Face Recognition Using Neural Network Technique Som (Self Organizing Maps)

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Abstract: Face recognition from still images or videos is challenging due to the wide variability of face appearances and the complexity of the image background. Also uncontrolled conditions like illumination, expression and partial occlusion effects face identification and it has become a matter of concern. Faces are detected and recognized at various angles of face expressions. The process of recognition is performed by comparing the characteristics of the target face to that of known individuals face images. In order to overcome above challenges, we propose a Face Recognition System (FRS) that uses Principal Component Analysis (PCA) method for feature extraction and Kohonen Self- Organizing Maps (SOM) algorithm to identify and classify the human face images. The purpose of this study is to increase the speed and accuracy of existing face recognition systems. In this paper, we first discusses the characteristics of Kohonen self- organizing maps to highlight the advantages and disadvantages of neural networks in classifications approaches. In the second part, data used for classification of target images, obtained from publically available databases is pre-processed using appropriate methods using MATLAB software. The result of these computations is database, composed of publically available daily load images, used for SOM training. In the third part, the proposed software is tested on few scenarios in order to classify different face images. With the usage of SOM technique along with other neural networks, the system's accuracy is increased to 97%, with face detection rate of 100% and recognition rate of 86.84%, which is higher than existing algorithms.

Keywords: SOM, FRS PCA, Neural Network, Artificial Intelligence

1. INTRODUCTION

In face recognition, an image is compared with a database of stored faces to identify different input images. Since recognizing humans with the help of facial images, it offering a non-intrusive way for human identification, we use face as an important biometric method in security implementations and accessing issues. The related task of face detection has direct significance to face recognition because images must be analyzed and faces detected, before they can be recognized [1]. The computational resources of the face recognition system can be measured by analyzing various algorithms that help us to detect faces from a still image or video and this procedure can help in enhancing the systems speed and performance. Recently researchers have revealed that one can extract not only the texture and shape information from facial images but also the configured information of the face, directly from its raw-pixels-based representation [2]. In order to access these face properties; we divide detected face images data into sub-face parts which can be called as subspaces. Also to construct the face subspaces with good generalization, a large and representative training data set is required due to the high dimensions of the face images [3].

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However, in most face recognition system, a target subject usually lacks availability of large number face images and with only a few number of face images present in the sample, there remains a high uncertainty. But this uncertainty can get reduced if adequate virtual samples are synthesized. After that, we can choose only those useful training samples that have common features as those of the test samples. Applying such a procedure has various benefits as, even when the sample size is too small, as in most real face recognition cases, the SOM algorithm, due to its unsupervised and nonparametric characteristic, can still extract all the significant information of local facial features from the available sample subjects to detect the target face image in addition to removing possible variations like varying appearances, noise, outliers, or missing values. The SOM generates a feature vector from given face images based on normalized face image and facial feature locations derived from previous stages and compared with a database of known faces. After performing these processes and if a close match is found, the algorithm returns the related identity. In this way the robust and compact representation of the face recognition system can be reliably learned and achieved [4]. In this study, we performed our experiments on publicly available database 'the AR face database [5]' and the results show that our algorithm performed better than other existing methods without any preprocessing necessities such as face alignment. Also by having richness in the reference set and subspace construction, SOM can also handle expression and illumination variation [6].

2. LITRATURE REVIEW

Biometric recognition has taken an important place in our life. Quite from early time various efforts have been made for recognizing humans and different authors have presented different approaches to perform such task. The different methods proposed from the early times can be classified into the following main categories.

2.1 Holistic methods

The Holistic methods were used much early and these methods need the complete face region to be captured in the recognition system [7]. Template based:/Feature BasedIn Template Approach, face acts as a template and local features based on eye, mouth, cheeks and nose are first captured and extracted and classifier acts on their geometrical locations [8], [9].

2.2 Model based methods:

Here 3D depth along with face shape and texture gives information which is extracted by the model based methods. Model-based are classified into 2-Dimensional and 3 Dimensional types [10].

