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Face Recognition Based on Facial Features

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Abstract: Commencing from the last decade several different methods have been planned and developed in the prospect of face recognition that is one of the chief stimulating zone in the area of image processing. Face recognitions processes have various applications in the prospect of security systems and crime investigation systems. The study is basically comprised of three phases, i.e., face detection, facial features extraction and face recognition. The first phase is the face detection process where region of interest i.e., features region is extracted. The 2nd phase is features extraction. Here face features i.e., eyes, nose and lips are extracted out commencing the extracted face area. The last module is the face recognition phase which makes use of the extracted left eye for the recognition purpose by combining features of Eigenfeatures and Fisherfeatures.

Keywords: Detection, eigenfeatures, face, fisherfeatures, recognition, segmentation

INTRODUCTION

Various operations make use of computer based procedures and methods in order to execute processing on digital images. These operations are comprised of methods such as image reconstruction, enhancement, compression, registration, rendering, analysis, segmentation, feature extraction, face detection and recognition, respectively all these processes are component of a huge field called digital image processing.

Face recognition is an enormous field comprised of huge processes of investigation and examination based methods. Each year the attempted solutions grow in complexity and execution times. If we examine the history of face recognition filed then we can see that the work on this field has its initialization roots in the times almost 35 years back from the present time. Most demanding field in the image processing is face detection and recognition system, numerous methods and techniques have been proposed and developed in this regard, but still there is a huge room for new and effective work. If we talk in general about the face recognition process then we can say that it is a process comprised of examining a person's face and then relating and matching the scanned face next to a data base consisting of acknowledged faces. It identifies individuals by features (Hiremath *et al.*, 2007).

Pattern recognition is a dynamic subject in prospect of human face recognition. It has huge range of applications such as recognition, driving certification and identification portrait confirmation, check organism of banks, mechanical safety methods, image dispensation, visualization centred human device communication, face detection and recognition and in the prospect of entertainment.

There exist two main types in regard of human face identification centred on holist or examination of facial features. One type makes use of all the characteristics of a pattern or facial features. The main methods under this field are neural network based face recognition (Khanfir and Jemaa, 2006), elastic graph match method for face recognition (Wiskott *et al*., 1999), Eigenface (Turk and Pentland, 1991), fisher faces and face recognition through density-isoline examination face equivalent. The second type in this regard works on specific features extracted from the face. The main methods under this type include face recognition through facial feature extraction, template matching approach (Hsu *et al*., 2002) and boundary tracing approach. Face recognition base on human face geometry was also an area under consideration (Basavaraj and Nagraj, 2006).

Face recognition in many techniques seems like three phase process i.e., face detection, features extraction and lastly the face recognition phase (Zhao *et al*., 2003).

In this study face detection, features extraction and recognition technique is presented which detects the face from the frontal view face images based on skin colour information. After that face region containing the face is extracted. After having the detected face, the eyes are

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extracted using eye maps. Then nose and lips are extracted on the basis of distance between the two eyes. After the features extraction, a small face region is picked in order to improve the computational time. The picked region is the left eye from the extracted features. For the recognition purpose combination of Eigenfeatures and Fisherfeatures is used.

LITERATURE REVIEW

Existing work: There are various diverse methods proposed in the perspective of face recognition. Huge work has been done in this area and many different methods had been used for the face detection and recognition purpose. These methods are ranging from Eigen face approach (Turk and Pentland, 1991), Gabor wavelets (Duc *et al*., 1999; Zhang *et al*., 2005) to 2D discrete cosine transform for facial features extraction (Eickler *et al*., 2000), geometrical approach (Hiremath and Ajit, 2004; J´and Miroslav, 2008). PCA based facial features extraction (BELHUMEUR *et al*., 1997 a, b) has a drawback that the method is sensitive to the illumination changes. Few most commonly used methods are PCA (Turk and Pentland, 1991), LDA (Belhumeur *et al*., 1997 a, b), ICA (Bartlett *et al*., 2002), kernel methods, Gabor wavelets (Yousra and Sana, 2008; Zhang *et al*., 2004), neural networks etc. Many researchers used the facial features for the recognition purpose. Some extracted the face features values in the form of Eigen values or Fisher values and some used the features of face i.e., eyes, nose and lips to recognize the face images.

