Human Face Recognition Using PCA based Genetic Algorithm

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Abstract— **This paper illustrates an approach to recognize a face using Principal Components Analysis based Genetic Algorithm in the area of computer vision. Facial image analysis plays an important role for human computer interaction, although automatic face recognition is still a big challenge for many applications. The PCA is applied to extract features from images with the help of covariance analysis to generate Eigen components of the images and reduce the dimensionality. Genetic Algorithm is an optimization technique which gives the optimal solutions from the generated large search space. For our experiment we used Japanese Female Facial Expression (JAFFE) face database with an encouraging result approximately 96%.**

Keywords—*Face recognition, Principle Component Analysis, Genetic Algorithm, Feature Extraction, Biometrics.*

I. INTRODUCTION

In the field of computer vision the face recognition has become increasingly relevant in today's scenario. Face recognition has been one of the interesting and important research fields in the past years [2]. Face recognition is a method by which a face is automatically identified. There are training image with high resolution and if there is any noise then it is filtered and [back groundless] image are taken as a training image and identifies it by a test image [6]. To identify the facial expression still a challenging task now a days. In this paper we discuss face recognition process of human various facial expression using PCA based Genetic Algorithm. To better use the face recognition for the purpose of compression of data is mandatory. Image can be compressed as structural features such as contents and region [1].The image is reshaped in low dimensional subspace.

This lower dimensional subspace can be represented as a linear combination of eigenfaces .this Eigen faces later used in GA. Most of the face recognition approaches are based on either the overall analysis of the face image that retails to the global information of the face on the location on shape of facial attributes as the eyes, eyebrows, nose, lips etc [Neural+GA].there are various algorithm to implement it such as LDA, PCA, HMM, SVM,ICA.

Genetic Algorithms (GAs) are a part of Evolutionary computing, a rapidly growing area of artificial intelligence. It was first developed by Jon Holland-university of Michigan based on the Darwin's theory "survival on the fittest" to provide an efficient techniques for optimization[7].Genetic Algorithms represent an intelligent exploitation of a random search used to solve optimization problems. Although it randomized, exploit historical information to direct the search into the region of better performance within the search space. Genetic Algorithms are the ways of solving problems by mimicking processes nature uses; i.e. Selection, Crossover, Mutation and Accepting, to evolve a solution to a problem.

In Genetic Algorithm some necessary terms are

− Chromosome: A set of genes; a chromosome contains the solution in form of genes.
− Gene: A part of chromosome; a gene contains a part of solution.
− Population: number of individuals present with same length of chromosome.
− Fitness: the value assigned to an individual based on how far or close an individual is from the solution; greater the fitness value better the solution it contains.
− Fitness function: a function that assigns fitness value to the individual. It is problem specific.
− Mutation: changing a random gene in an individual.
− Selection: selecting individuals for creating the next generation.
− Crossover: Crossover is a genetic operator that combines two chromosomes to produce new chromosomes for the offspring.

In solving problems, some solution will be the best among others. The space of all feasible solutions (among which the desired solution resides) is called search space. In this process after extracting the features we calculate the weights of all Eigenfaces and these value acts as search space. Each point in the search space represents one possible solution**.** Each possible solution can be "marked" by its value or fitness for the problem. The GA looks for the best solution among a number of possible solutions represented by one point in the search space. Looking for a solution is then equal to looking for some extreme value in the search space. This is motivated by the possibility that the new population will be better than the old one. Solutions are selected according to their fitness to form new solutions called offspring; more suitable they are more chances they have to reproduce. This is repeated until some condition is satisfied. In this system PCA is used for

feature extraction and Genetic Algorithm is used for recognition.

II. Related work

Many papers published on face recognition for different purpose to overcome different problem. Such as illumination conditions, facial expressions, facial accessories, aging effects, pose etc. To overcome these problems many researchers have developed many systems. Some are on Principal Component Analysis based , some system are on LDA, some system have been used Neural Network, some systems have been used combining Neural Network and Genetic Algorithm and some are on combining Principal Component Analysis and Genetic Algorithm etc. But still it is a challenging task to recognize face images from a set of face images. Still there is no method by which it can be possible to recognize images successfully with the recognition rate 100%. Some researchers have developed a system which gives better recognition rate, some have developed better system which reduces the computational time.

such as using the concept of Genetic algorithm and Step Error Tolerance Back-propagation Neural Network and digital image processing has been published some paper. A static Face Recognition system has been developed. The maximum efficiency is 82.61% for Face Recognition System by using Genetic algorithm and the maximum efficiency is 91.30% for Face Recognition System by using SET-BPN.

