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Design and Implementation of a Novel Face Recognition System

Manan Kumar Tiwari, Dr. Neeta Tripathi

Abstract— **Biometrics is the field of statistical analysis of biological data and it becomes the most promising but also a challenging task when it comes to recognition of a particular personal. Face is one of the best accepted biometric characteristics of a person for identification as it is always open to society. Therefore face recognition finds application in security systems, criminal identification, social networking and many other image and film processing. Present work proposes a robust and efficient face recognition system.**

In the present approach a novel face recognition system is proposed which detects a face in a given test image, extracts features from the test image and then recognizes the person by locating the extracted features of the person on the face images of known individuals present in the database. The image on which maximum features are located is said to be the recognized person. For the extraction of the facial features like eyes mouth nose etc, from the facial image morphological operations and canny edge operator are applied. The proposed system is trained using Genetic Algorithm.

The proposed system is tested on a great variety of human faces of varying pose, and wears (glasses, moustaches, beard etc.). Experimental results show that the proposed system recognizes an individual with a good accuracy even if the person comes in different poses. The recognition rate increases when the number of images per subject increases in the database.

***Index Terms*—Feature Extraction, Genetic Algorithm, Localization, Morphology, edge detection.**

I. INTRODUCTION

Pattern recognition is a modern day machine intelligence problem with a number of applications, including face recognition, character recognition, speech recognition as well as other types of object recognition.

Approaches to pattern recognition may be divided into two principal areas: decision theoretic and structural approach. The first category deals with quantitative descriptors such as length, area, texture, and many others. The second category deals with patterns best represented by symbolic information and described by the properties and relationship between these symbols. The nature of the components of a pattern depends upon the approach used. In some applications the pattern characteristics are best described by structural relationship, for example, face recognition is based on the inter relationship of eyes, nostrils, mouth, etc. called as features. Together with their relative sizes and locations, these features are primitive components that describe the face. Recognition of this type in which not only the quantitative measures about each feature but also the spatial relationship between the features determine class membership, generally are best solved by structural approaches.

Face recognition can be considered as a pattern recognition task which is performed specifically on faces. Face recognition is a pattern recognition problem where we classify a face either "known" or "unknown", after comparing it with stored known individuals. It becomes more fast and accurate if we have a system that has the ability of learning to recognize unknown faces. [4]

Face recognition involves comparing an image with a database of faces in order to identify the individual in the input image. The related task of face detection has direct relevance to recognition because images must be analyzed and faces identified, before they can be recognized.

Any recognition process is divided into two main operations: face identification and face verification. Facial identification consists in assigning the input face image to one person of a known group, while face verification consists in validating or rejecting the previously detected person identity.

Also, face recognition techniques could be divided into two categories: geometric and photometric approaches. Geometric techniques look at distinguishing individual features, such as eyes, nose, mouth and head outline, and developing a face model based on position and size of these characteristics. Photometric approaches are statistical techniques that distill an image into values and compare these values with templates.

A number of points have to be considered during the analysis phase of a face such as pose, occlusion, lightening conditions, background, illumination and many other environmental factors. For this reason there are some methods which use frontal face image for identification [2].

Contribution: In this paper a robust and efficient face recognition algorithm is proposed which pre-process the image, train the database using Genetic algorithm, extract features, and locate these extracted features on the face database to recognize a person. In Preprocessing color conversion, noise reduction and edge detection is performed

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Manan Kumar Tiwari, *Electronics & Telecommunication, CSVTU Bhilai/SSGI Junwani/). Bhilai, India, 9907306226*

Dr. Neeta Tripathi, *Principal SSITM Bhilai /SSGI Junwani/ CSVTU Bhilai,C.G India*

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to increase the quality of the face image while retaining the important characteristics. The database is trained using BPNN and the weights are calculated using genetic algorithm. The geometric features from a facial image are obtained by considering the face image as a surface, and with the help of edge detection and a sequence of morphological operations eyes, nose and mouth are extracted as feature. The person is classified as known or recognized if all the features are correctly located on a particular image present in the database.

II. Background and Related Work

J Canny [1] in 1986 presented a computational approach to edge detection. He defined detection and localization criteria for a class of edges, and presented mathematical forms for these criteria. L.S Davis [2] in 1975 presented a survey of edge detection techniques employed for extracting facial features which used directional derivatives estimated with a random field model.. Aysegul Gunduz et.al [13] presented a robust model where the facial image was considered as a surface**.** Topological properties of the facial surface, such as principle curvatures were used to extract the eyes and mouth which form deep valleys on the surface**.** Aishy Amer [14] in his paper proposed, new operational definitions of binary morphology, both conditional and non-conditional, operations were proposed. The new operations were applied to detect boundary points from binary images. Y. T. Zhou et. al. [17] suggested the edge detection problem as one of detecting step discontinuities in the observed correlated image, using directional derivatives estimated with a random field model.