Accurate facial features extraction is important for accurate face recognition. Features are extracted in many different ways that provide different types of issues to be considered. An earlier approach to face features extraction was proposed by Yuille *et al*. (1989). He mainly used templates of deformable parameters to extract eyes and mouth. But the method was computationally expensive and accuracy was not guaranteed.

An existing method that extracts facial features and performs recognition based on these extracted features is developed by Wiskott *et al*. (1999). In this technique a feature extraction (iris, mouth) and face recognition approach is presented. Iris and mouth are extracted and the template matching approach is used for the recognition purpose. The algorithm first locates the face area by means of skin colour subsequent to the extraction of applicants of iris centred calculated costs. After that the mouth region is extracted by making use of colour space called RGB. After that associated component process is utilized to accurately extract out the lips region. In order to assure that detected lips are mouth, mouth corner points are extracted using a method called SUSAN approach. Lastly face identification is carried out using template matching process.

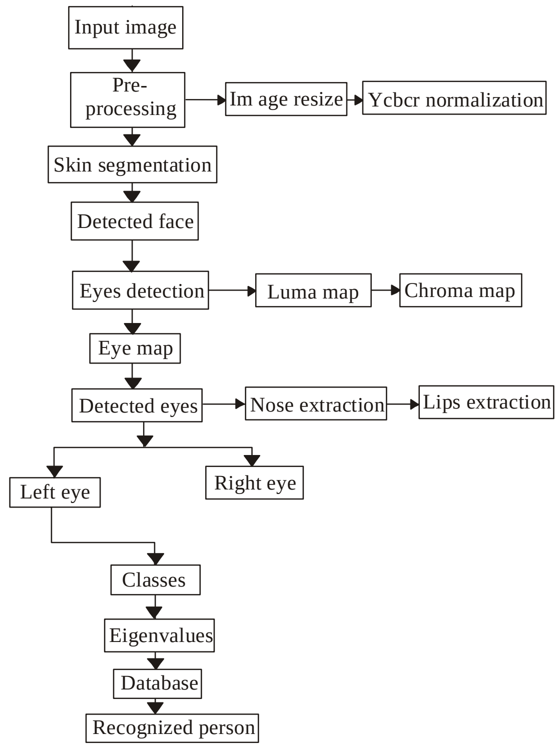


Fig. 1: System block diagram

Fig. 2: Input image

In proposed work, both methods were used for the recognition purpose. The features of the face are detected commencing the detected face and then left eye is picked whose Eigen and Fisher values are calculated for the recognition purpose.

MATERIALS AND METHODS

The proposed technique is basically face detection features extraction and recognition technique. The system contains there main phases which are:

- Face Detection
- Features Extraction
- Face Recognition

The basic working of the system is as follows (Fig. 1):

Face detection: The face detection phase further involves2 steps which are:

- Pre-processing
- Image resize
- Ycbcr conversion and normalization
- Skin Segmentation
- Face detection

Pre-processing: First an input image is presented to the system Fig. 2 represents an example input image.

Image resizes: When the method is offered with an input image the image is resized to 200×180 pixels in order to apply further processing.

Ycbcr conversion and normalization: The objective of this step is to compensate the lightening effects in the input image. The basic purpose is to attenuate noise from the image; this step works by converting the image to YCbCr colour space and finding the maximum and minimum values of luminance Y. Next average value of Y is calculated. Then according to that average value the values of red, green and blue components are adjusted. The process works as:

Y = Ycbcr conversion of the input image.

$$Y = 0.25\,R + 0.504\,G + 0.098B + 16 \quad (1)$$

$$Cb = 0.439\,R - 0.368\,G - 0.071B + 128 \quad (2)$$

$$Cr = 0.148\,R - 0.291 + 0.439B + 128 \quad (3)$$

First maximum and minimum values of Y are calculated using:

$$Ymin = min(min(Y) \quad (4)$$

$$Ymax = max(max(Y) \quad (5)$$

where Y=Ycbcr conversion of the input image.

