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# FACE RECOGNITION IN EIGEN DOMAIN WITH NEURO-FUZZY CLASSIFIER AND EVOLUTIONARY OPTIMIZATION

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**Abstract** – Face Recognition is a nascent field of research with many challenges. The proposed system focuses on recognizing faces in a faster and more accurate way using eigenface approach and genetic algorithm by considering the entire problem as an optimization problem. It consists of two stages: Eigenface approach is used for feature extraction and genetic algorithm based feed forward Neuro-Fuzzy System is used for face recognition. Classification of face images to a particular class is done using an artificial neural network. The training of neural network is done using genetic algorithm, a machine learning approach which optimizes the weights used in the neural network. This is an efficient optimization technique and an evolutionary classification method. The algorithm has been tested on 200 images (20 classes). A recognition score for test lot is calculated by considering almost all the variants of feature extraction. Test results gave a recognition rate of 97.01%.

**Keywords** : *FaceRecognition,PrincipalComponentAnalysis,Eigenfaces,Fuzzification,ANN,Genetic algorithm.*

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## I. INTRODUCTION

ACE is a heterogeneous multidimensional optical model and exploiting a computational model for face recognition is difficult. Systems for face identification are based on information theory approach of coding and decoding the face image. Generally, a face recognition system consists of two stages: learning and classification.

The methodology proposed here is to differentiate face images from a large set of stored images, considering possible variations in face orientation as well. In our system, we use Principal Component Analysis (PCA) for feature extraction and a Genetic Algorithm based neuro-fuzzy system for recognition. The eigenface approach used gives us the best path to find the lower dimensional space of an image. Any new face image can be then represented as a linear combination of these eigenfaces. Classification in eigenface approach is normally based on Euclidean distance. However, Euclidean distance does not work well for irregular face

A new training method using Genetic Algorithm is introduced here for effective training of the artificial neural network, which improves the accuracy of the system and reduces the time requirements. Fuzzification of PCA values is also introduced before the neural network stage to further improve the accuracy. The entire problem is treated as an optimization problem and the technique used here is one of the most efficient.

## II. RELATED WORKS

There are two basic techniques for face recognition. The first technique is to draw out feature vectors from the basic parts of a face such as chin, mouth, nose, and eyes, with the help of constant templates and enormous mathematics. Then key

entropy from the basic parts of face is collected and commuted into a feature vector. Another technique is based on the information theory methodology, known as principal component analysis method. In this method, feature vector is derived from the entire face image. These are the eigen functions of the average covariance of the ensemble of faces. Later, Turk and Pentland [1] proposed a face recognition method based on the eigenfaces approach. But Euclidian Distance approach is not best method for images with irregular shape areas or regions. Mapping to a particular class is time consuming and not accurate.

Another technique used for face recognition is Hidden Markov Model (HMM) [2],[3]. Hidden Markov model is a better method that works well for facial images with huge change in illumination, and orientation of head, expression of faces.HMM used to enhance the features of signals. HMM is a statistical model. It will give good results when it is applied on the speech recognition and character recognition. Face recognition rate will be decreased when the head orientation and illumination is varied. This can be avoided in the above model up to a certain limit.

In neural network classification, the training using back propagation is very much time consuming method. Time complexity will increase if the number of feature points large and the accuracy achieved in this method is up to 88%-94%. Face recognition is still not implemented successfully.

## III. PROPOSED SYSTEM

In statistics, principal components analysis (PCA) is a technique that can be used to simplify a data set more formally. It is a transform that chooses a new coordinate system for the data set such that the greatest variance by any projection of the data set comes to lie on the first axis (then called the first principal component), the second greatest variance on

the second axis, and so on. PCA can be used for reducing dimensionality in a data set while retaining those characteristics of the data set that contribute most to its variance by eliminating the later principal components. Eigenfaces method seemed to be a decent technique to be used in facial recognition due to its easiness, fastness and understanding capability.