2.3 Neural networks:

Neural networks are algorithms which are inspired by the types of computational structures found in the brain, enabling computers to learn from experience. Neural Networks can be classified into two groups:

Based on one architecture, different methods of ANN are:-

Multilayer Perceptron (MLP)
Back Propagation Neural Networks (BPNN)
Retinal Connected Neural Network (RCNN)
Rotation Invariant Neural Network (RINN)
Fast Neural Networks (FNN)
Convolution Neural Network and
Polynomial Neural Network (PNN).

Combining ANN with other techniques, different methods are: -

Principal Component Analysis with ANN (PCA & ANN)
Evolutionary Optimization of Neural Networks
ANN with Gabor Wavelet Faces
BPNN and Skin Color.

3 OBJECTIVES

Main objectives of the proposed work are as follows:
(a) To develop a model for a high-speed and robust facial Recognition system
(b) To reduce training time of SOM classifier and speedup recognition rate by combining feature extraction algorithms like 2D-DCT and PCA with neural network-SOM.

The Face Recognition System uses the following steps of the algorithm to improve the efficiency of feature extraction and matching with the target subject. First the number of those sample images is found that are to be taken as training images and thus the image matrix is created which in turn forms a feature vector matrix. Next all image vectors are subtracted from the mean image vector. Then PCA is applied to extract Features. After that extracted features are classified using SOM to match with the test image.
Implementation of proposed work in MATLAB for simulation of the algorithm.

Generation of Results.

3 WORKING AND EXPLANATION OF OUR PROPOSED MODEL:

This section briefly describes and explains working of proposed model.

2.3 Training

Image Database: A large number of images of different persons were captured at different times with varying light, different facial expressions like closed/open eyes, smiling / not smiling, beard/no beard etc. A dark homogeneous background was used to capture all the images. Feature Extraction: Feature extraction is a special form of dimensionality reduction. To transform high dimensional dataset into low-dimensional dataset, the input images are transformed into a reduced representation set of features also called as Features Vector. Also instead of taking full size input data, which might lead the algorithm to take more processing time , the features having only relevant information are chosen and taken as the input data to the algorithm. Training of SOM: In recognition process input and target vector is involved. SOM has a big advantage that it learns to classify the training data and forms different clusters or classes without the need of any external supervision. For this various cluster topologies are available that can be used for recognition.

3. Testing

Trained SOM: The trained clusters of the database are used to perform mapping with the input image by applying Euclidean distance formula.
The initial weight vectors $w_j(0)$ take random values, $j = 1, 2, \ldots, q$ where q is the total number of neurons.
The input high-dimensional space R^n can be expressed as

$$w_i = [w_{i1},\ w_{i2},\ \ldots,\ w_{iq}]^T \in R^n \qquad (1)$$

Then a Sample X having certain probability is taken from the input space

$$X = [X_{1,}\ X_{2,}\ \ldots,\ X_q]^T \in R^n \qquad (2)$$

Finally we find the best matching $i(x)$ at time t, $0 < t \leq n$ by applying the minimum distance Euclidean standard:

$$i(x) = arg\,min\ |\ x(n) - w_j\ \ j = 1, 2, \ldots, q \qquad (3)$$

Recognized Faces: The output of this process is the best match decided by Euclidean distance criterion. The final recognized image is the shortest distance between input image and classifiers or clusters.

4 EXPERIMENTAL DATASET AND OBSERVATIONS

3.1 Image Database

We have taken a publicly available database ‘the AR face database [5] to conduct our experiments for evaluating our proposed face recognition system. First we separated the image database into two subsets, one for training and other for testing purposes. SOM was trained on 35 images. This dataset contained seven subjects and each subject had 5 images varying in their facial expressions. This setup of training and testing images is shown in Fig '1'.