R. C. Gonzalez [16], in his book Digital image processing, has mentioned object recognition as a pattern recognition problem. He has described two approaches for the pattern recognition problem which depend upon the type of application of interest. The first approach deals with quantitative descriptors and the second category deals with patterns best represented by symbolic information and described by the properties and relationship between these symbols

Afsaneh Alavi Naini et al. [18] proposed a face detection method based on dimensionality reduction and genetic algorithm. They used Genetic Algorithm (GA) to select a subset of features from the low-dimensional representation by removing certain eigenvectors that do not seem to encode important information about face. P.Latha et al. [19] presented a neural based algorithm, to detect frontal views of faces. The dimensionality of face image is reduced by PCA and the recognition is done by the Back propagation Neural Network (BPNN). Philipp Koehn [20] Presented in his thesis that a network can be trained using BPNN and the initial weights can be calculated using GA**.**

III. Methodology

The proposed face recognition system consist of following phases

IV. The Database creation phase
V. Training phase
VI. Testing (Recognition) phase.

The block diagram of the proposed face recognition system is presented in Figure.1.The basic face recognition system works in three phases. The first phase comprises of pre-processing of face image which includes removing noise from the image, blur, resizing, and normalization. In Preprocessing color conversion, noise reduction and edge detection is also performed to increase the quality of the face image while retaining the important characteristics. In the second phase the geometric features from a facial image are obtained by considering the face image as a surface, and with the help of edge detection and a sequence of morphological operations eyes, nose and mouth are extracted as feature. The system is trained by means of BPNN training methods and the weights are calculated using Genetic Algorithm [20]. The extracted feature vectors are then applied to the classifier algorithm in the last phase, which tries to recognize a face as known or unknown. The person is classified as known or recognized if all the features are correctly located on a particular image present in the database.

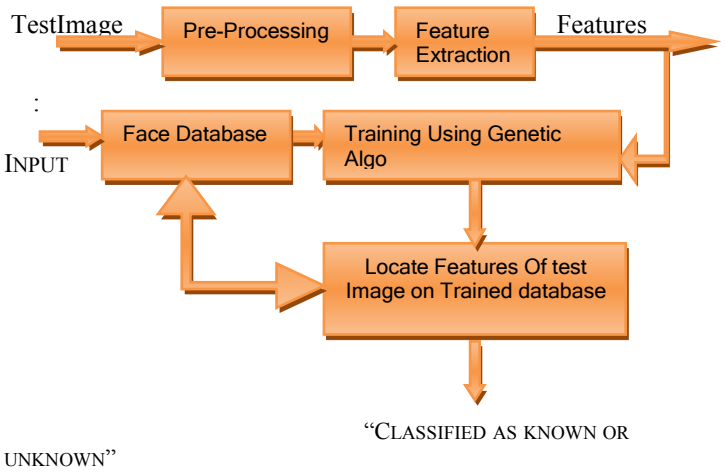

Figure.1. Proposed face recognition system

The block diagram of the database training phase is presented in Figure.2.

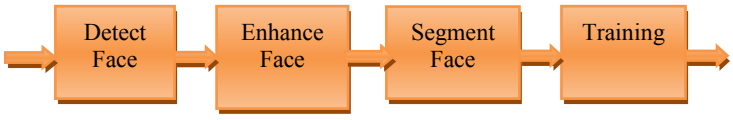

Figure.2 Database training phase

A. *Face detection*: A proper image face registration is essential for a good face-recognition performance. In the proposed system face detection is a necessary first step, with the purpose of localizing and extracting the face region from the background. In the present work feature based approach has been for detecting a face.

B. *Enhance face:* After detecting a face from a complex background the necessary next step is to perform some image pre-processing operations [4]. First, the original face images have to be converted to the grayscale form. Then, some contrast and illumination adjustment operations are performed. Such as histogram equalization operations, to obtain a satisfactory contrast [4]. Also, the facial images are often corrupted by various types of noise. So, the images are processed by proper low-pass filters, for noise removal and

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restoration [6]. In the present work a robust image denoising and restoration techniques called as Gabor filter is used.