In PCA based face recognition the algorithm for real-time human face tracking is realized. The algorithm takes the advantage not only of geometric relations between a human face, but also of a good feature extraction. The accuracy of the single-face detection is better than 92% with a simple background and sufficient light source. From experiments, the multi-face detection results in slightly higher rate of misjudgment. The f ace detection is accomplished regardless of the viewpoints no matter it is a front view or a side view.

In LDA the ability of discriminant analysis to extract discriminant functions that are capable of producing accurate classifications is enhanced when the assumptions of normality, linearity, and homogeneity of variance face is represented as a collection of LDP codes for face recognition process. PCA encodes information in an orthogonal linear space, while LDA encodes discriminating information in a linearly separable space and it is not necessarily orthogonal. It is generally believed that algorithms based on LDA are superior to those based on PCA are satisfied.

LDA (Linear Discriminant Analysis) is not an unsupervised learning Algorithm, it is a supervised learning Algorithm. In LDA, the LDP features are obtained by computing the edge response values in all eight directions at each pixel position. It generates a code from the relative strength magnitude. Each

Some times to recognize image combining two or more systems give better recognition rate. In this paper we have discussed a combining system "PCA based Genetic Algorithm" which gives a good recognition rate and reduces computational times.

III. PrincipalComponent Analysis

In PCA the probe and gallery image must be the same size. The image is treated as the 2-D matrix and as a single vector. The first step is to load the training images. The images must be grayscale image with a consistent resolution. If the image includes background the face recognition approach will not work properly. Each image is converted into column vector by concatenating the row and the images one loaded into a matrix of size M*N, where N is the number of pixel s in each image and M is the number of images .The average image has to calculate and then the deviation is called by subtracting the mean from each original image .Calculate the covariance matrix and then calculate the Eigen vector and the Eigen values of the covariance matrix. These Eigen vectors are called Eigen faces.

Block diagram of Eigen face extraction using PCA:

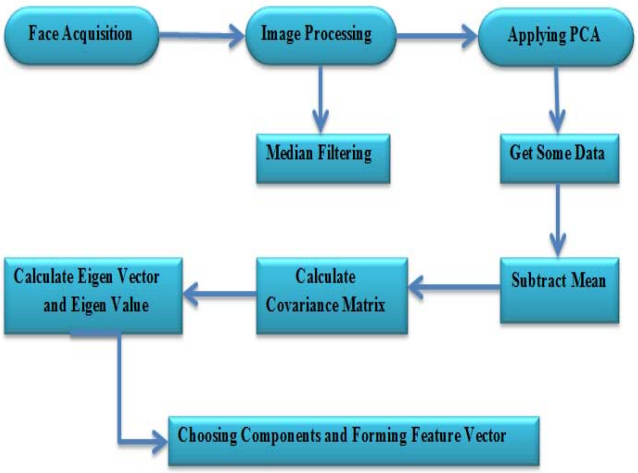

Fig. 1. Block Diagram of PCA

IV. Genetic algorithm

A genetic algorithm is an adaptive heuristic search Algorithm based on the evolutionary ideas of natural selection and Genetics. It is a search technique to find approximate solution for optimization and searching problems. Fitness function is derived from the objective function .The value of the fitness function will not be negative.

The basic genetic Algorithm is as follows

1. Initialize the population with random candidate solution.
2. The algorithm then creates a sequence of new population .In at every step the algorithm uses the individuals in the current Generations to create the next population. To create new population the Algorithm performs the following step.

a. Scores each number of the current population by computing its fitness value. Greater the fitness value better the solution it contains.

b. Select individuals for creating the next generation according to their fitness value.

c. The lower fitness is the current populations are chosen as elite and that does not include in the next population.

d. Operate the cross over operation on the population .If the best fitness value is calculated then go to step 2.If not then operate mutation operation that changes a random gene is individual.