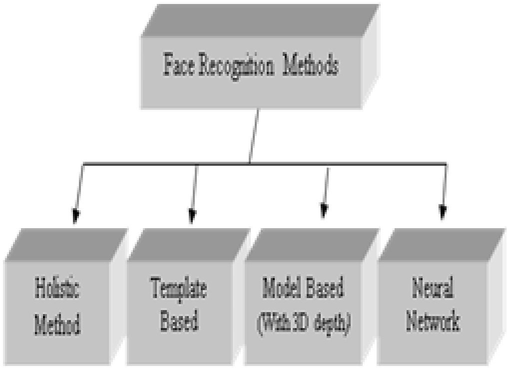

Fig. 1 *Showing Training image Db*

MATLAB™ 7.5 was used to train, develop and test the proposed Face recognition system.
The configuration used was a Windows 8 with Processor Intel(R) Core(TM) i3 CPU M 380 @ 2.53GHz, 2527 MHz, 2 Core(s), 4 Logical Processor(s)and 3 GB of RAM.

3.2Training neural network and simulating the images:
During Training, an array of 64x1 images was constructed with 64 rows and 1 column after redesigning preprocessed grayscale images in MATLAB. Whole input data was prepared for testing the proposed system following this same procedure on all 5 test images. Likewise a matrix of 64x35 with 64 rows and 35 columns formed the image database for final training. The intensity levels of the grayscale pixels is represented by input vectors defined for the SOM that are distributed over a 2D-input space differing over [0 255]. These vectors with dimensions [64 2] were involved in training SOM, where each face sample is represented by 64 min and 64 max values for pixel intensities. A single-layer feed forward SOM map with 128 weights and a competitive transfer function results by after using these parameters, where the weight function is the negative of the Euclidean distance [11]. All succeeding experiments are performed with this network. The results of the experiments carried out with 5 test images without overlapping Training and Testing are shown in Fig. 3. This study shows that identification of face images can be achieved easily despite varying facial expressions in test images. This procedure leads to increase in magnitude of the layer weights after transforming 20-dimensional trained image database into a 64-dimensional map with decrease in Euclidean distance for feature vector for trained image than untrained image. A better classification is produced with this transformation by grouping similar clusters together. Processing time of overall system is concerned and this experiment wins in the reduction of training time while maintaining the recognition rate. The recognition rate and training time for 100 epochs is presented in Table 1.

Testing
In this phase, minimum Euclidean distance criterion is used to find the best match by comparing each input with all nodes of the SOM network, as given in Fig. 2. Finally the system shows if the test image exists or not in the image database.

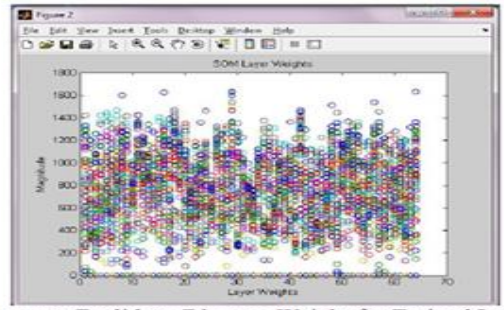

Figure 2 : Euclidean Distance Weight for Trained Image Database with SOM Network.

Result Analysis of training time and recognition rate:

Fig. 3 *Result of best match is found with varying expressions and environment*

3.3 RESULTS AND ANALYSIS
We evaluated the system in MATLAB on database containing 35 facial images with five subjects and each subject containing seven images with varying expressions. We tested about 850 epochs and for 10 consecutive trials, a recognition rate of 86.84% was achieved. Thus SOMs high-speed in terms of its processing ability low computational space was achieved.

4 EXPERIMENTAL RESULTS
We performed several experiments with SOM in terms of:-
1. Since DCT block size has a much effect on the recognition rate of a system, our first experiment illustrated the effect of each DCT coefficient that we used in the feature vector [12].
2. In 2nd experiment, the effect of computational load that arises from large sized DCT-feature vectors was evaluated [12].
3. Finally our 3rd experiment evaluated the processing time of the overall system, which mainly is the time required for training the SOM network.