C. *Segment Face:* The goal of image segmentation is to cluster pixels into salient image regions, Segmentation produces homogeneous regions where each region has uniform gray level, each region is a binary image (0: background, 1: object or the reverse) and binary images are easier to process and analyze as compared to other forms of image. In present work after denoising the image segmentation is performed on all the images present in the database so as to convert them in a form easy to be processed.

D. *Training Using Genetic Algorithm*: The database is trained using back propagation neural network genetic algorithm. In the present work Genetic Algorithms [18] are adopted to solve the task of assigning initial weights for the neural network. The segmented face images in binary form acts as population P, which consist of N elements, where N is the population size. Each element in P is called a chromosome. The population P evolves into another population P' by performing some genetic operations. The chromosomes with higher fitness values will have more probability to be kept in population of the next generation and to propagate their offspring. On the other hand other stronger chromosomes will replace the weak chromosomes whose fitness values are small. Therefore the quality of chromosomes in the population will be better. After a suitable number of generations the mature population will be expected to contain the element with the optimum value of weights. Figure.3 presents a sample image database input to the training algorithm.

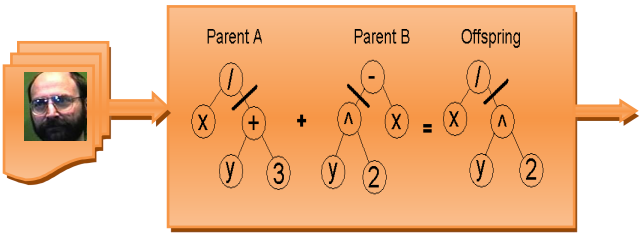

Figure.3 Training of Database

Testing Phase

In the testing phase the features are extracted from the test image and these features, after some steps of processing, are projected on the trained face database for locating the features. Figure.4 presents the sequence of steps.

Centroid specifies the center of the mass of the region. After selecting the strong features Centroid of each feature is Figure 5 presents an image of subject Vivek input to system. Calculated. It has been experimentally observed that without calculating Centroid the recognization process takes much longer time.

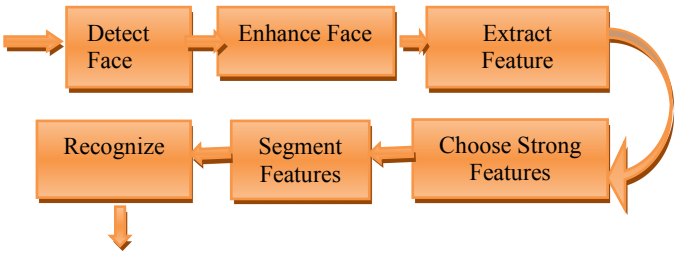

Figure.4. Testing phase of proposed system

A. *Feature Extraction*:

Facial feature extraction, in general refers to the detection and extraction of eyes, mouth, nose and other facial components. In the feature extraction the set or groups of pixels having same information or approximately same pixel value are extracted. Out of the total number of pixels of a face image there are set of pixels which have nearly same pixel value and thus convey same information. This information is unique for a particular individual, for example the information conveyed by the left eye pixel value and the right eye pixel value of a individual will serve as a unique information for that particular individual. If this information is stored in a gallery in form of features for the individual these features can be used to recognize him for the next time.

In proposed face recognition system the features are extracted by considering the facial image as a surface [13]. The properties of a surface such as deep valleys and ravines are applied to the facial image. Considering the fact that a surface can be uneven, our aim now becomes to detect the points or boundaries of unevenness.

The eyes and mouth are singularities in the facial image and form deep valleys on the facial surface. The key point here is to model the feature of interest as ravines on image surface.

To detect the boundaries of the valleys and ravines, edge detection operators such as canny edge detection operator, Sobel, Prewitt, Robert are used. Among these Canny Edge operator [1] provides better results and has been used in present work. For extraction of the ravines, morphological operations such as dilution, erosion, opening, closing and combination of opening and closing have been applied.

B. *Choose Strong Features*

After extraction of features from the facial image the algorithm selects strong features among different features extracted. Strong features are those features which represent the facial image strongly such as left eye, right eye, nose, mouth as these features are unique for an individual.

C. *Calculate Centroid*

D. *Recognize*

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The system starts the recognition process by trying to locate each selected strong feature on the trained database images one by one.

IV. Experimental Results

In proposed work for experimentation 150 images are considered. The database of images is formed by clicking real time pictures by a 10 mega pixel camera. Some image from the Yale database has also been taken. The database includes a great variety of human faces of varying pose, and wears (glasses, mustaches, beard etc.).