After calculating the values, the subsequent step is to normalize the value of Y (luminance) which is done by:

$$Y = 255.0*(Y-Y_{min})/(Y_{max}-Y_{min}) \quad (6)$$

After that the average value of Y is calculated that is used for lightning compensation purpose:

$$Yavg = sum\ (sum(Y))/(W*H) \quad (7)$$

where,
W = Width of the input image and
H = Height of the input image

Input image resized YCbCr conversion

Fig. 3: Preprocessing stage

Fig. 4: Extracted skin

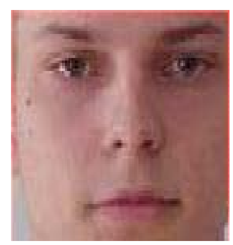


Fig. 5: Detected face region

The output of this step is shown in Fig. 3:

Skin segmentation: In the next step the image after preprocessing is used as input and skin region is extracted using the YCbCr colour space. This process basically utilizes the skin colour in order to separate the face region.

For this process the value of Cr (red difference chroma component) is fixed in a range and only pixels in that particular range are picked as skin pixels of the face. The range defined here is 10<Cr & Cr<45. Figure 4 represents the segmented skin region.

The process of skin extraction works as follows:

$$\sum_{i=1}^{j} R(i), C(i) = 1 \quad (8)$$

where,
j = Length(R,C)
R = Skinindexrow
C = Skinindexcolumn

Face detection: After having the skin region the face is isolated from that extracted skin region. Extra information is eliminated to obtain the region of concern i.e. the facial features region. Figure 5 represents the segmented face region.

Features extraction phase: The second phase is the features extraction phase. This phase receives the detected face as the input. Once the face is detected from the image, subsequently step is to find the features from the face region being detected. The extracted features are:

- Eyes
- Nose
- Lips

First of all eyes are detected using chrome and luminance maps Fig 6 and 7. After eyes nose and lips are extracted using a formula centered on the space existing among both eyes.

For the features extraction purpose 7 points are extracted resting on the face which are:

- Left eye center
- Right eye center
- Eyes midpoint
- Nose tip
- Lips center
- Lips left corner
- Lips right corner

Eye extraction: To extract the eyes from a human face the information of dark pixels on the face are needed. As the eyes are different from the skin colour, so using a colour space and separating the colours could be a good way to locate the eyes. The YCbCr colour space provides good information about the dark and light pixels present in an image. The colour space called YCbCr has the tendency to demonstrate the eye area with a high Cb and low Cr values. To detect the eye region 2 eye maps are constructed in the YCbCr colour space which show the pixels with high Cb and Low Cr values for the eye region Fig. 6.

$$ChromaMap = 1/3\ (Cb/Cr + Cb^2 + (1-Cr)^2) \qquad (9)$$

The luma chart is built by applying the morphological (Sawangsri *et al*., 2004) operations of erosion-dilation on the luminance component of the YCbCr image. These operations are applied to enhance the brighter and the darker pixels around the eye region in the luminance component of the image.

$$LumaMap = Ydialte / (Yerode -1) \qquad (10)$$

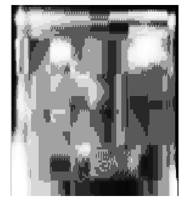


Fig. 6: Chromamap

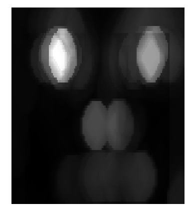


Fig. 7: Lumamap

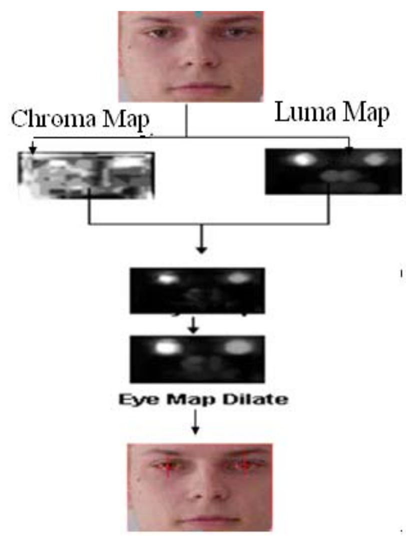


Fig. 8: Eyes extraction process

The Y image is dilated and eroded by a structuring element. Then both ChromaMap and LumaMap (Fig. 7) are added together to make a Map. This map is further dilated to brighten the eye pixels. The eye region is detected by applying thresholding and erosion on the Map.