5 VALIDATION OF TECHNIQUE
This simulation resulted that the subject from the input image is present in the image database, shown in Fig. 8.

Also experiments proved that the best match can easily be obtained despite of varying facial expressions. We took DCT block size of 8x8 and it obtained maximum recognition rate in our case and hence the same size was repeated in all subsequent experiments.

Table I Compare DCT Block Size with Recognition Rate

	DCT Block Size					
	4x4	*6x6*	*8x8*	*10x10*	*12x12*	*16x16*
Recognition rate (%)	*73.23*	*77.34*	*78.16*	*75.83*	*74.54*	*73.15*

6 REDUCING DCT-FEATURE VECTOR SIZE

In this experiment the size of the Feature Vector and its effect on DCT coefficients is evaluated and the main concern is to construct a smaller sized feature while maintaining the performance of the system in study. By using 8 sized DCT block and with the help of statistical analysis while keeping variance of each 64 dimensions of the Feature Vector in consideration, we can identify which coefficient contributes highest in final decision making of the classifier. The variances were computed using the following expression [12]:

$$ar(x_j) = \sum_{i=1}^{k}(X_i - \bar{X})^2(i) \qquad (4)$$

, j denotes coefficient index, i is sample index and k gives total number of samples available.

Also this study reveals that two places occur while evaluating 64 DCT-Feature Vectors during training and testing where high variance is achieved and this difference plays an important part during classification [12]. Thus it is better to choose a reduced sized feature space and exclude other coefficients. In Table II, the effect of size of DCT-Feature Vector on system's performance is compared and it also evaluates training time and space computation. The results show that better performance of recognition is achieved by choosing reduced sized Feature Vectors.

Table II Effect of Reducing Size of DCT-Feature Vector

DCT Coefficients	*Training Time (s)*	*Recognition Rate*	*Memory Consumption (Bytes)*
4	*97.53*	*86.84%*	*29123650*
8	*161.22*	*76.93%*	*6493214*

7 REDUCING PROCESSING TIME BASED ON EPOCHS

A Networks Training time is mainly effected by using the number of epochs during its training phase [13]. We conducted this experiment for Network to perform better by using lesser training time, while maintaining the already achieved recognition rate for the reduced DCT-Feature Vectors during our 2nd experiment. Different number of epochs was selected and least amount of processing time was taken in case of 850 epochs for training, also it to be noted that recognition rates obtained were the average of ten consecutive simulations. Table III shows effect of number of epochs on recognition rate for training time.

Table III *Optimizing Number of Epochs for Training to reduce processing time*

Number of epochs	*Training Time (s)*	*Recognition Rate*
600	*39.87*	*71.23%*
700	*49.86*	*72.13%*
700	*49.95*	*73.01%*
750	*5715*	*77.81%*
800	*63.84*	*78.14%*
850	*72.43*	*86.84%*
900	*85.35*	*80.32%*
950	*90.12*	*79.85%*
1000	*96.72*	*79.32%*
1050	*108.85*	*75.96%*
1100	*110.58*	*74.36%*

8 CONCLUSION AND FUTURE SCOPE

In this paper face recognition system has been presented that is based on SOM neural network and more importantly SOM-based classifier has been used for large databases to reduce Feature Vector size to easily verify the matched face images. The experiments conducted in MATLAB showed that the performance of recognition rate is increased by reducing DCT-Block Size (reducing high dimensional feature vector into low-dimensional feature vector) and choosing lesser number of epochs. This has led to reduced computational requirements by the method and makes our system well suited for low-cost and real-time hardware implementation. Moreover instead of using PCA for extracting features we can also use LDA with SOM; also there is much possibility of combining DCT with LDA and SOM, which may give better results. Existing papers have 92.40% accuracy for 35 Images while our experiments with the proposed system gave 97% detection rate for 35 Images and recognition rate of 86.84%. Since SOM's dynamic and unsupervised nature, we can also get different results for different datasets.

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