For the database training BPNN has been used and the weights are calculated using the genetic algorithm. (GAs) operates iteratively on a population of structures, each of which represents a candidate solution to the problem, encoded as a string of symbols (chromosome). A randomly generated set of such strings forms the initial population from which the (GAs) starts its search. Three basic genetic operators guide this search: selection, crossover and mutation.

In feature extraction the extracted ravines comprise all the important features of the face: eyes, eyebrows, mouth opening, nose and nostrils. Although we have only focused on the extraction of the mouth, eyes, and nose, the choice of an appropriate threshold may lead to the extraction of any other facial component of interest.

To start with, the experiment is carried out first for a single image for each subject and the recognition rate is calculated. Then for the second time we test the proposed system by including 2 image per subject (each in different pose) in the database, then for 3 image per subject(each in different pose) in database, and so on.

One of such experiment is shown in Figure.5. A test image is input to proposed system. After a sequence of pre-processing and after feature extraction, the features of test image are projected on to the face space present in the database and the recognization algorithm tries to locate the features of test image on the images present in database.

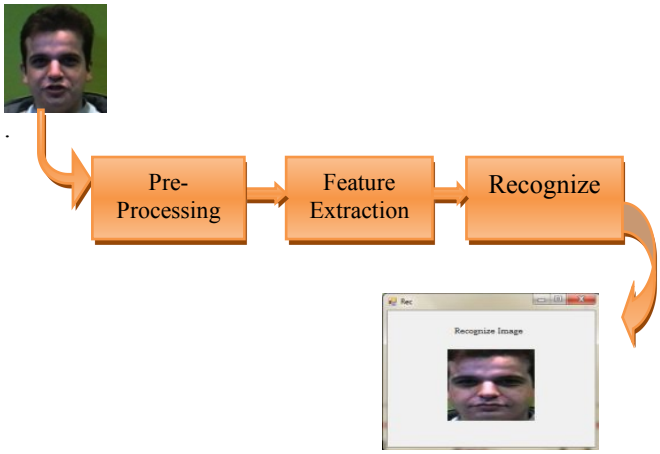

Figure.5 Test Image of Subject (Vivek) input to proposed system

The proposed recognition algorithm displays two outputs figures. The first figure is the Recognized Image and the second figure shows the percentage that how much features of test image is located on to a particular image present in the database.

The percentage location of test features on database images is presented in Table No. 1. At the time of this experiment the numbers of images per subject in database were 5 and total numbers of subjects were 7.

Table No. I. Results showing percentage match of test features on database image

S.NO.	NAME OF SUBJECT	NUMBER OF IMAGE/SUBJECT	%AGE LOCATION OF TEST FEATURES ON DATABASE IMAGES
1	ASHOK	5	46.3506%
2	GOPI	5	00.00%
3	JIM	5	43.970%
4	SAHU	5	00.00%
5	VERMA	5	44.658%
6	**VIVEK**	5	**88.199%**
7	VIRU	5	00.00%

Figure.6 presents the experimental result that how much features of test image is located on to a particular image present in the database, when the features of the test image were projected on face space.

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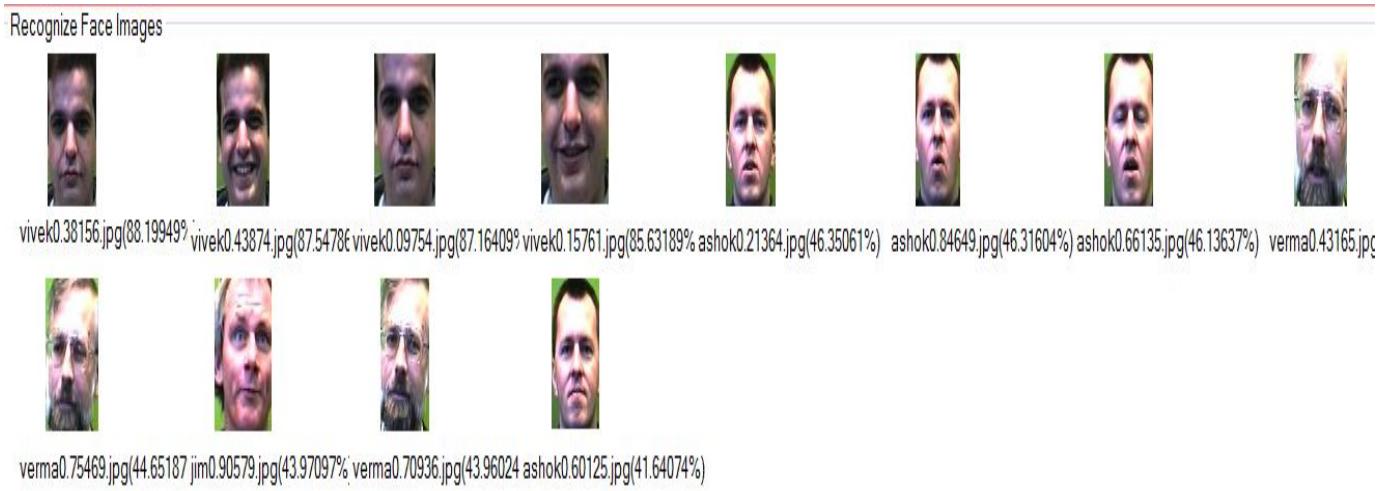