The detected eye region is then marked and the eye is extracted from the image. Figure 8 represents the whole extraction process.

Nose and lips detection: The nose and lips are extracted on the basis of distance between the two eyes. The nose and lips are extracted by assuming that they lie at a specific ratio of the distance between the two eyes.

Nose detection: For nose extraction the distance between the two eyes is calculated as:

$$D = \sqrt{(L_x - R_x)^2 + (L_y - R_y)^2} \quad (11)$$

where,
D = Distance between the center points of two eyes
Lx = Left eye x coordinate
Rx = Right eye x coordinate
Ly = Left eye y coordinate
Ry = Right eye y coordinate

After having the eyes distance a formula is generated on the basis of that distance to extract the nose. It is assumed that nose lies at a distance of 0.55 of the eyes distance. This is done as:

$$N = (M_y + D)*0.55 \quad (12)$$

where,
N = Nose tip point
My = Eyes midpoint
D = Distance between the center points of two eyes

Lips extraction: For lips extraction the three lips points extracted are:

- Lips center point
- Lips left corner point
- Lips right corner point

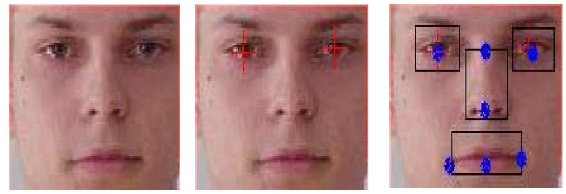
For lips extraction the distance between the two eyes is calculated as:

$$D = \sqrt{(L_x - R_x)^2 + (L_y - R_y)^2} \quad (13)$$

where,
D = Distance between the center points of two eyes
Lx = Left eye x coordinate
Rx = Right eye x coordinate
Ly = Left eye y coordinate
Ry = Right eye y coordinate

After having the eyes distance a formula is generated on the basis of that distance to extract the lips. For the lips center point, it is assumed that lips lie at a distance of 0.78 of the eyes distance. This is done as:

$$L = (M_y + D)*0.78 \quad (14)$$



Detected Face Detected Eyes Extracted Features

Fig. 9: Features extraction

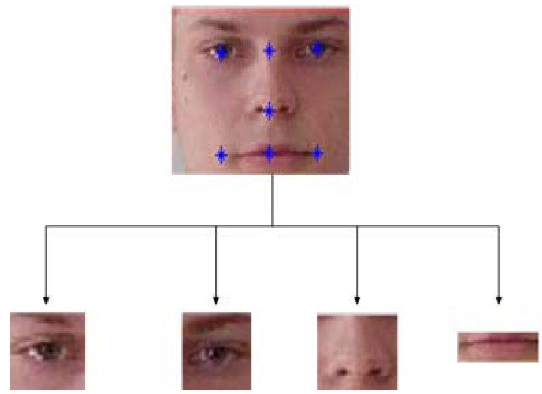


Fig. 10: Output of features extractionphase

where,
L = Center point of lips
My = The midpoint of the space among both eyes
D = Space among the center points of two eyes

Now for lips right and left corner point's extraction it is analyzed that the lips corners are almost located at a distance 0.78 of the eyes center points. These points are extracted as:

$$L_l = (L_y + D)*0.78 \quad (15)$$

where,
Ll = Left corner point of lips
Ly = Left eye y coordinate
D = Distance between the center points of two eyes

Similarly the right corner point of mouth is extracted as:

$$L_r = (R_y + D)*0.78 \quad (16)$$

where,
Lr = Right corner point of mouth
Ry = Right eye y coordinate
D = Distance between the center points of two eyes

The output of this phase can be seen in Fig. 9 and Fig. 10:

Face recognition phase: The last phase of this system is the face recognition phase. The phase makes use of two algorithms for the recognition purpose which are:

- Eigenfaces
- FisherFaces

The recognition stage makes use of extracted eyes for the recognition process. Here a small portion of the face is chosen to perform the recognition so that it can save the computational time and to increase the accuracy. For this purpose the chosen part from the face is the extracted left eye in order to recognize individuals.

