Volume 4, Issue 3, March 2014 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

A Biometric Authentication Approach using Face Recognition System

Pallabi Saikia, Margaret Kathing
Dept. of CSE, NERIST, Nirjuli
India

Abstract— Today, face recognition is extensively used in Computer Vision Applications such as for recognition as well as authentication purpose. The main backbone of the algorithm is to detect the face portion from the entire image, and for detecting the face, we have to detect the skin first. Conducting our research in various color transformation algorithm, it is found that the best method is to transform the RGB image into the YCbCr image to detect the skin color of humans by setting appropriate thresholds. The reason for using this color model is to remove the illumination component, Y. We have proposed and implemented a method to locate the face portion of human by determining the number of holes in the skin region using Euler's method and also by taking eye distance. Once the face is detected, these are stored as database. We use principal component analysis for the recognition purpose. The result of this entire system is shown in the figures and also their accuracies.

Keywords— Skin Color, Color Transformations, Euler's number, Eigenfaces, Eigenvectors, Principal Component Analysis, Euclidean distance.

I. INTRODUCTION

Face recognition is one of the extensively used biometric authentication systems that have been used in many applications right from giving attendance in an organization, authentication purpose to the criminal identification.

For recognition of face, the main step is to perform the detection of the face portion which is performed by transforming the RGB color space to YCbCr color space. After the detection of the face, the important step is to select the features and then to feed into a classifier for the recognition purpose. So, from all the classifiers, the most extensively used classifier is principal component analysis, discussed later, which reduces the time complexity for the entire algorithm.

II. LITERATURE REVIEW

A lot of research works have been carried out for face detection and recognition. Among all the methods for face detection, YCbCr color transformation is used extensively. Wang [1] established Gaussian model by removing luminance Y component information. Y channel contributed much towards the effect of illumination. R. Hassanpour et al. [2] proposed a segmentation process not considering Y component to build an efficient Gaussian Mixture Model for the detection of skin color.

Pallabi Saikia et al. [3] modified in which Y channel was ignored in order to reduce the effect of brightness variation and only the chrominance channels are used which fully represent the colour and for skin detection, the YCbCr color space was a favourable choice. These experiments are performed after neglect luminance Y information. The use of skin colour model is when the standard light source evenly exposures.

The next main part is to recognize the face, which is further used for the authentication purpose. Sirovich and Kirby[4] developed the idea of using principal components to represent human faces and Turk and Pentland[5] used it for face detection and recognition. The first working facial recognition technology was designed by the Eigenface approach, and it served as the basis for one of the top commercial face recognition technology products.

In [6], by independently matching the templates of three facial regions such as eyes, nose and mouth, face recognition was performed. The system did not include a geometrical model of the face and therefore the configuration of the components during classification was unconstrained. With an additional alignment stage, similar approach was proposed in [7]. To efficiently represent the pictures of faces, references [8, 9] used principal component analysis. According to them, any face image could be approximately reconstructed by a small collection of weights for each face and a standard face picture (eigenface). The weights describing each face are obtained by projecting the face image onto the eigenface. This paper clearly depicts the efficient algorithm for detecting the face portion and also about the classifier that is used for the recognition purpose. The organization of this paper is done into seven sections in which first two sections give the introduction and literature review. The third section gives our proposed algorithm. Feature extraction process and recognition is discussed in the section four and five. The sixth section gives the experimental details and the last section, i.e. seventh, concludes the paper.

III. OUR PROPOSED ALGROTHIM

The main block diagram for the face recognition process is shown in figure 1. As it can be seen from the block diagram, the authenticated images of the various persons are fed as input images, from which the face portions are detected. From the detected face portions, the features are extracted and fed into a classifier. So, whenever there is an input test image, after detecting the face portion, the features are extracted and fed into the classifier. The classifier plays an important role in the recognition purpose. The classifier gives the decision whether the input image is from the database or not. In this paper, principal component analysis is used as a classifier as it checks the time complexity for the recognition process.