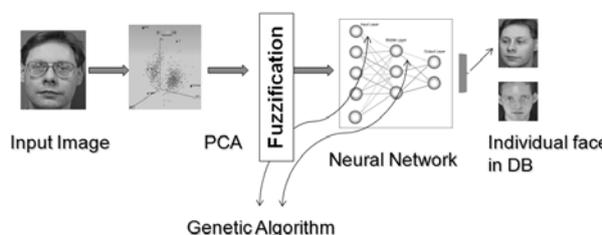


Fig. 1. Face Recognition System

Eigenfaces are a set of eigenvectors used in the computer vision problem of human facial recognition. Generally, the eigenfaces are the principal components of a distribution of faces, or equivalently, the eigenvectors of the covariance matrix of the set of face images. Eigenfaces are mainly used for the following purposes.

- Draw up the suitable face information, which may or may not be directly related to human face features such as the eyes, nose and lips.
- Interpret facial images efficiently. To cut down the calculation and space complexity, every face image can be represented using a small number of dimensions.

The PCA components were given to the input of a Neuro Fuzzy system (NFS). NFS consists of 2 main stages, Training of Neural network and Testing of Neural network. Both these stages require the input in the form of PCA values that has undergone Fuzzification. The Face recognition system is shown in fig 1.

*A) Fuzzification of PCA values:* Fuzzification is one of the powerful problems solving methodology having wide range of applications like image and information processing. It resembles human deciding with its power to work from near data and discovered accurate solutions. Fuzzy logic deals with logical thinking that is abstract thought rather than fixed and exact. Fuzzy logic may be two-valued logic ie truth value or false value, fuzzy logic variables can have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been elongated to treat the concept of partial truth, where the truth value may range between fully truth value and completely false value

Fuzzification [4],[5] is the process of altering a real value into a fuzzy value. For each input and output variable selected, we define two membership functions (MF). We have to define a qualitative category for each one of them, for example: Absence and Presence (High and Low). Absence membership

function having low values of input variables and Presence membership function having high values of membership variables. ie the input variables are divided into high and low values.

Neuro-fuzzy system (NFS) refers to combinations of artificial neural networks and fuzzy logic. Here input of NFS is principal components of images. The PCA is divided into High values and low values. Then high and low values are given to the hidden layers of neural networks (NN). Later operations are managed by neural network. Fuzzification is used to speed up the process and to increase the identification accuracy.

*B) Training of Neural network:* The trial and error method is basically used for training an artificial neural network [6]. If the network behaves in the way it should, then we change the weight of arbitrary link by an arbitrary amount. The changes will continue till the network shows good accuracy. It takes time, but the trial and error method does produce results. Regrettably, the amount of possible weights increases exponentially as one adds new neurons, making large number of neural nets. So it is not feasible to construct the network using trial and error methods.

The back-propagation algorithm [7],[8] compares the result that was obtained with the result that was expected. It then uses this information to systematically modify the weights throughout the neural network. This training takes only a fraction of the time that trial and error method take. It can also be reliably used to train networks on only a portion of the data, since it makes inferences.

But the back propagation method for training is also slow and inefficient. The other problem of back propagation is that it can get stuck in local minima resulting in sub-optimal solutions and it needs large amount of input/output data for training. We were not sure to relate these inputs and output variables properly. The problem appears to have overwhelming complexity, but there is clearly a solution. The solution to the problem may change over time, with in the bound of the given input and output parameters

In this work feed forward multilayered perceptron neural network is used for classification purpose. The training of neural network is made with respect to the exemplars. Exemplars are the representation of output. By looking the exemplars we can identify which face is given as input. The training of the neural network is based on a machine learning approach, ie; Genetic Algorithm, in order to optimize the result maximum. After the training phase the classification is made. In classification input PCA image will fuzzify and then apply to Neural network (Fig 2). The NN will map the input image into any one of the classes with respect to the exemplars.