3. Go to the step 2 and continue until best solution can be found.

4. End.

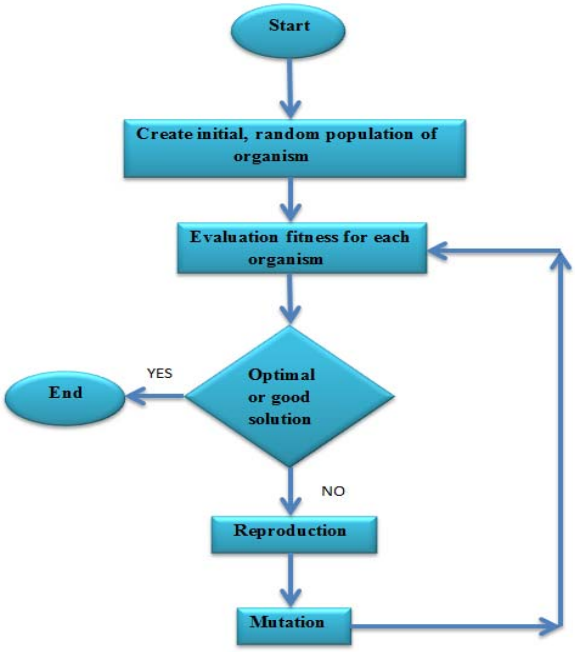

Fig. 2. Flow chart of Genetic Algorithm

V. METHODOLOGY

A. *Principle Component Analysis (PCA)*

In this thesis, Japanese female facial expression standard database has been used. A 2-D facial image can be represented as a 1-d vector by concatenating each row into a long thin vector. In below it has been used the main approach of PCA where the symbol M represents the number of training image, φ represents the mean or average image, C represents the Covariance matrix, ϕ represents the deviation. I_i also represents each image as a vector of T_i.

a. At first have M image, each image is N×N dimension. Each image can be representing as a point of N dimension space.

$$A=N^2\times M \qquad (1)$$

Fig. 3. Train & Test images

b. the mean,

$$\varphi = {}^{1}/_{M} \times \sum_{i=1}^{m} Tl \qquad (2)$$

Fig. 4. Mean image

c. Find the deviation,

$$\phi_i = T_i - \varphi \qquad (3)$$

d. Covariance,

$$C= AA^T \qquad (4)$$

Where $A=\lfloor \phi_1, \phi_2, \phi_n \rfloor$ and $C=N^2\times N^2$ matrix, because $A=N^2\times M$ matrix, so C is huge. Find out $L=A^TA$ that reduces the dimension.

Now calculate the Eigen vector of C using this equation

$$U_i=AV_i \qquad (5)$$

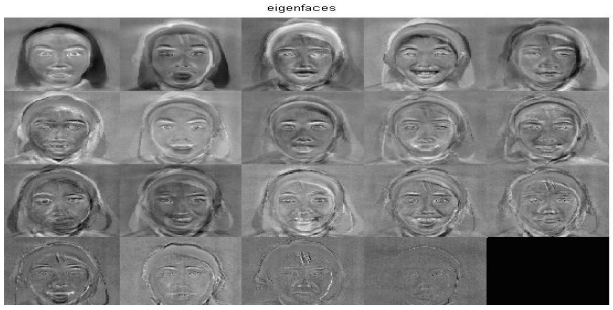

Fig. 5. Eigenfaces

e. Select the best Eigen vector, the selection of the Eigen vectors is done heuristically

B. *Genetic Algorithm*

1. At first we toke the Eigenfaces that were extracted by principle component analysis shown in figure 6.3.

2. Then calculate the frequency of each gray level.

3. Define a objective function and calculate the fitness value of each Eigenfaces.

4. Operate the Genetic Algorithm operation on the weights of each Eigenfaces. After operating Crossover we get the Following image.