The proposed approach to face recognition takes into account the fact that faces can be recognized using a smaller portion of the face. For this purpose the region of left eye is picked and a face eye space is defined. The eye area is professed through the Eigenfaces that are the Eigen-vectors of set of eyes of different individuals.

Most of the earlier exertion in the prospect of face identification using Eigenfaces focus on the fact that the faces are recognized by calculating the Eigenfaces of set of face features i.e., the whole face was considered and used for computing the Eigenvalues of different individuals. The proposed approach focuses only on the smaller region pf the face to recognize different individuals. Due to which the computational cost and time is efficient and reliable.

Calculating the eigenvalues: As there is a figure of diverse persons in a library called database, there is ensemble of different individual images creating different points in the eye space. The eye images that are much alike cannot be randomly distributed in the eye space because the purpose is to differentiate different individuals despite the fact that they may have features that are quite alike. So in order to describe such images a slight measurement area is needed. The chief objective of PCA is to discover such vectors that can effectively distribute the images in the whole area. These vectors basically describe the eye space of different individuals.

Creation of Eigenvalues is the main thing in this process. Once these are created the next step seems like a pattern recognition process. There are M different training images of eyes of different individuals whose Eigenvalues are created and are distributed in the eye space. We have to pick out M1 Eigenvectors which have largest Eigenvalues associated with them. The process of choosing these Eigenvectors is entirely dependent on the Eigenvalues being calculated of different individuals. Whenever an input image is received, its Eigenvalue components are computed. A weight vector is used which is used to define the involvement of every Eigenface in the process of demonstrating the image to be judged.

Table 1: Features extraction rate comparison

Facial features	Detection rate (%) Existing (Yuen *et al*., 2010)	Proposed	Processing time (Sec) Existing (Yuen *et al*., 2010)	Proposed
Eyes	93.08	99	2.04	0.592
Mouth	95.83	99	0.46	0.712

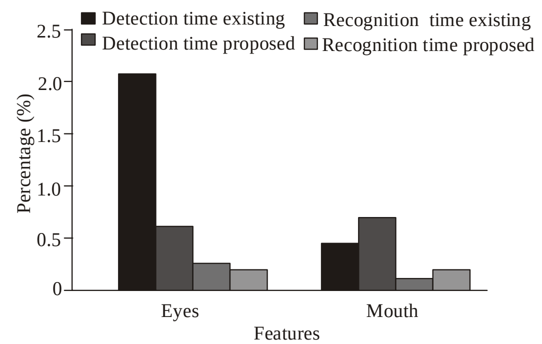


Fig. 11: Features and recognition rate comparison through bar chartse

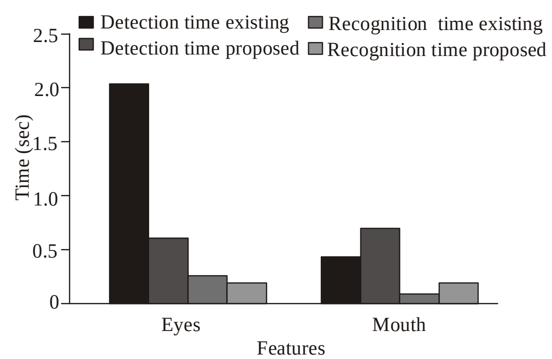


Fig. 12 : Processing time comparison

The main purpose is to determine which included class most closely resembles to the input image. The concept of classes of Fisherfaces is used to differentiate different individuals. For this purpose classes equal to the figure of diverse persons present inside the database being used with the system. The best suited class to the input image is selected centered on the minimum Euclidian distance of the class from the input image.

