO. In future work, we plan to apply deep learning architectures to increase RR at low computational cost.

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