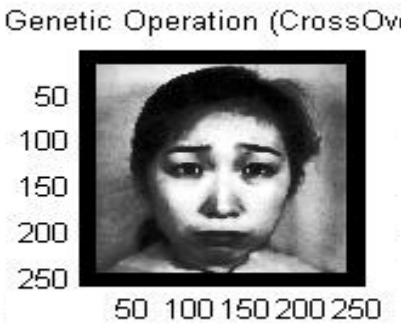

Fig. 6. Image after applying Crossover

5. If the total Eigenfaces are 20 then we will find the 20 fitness values.

6. Sort the fitness value.

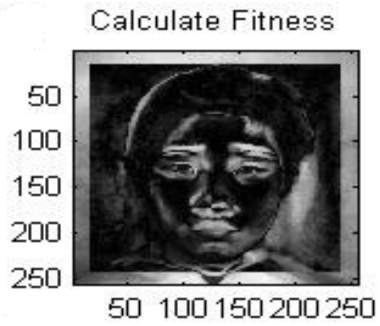

Fig .7. Corresponding image of Fitness value

7. Get a Test image from Test folder.

8. Then go to step 2-4.

9. Subtract the Test image fitness value from the Train images fitness value.

10. Sort the difference values.

11. Minimum value is selected.

And the stop condition of the GA scheduling function is as Eq.1 where bf_c is the best fitness value in the current population, bf_p is the best fitness value in the past population, θ is a boundary variation, and f_t is the minimum fitness threshold.

$$|bf_c - bf_p| \leq \Omega, \quad (ft \leq bf_c \qquad (6)$$

If, the above stop condition is met, then the GA scheduling function stops and outputs a chromosome with the best fitness value, i.e., the best task schedule otherwise, the GA scheduling function continues restarting or reproducing a population.

VI. RESULT AND ANALYSIS

Face recognition system using the concept of principal component analysis and Genetic Algorithm has been discussed. The simulation is done in MATLAB environment. For implementation this work different sample images for Train and Test Database were taken. The MATLAB code was run for a single Test image approximately 20 seconds for 20 Train and Test images and 78 seconds for 100 Train and Test images. The efficiency calculation for our experiment is given in table 1.

Table 1 Efficiency calculation for PCA based GA.

No. of Face Image	Successfully Recognized Image	Unsuccessfully Recognized Image	Efficiency (%)	Error (%)
10	9	1	90%	10%
20	19	1	95%	5%
50	48	2	96%	4%
100	96	4	96%	4%

The efficiency for face recognition using PCA based Genetic Algorithm is 90% for 10 sample images, 95% for 20 sample images, 96% for 50 sample images, and 96% for 100 sample images. The error rate is 10% for 10 sample images, 5% for 20 sample images, 4% for 50 sample images, and also 4 % for 100 sample images.

We can see from the above that if the no. of sample images are increased then the accuracy is also increased and the error rate is decreased.

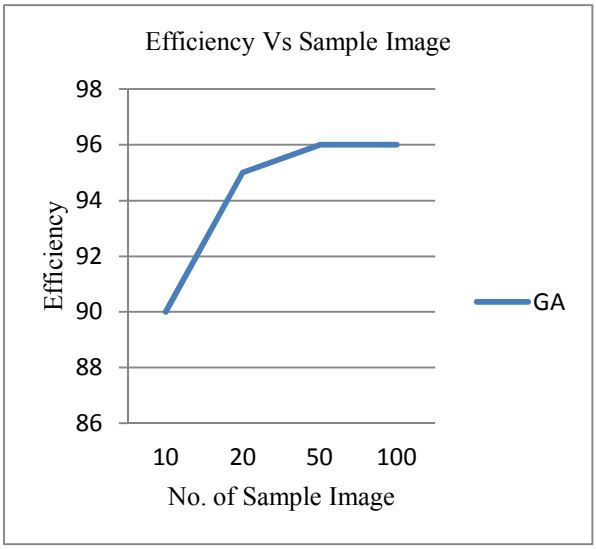

Fig.8. Efficiency versus No. of Sample Image.

VII. CONCLUSION

Face recognition is highly popular area of research. In this paper, we try to explain basic concepts of face recognition using PCA based Genetic Algorithm. It is an efficient method for recognizing the face in the images.

The PCA based face recognition reduces the computational time and improves the processing speed of face recognition. We used different facial expression of human face images for this experiment. The average Efficiency of this experiment was 94.25% and the average error rate was 5.75%. The experimental result of this paper shows that this method is better robust suitable and high Efficiency than any other before. There are some problems in the time of data processing and extracting feature of face images by which the efficiency is less than 100%.

VIII. REFERENCES

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