RESULTS AND DISCUSSION

In direction to check the performance, the projected system the database is tested against three databases which are:

- Self-selected AR database
- Self-selected CVL database
- Database containing 300 images of different individuals with illumination change

Table 2: Recognition rate comparison

	Detection rate (%)		Processing time (Sec)	
Facial features	Existing (Yuen *et al*., 2010)	Proposed	Existing (Yuen *et al*., 2010)	Proposed
Eyes 79.17		97	0.24	0.1754
Mouth	51.39	75	0.10	0.194

Table 3: Results on 72 images tested with nose of individuals

Feature	Detection rate (%)
Nose	98

Table 4: Results on 72 images tested with right eye of individuals

Feature	Recognition rate (%)
Right eye	96

Table 5: Features results + processing time comparison

	Detection rate (%)	
Facial features	Existing (Yuen *et al*., 2010)	Proposed
Eyes	93.08	98
Mouth	95.83	97

The results are compared with the existing technique results proposed by Yuen *et al*. (2010) which is based on template matching.

Results comparison:

Results on the self-selected AR database: For the comparison purpose system is tested with the same number of images i.e., 72 images, 3 images per person are used in the existing paper. 12 males and 12 females' images are used for this purpose and also with 30 males and 30 females each having 3 images. Table 1, Fig. 11 (for detection and recognition rate) and Fig. 12 (for processing time) shows that the features extraction rates and the processing time of proposed technique is far better than that of existing technique.

Similarly, Table 2, Fig. 11 (for detection and recognition rate) and Fig. 12 (for processing time) show that recognition rate and recognition time of proposed technique is far better than that of existing technique.

In the features extraction process nose is also extracted of all the tested images. The extraction result of nose images (Detection rate) at 72 persons is 98 % (Table 3):

The results on 72 images are also tested with right eye of individuals. The results (Detection rate) using right eye are 96% (Table 4):

Results on self-selected CVL database: The self-selected CVL database contains 70 individuals with three images per person. The images selected were frontal faces with eyes visible and open. Table 5 shows that the detection rate of facial features using proposed technique is better than the existing technique.

Table 6: Recognition rate comparison

	Recognition rate (%)	
Facial features	Existing (Yuen *et al*., 2010)	Proposed
Eyes 79.17	95	

Table 7: Nose extraction on CVL database

Feature	Detection rate (%)
Nose	97

Table 8: Face features extraction results (%)

	Detection rate (%)	
Facial features	Existing (Yuen *et al*., 2010)	Proposed
Eyes	93.08	99

Table 9: Face recognition rate %

Facial features	Recognition rate (%)	
	Existing (Yuen *et al*., 2010)	Proposed
Eyes	79.17	94

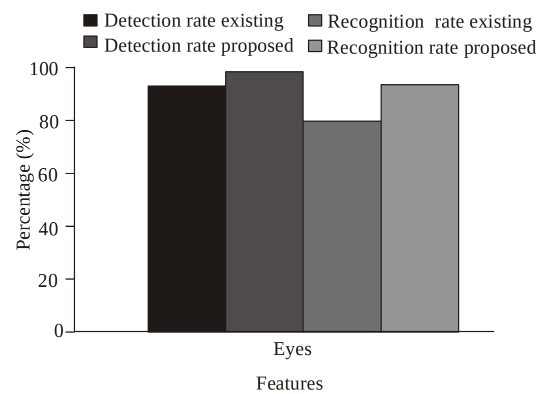


Fig. 13: Detection and recognition comparison (%)

Recognition rate (%): The results for extraction on CVL database is as follows Table 6 and Table 7

Results on database with illumination changes: The database contains 20 persons with 8 images per person. The results in Table 8 and 9 and Fig. 13 for the images with illumination and background changes show the strength of the proposed work.

CONCLUSION

Although numerous methods have been planned and projected in the perspective of face recognition, little work has been done on face identification based on the facial features. In this study face detection, features extraction and face recognition technique has been presented. The main purpose of the system was to check whether it is possible to efficiently recognize different individuals using a small region of the face or not. For this purpose the eye region of face is used to recognize different individuals. Results were tested on three databases. The results obtained are satisfactory and the system can be used efficiently for recognition purpose for different applications.

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