The training of the weights in the neural network

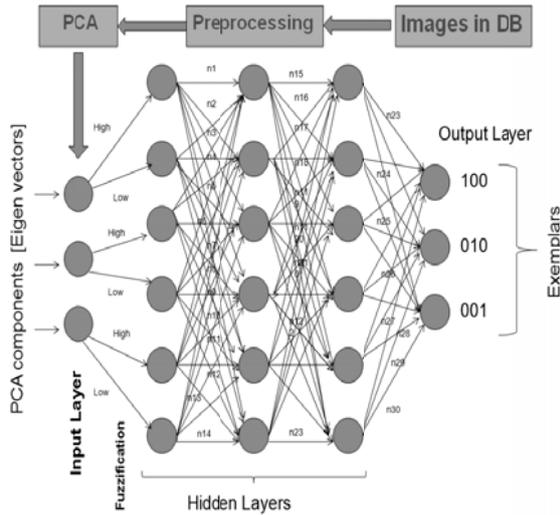


Fig 2. Training of Neural network

is done using Genetic algorithm. Genetic algorithm is one of the evolutionary classification methods for machine learning purpose. It is a Class of probabilistic optimization algorithms inspired by the biological evolution process. GA is particularly well suited for hard problems where little is known about the underlying search space. The number of determination errors should be minimal which is taken as the objective function. The genetic algorithm generally consists of

- **Selection** replicates the most successful solutions found in a population at a rate proportional to their relative quality.
- **Recombination** decomposes two distinct solutions and then randomly mixes their parts to form novel solutions.
- **Mutation** randomly assigns a candidate solution

1) *Usage of Genetic Algorithm:* The use of genetic algorithm [9],[10] reduces the number of features needed by approximately 30% while improving the identification accuracy over the baseline. Genetic-based feature weighting significantly improves the accuracy than now exists. Genetic algorithm is used in this work to train the entire neural network with respect to their exemplars. For example, create the random population first (arbitrary weights) denoted by *Npop*. Find out *n* solutions from *Npop* which shows most fitness (fig 3). For each training purpose need to fix an objective function. With respect to that objective function the neural network should be effectively trained. The number of output determination errors should be minimum is took as the objective function for training. Fitness population is found out by considering the objective function. On apply mutation or crossover on *n* solutions, it produce most fitness and which is again used to produce number of solutions. These processes are repeated

several times to get an efficient optimized result.

<i>Npop</i>	<i>Fitness percentage</i>
[n1,n2.....,n20]	70
[n21,n22.....,n40]	75
[n41,n42.....,n60]	80
[n61,n62.....,n80]	90
[n81,n82.....,n100]	45
[n101,n102.....,n120]	55
[n121,n122.....,n140]	77
[n141,n142.....,n160]	79
[n161,n162.....,n180]	93

Fig 3.Example

In above example 80%, 90% and 93% populations were taken as the fittest .That is

[n41,n42,n43.....,n60]	80
[n61,n62,n63.....,n80]	90
[n161,n162,n163.....,n180]	93

Taken the last two populations then apply cross over or mutation to get new solutions. Cross over is the process in which two solutions from the populations are selected, split at a random cut point and the latter halves are interchanged. In mutation a solution in randomly selected from a population, one of its weights is changed to an arbitrary value. It is a process that happens with low probability. Mutations (Fig 4) and crossover (Fig 5) shown below.

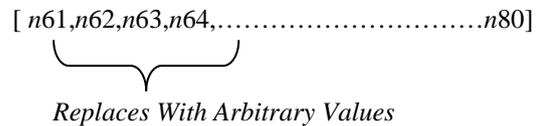


Fig 4: Mutation

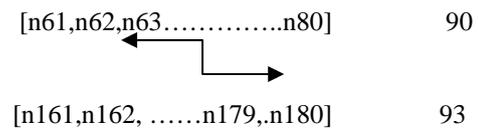


Fig 5.Crossover

C) *Testing of neural network:* Testing of Neural network [11],[12] is performed on a new face by comparing with known output faces. The input of neural network is the fuzzified PCA components of unknown face. The output is the number of individual faces (classes) in the databases. Testing phase results mapping of the input to any one of output classes (Fig 6). The output classes are represented by exemplars (The highest value may be represented may be 1). By considering the exemplars the system can identify output classes.