Figure. 6 Percentage of how much features of test image is located on to a particular image present in the database

To have a more clear insight of the results, some of such experiments are presented in Table No. II. The experiments were carried out in different rounds for same subjects. In Table No. II below five rounds are presented for different subjects. In each round number of images per subject is increased.

Table No. II. Some Experimental Results for five different subjects

S.NO.	SUBJECT NAME	NUMBER OF IMAGES PER SUBJECT	TOTAL IMAGES	RECOG. RATE PERCENTAGE
1	ASAMA	1	5	20%
2	DESHMUKH	1		
3	SEEMA	1		
4	LYOD	1		
5	RAMESH	1		
6	ASAMA	2	10	60%
7	DESHMUKH	2		
8	SEEMA	2		
9	LYOD	2		
10	RAMESH	2		
11	ASAMA	3	15	87%
12	DESHMUKH	3		
13	SEEMA	3		
14	LYOD	3		
15	RAMESH	3		
16	ASAMA	4	20	94%
17	DESHMUKH	4		
18	SEEMA	4		
19	LYOD	4		
20	RAMESH	4		
21	ASAMA	5	25	96%
22	DESHMUKH	5		
23	SEEMA	5		
24	LYOD	5		
25	RAMESH	5		

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It can be observed from the above Table No. II that if the number of images (each in different pose) per subject is increased. Recognition rate of individual also increases.

. The overall recognition rate results have been presented in the Table No. III for different experiments. And the Recognition rate graph is presented in Figure.9.

Table No. III Overall Results of the proposed face recognition system

	Exp .1	Exp .2	Exp .3	Exp .4	Exp .5	Exp .6	Exp .7	Exp .8	Exp .9
Total No. of Subject	5	5	5	5	6	7	8	9	10
No. of Image Per subject	1	2	3	4	5	6	7	8	9
Total Images	5	10	15	20	30	42	56	72	90
Recognition rate %age	20 %	60 %	80 %	85 %	87 %	95 %	92 %	95 %	94 %

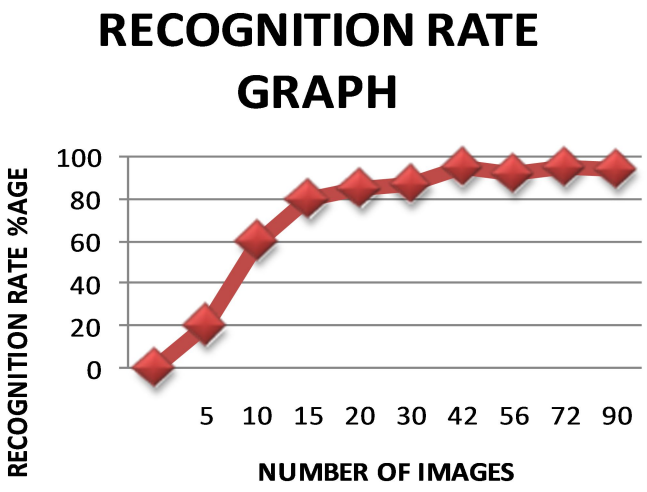

Figure.9 Graph showing Recognition rate vs Number of images of same person

V. Conclusion

In this paper a new method for face Recognization system is proposed. In this method features are extracted using an edge detector and morphology. The recognization algorithm tries to locate maximum features of the test image on the face space of trained database. The image on which maximum features are located is said to be the recognized person. The method gives good results when number of images per subject (each in different pose) increases in the database.

VI. Future Scope

The proposed system use Edge detection and morphology for extracting the features from the face image, therefore in future the system can be made to extract features by more robust methods of feature extraction. The present system works for still images, therefore in the future the system can be implemented for moving films.

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