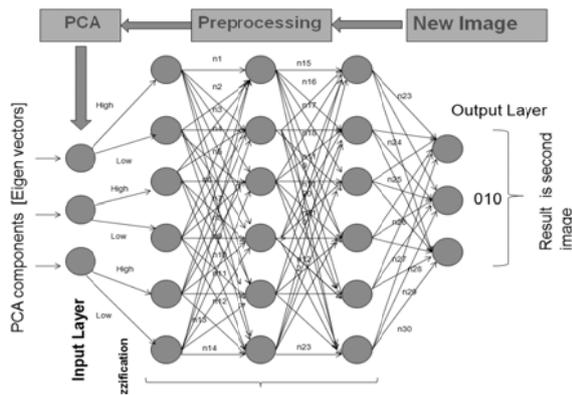


Fig 6: Testing of Neural network

IV. EXPERIMENT

The proposed system is tested using a database containing face images of 20 distinct subjects. We have ten different images each for these subjects taken under different conditions like expression, illumination etc. Each image is 112 x 92 pixels in size with 256 levels of grey. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open/closed eyes, smiling/not smiling etc.) and facial details (glasses/no glasses). All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement). Reduce the size of input image into 8 x 8 matrix (Total 64 components). An image of size 8 x 8 describes a vector of dimension 64, or a point in a 64-dimension space. To reduce the number of dimensions for computability, some principal components having values close to zero are omitted. Principal component having high eigenvalues are retained. In this experiment, the image is represented in a 3 or 5-dimensional space.

The PCA values (vector value 3 or 5) obtained are then supplied to a Fuzzification stage. Fuzzification is a powerful problem solving methodology having a wide range of applications in areas like image and information processing. Fuzzification is the process of altering a real value into a fuzzy value, for e.g., absence and presence (high and low). During this stage, the number of the PCA component is doubled (fuzzy value) and is given to the neural network. The rest of the process is managed by the neural network.

These fuzzy PCA value is applied on a feed forward perceptron multilayer neural network. The training of neural network is done with respect to the exemplars which are representations of the output. The faces in eigenspace represented with each face in a column. Value 1 is substituted for largest output value. By looking at the exemplars, we can identify whose face is given at the input. The neural network is trained based on a machine learning approach i.e.

Genetic Algorithm, in order to optimize the result. The network will map the input image into any one of the classes with respect to the exemplars by adjusting the weights. Genetic-based feature weighting significantly improves the accuracy compared to presently available solutions. The objective function for the training phase is taken as "the number of output determination errors should be minimal". Fitness population (weights) is then found out by considered the objective function. Mutation and/or crossover are applied on the population which improves the fitness of the solutions. This process is repeated several times to get the optimum result. (Fig.7)

No. of Face Image	Successfully Recognized Face Image	Unrecognized Face Image	Efficiency (%)
5	5	0	100
13	13	0	100
25	24	1	96
50	48	2	96
100	95	5	95
200	185	15	95

Fig 7: Experimental Result

It is observed from the experiment that the efficiency of the proposed face recognition system is 97.01%.

V. CONCLUSION

In this paper we have presented the model of a static Face Recognition System using the concept of Eigen Domain with Neuro-fuzzy Classifier and Genetic Algorithm based optimization. A new training method using Genetic Algorithm is introduced here for effective training of the artificial neural network, which improves the accuracy of the system and reduces the time requirements. Fuzzification of PCA values is also introduced before the neural network stage to further improve the accuracy. The entire problem is treated as an optimization problem and the technique used here is one of the most efficient. The maximum efficiency is observed to be 97.01%. The efficiency can be further increased by using a better face scanner, better techniques for scaling as well as efficient techniques of edge detection and feature extraction of the face image.

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