The back bone of the system is to detect the face portion from the entire image shown in figure 2 and for performing this, we are required to detect the skin portion, which can be done by YCbCr color space model. Because, as it is

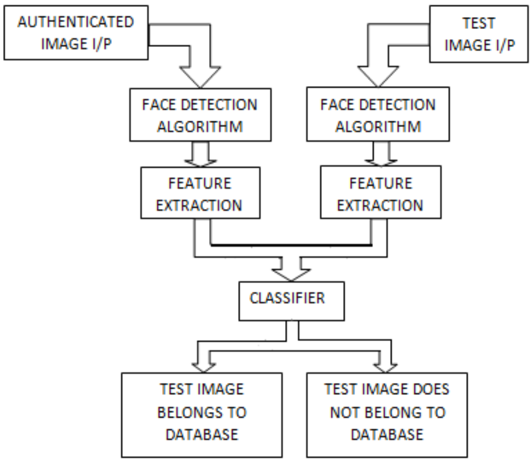

Fig 1 Block Diagram of Face Recognition System

explained, the color channel Y, which gives contribution to the illumination can be separated out. Also, using another algorithm, Y channel is normalized to get a proper skin color model. [10]Normalization of Y channel gives the lightening compensation instead of removing it

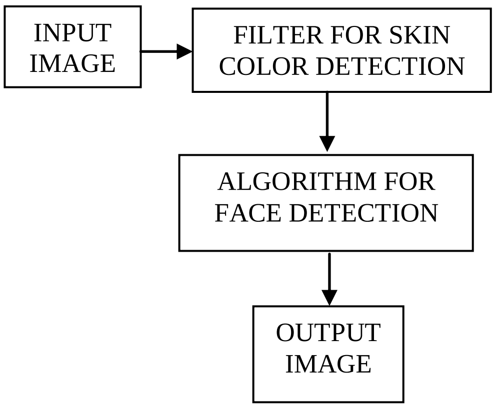

Fig 2 Face detection Model

In response to increasing demands for digital algorithms in handling video information, YCbCr color space has been defined which has become a widely used model in a digital video.

As a part of the color image pipeline in video and digital photography systems, YCbCr [11] is used. Y gives the luma component and Cb and Cr give respectively the blue-difference and red- difference chroma components. As Y gives luminance, meaning that light intensity is non-linearly encoded using gamma correction [12].

In YCbCr, the Y is the brightness (luma) which is given by the combinations of R, G and B with some pre-assigned weights, Cb is blue minus luma (B - Y) and Cr is red minus luma (R - Y). From ‘‘digital 8-bit RGB’’, YCbCr can be obtained from RGB [13], if R, G and B are given with 8 bit digital precision.

Chai and Ngan in [14] first proposed YCbCr algorithm, which is comprised of a skin segmentation step followed by a set of regularization processes to reinforce those skin regions that are more likely to belong to the facial regions.

The conversion of RBG to YCbCr is done by the equation given as in equation (1):

$$\left.\begin{aligned} Y &= 0.299R + 0.587G + 0.114B \\ Cb &= B - Y \\ Cr &= R - Y \end{aligned}\right\} \quad (1)$$

The skin segmentation step thus employed exploits the 2D chromatic subspace to reduce the dependence of illumination. A skin color map is derived and used on the chrominance components of the input image to detect pixels that are of skin color[my paper]. According to the authors the most suitable ranges of Cb and Cr that can be used to represent skin color pixels are shown in equation (2) as:

$$77 <= Cb <= 115;\ 133 <= Cr <= 173 \qquad (2)$$

This filter was tested against a set of pictures obtained from the World Wide Web and also against pictures obtained from Compaq database for skin Segmentation [15] and was found to be useful for possible inclusion in File Hound.

So after detecting of the skin color region, the next main step is to locate the face portion in the image. This is the backbone of the face detection algorithm. To detect the face portion, we need to consider some of the features that are present in our face only. So, in our case we have considered eyes, mouth, moustaches, and eyebrows as features for the location of the face.

When the image is converted into a binary image, these features are considered to be holes. Human eyes and mouth are the major holes for detecting human face. For the skin region which doesn't contain any holes then, we can say that this portion is not skin and we can discard this region. This rejection is done by using Euler number method [16]. The equation to determine Euler number is given by equation (3):

$$E = C - H \qquad (3)$$

E is the Euler number, C is the no. of connected components in the skin region and H is the no. of holes in that region. This Euler number computation is done for different skin regions like hands, legs or the face portion. The condition for determining whether the region is a face or not can be given as[3]:

If $E<1$, the skin region is a human face portion.
If $E>1$, the skin region is not a human face portion.

Not only the Euler number, we have also considered the distance between two eyes. For that, we have taken average distance between our two eyes. And by setting up an appropriate threshold, it can be determined that if the distance between the two holes in the skin detected region lies in the range of threshold, then this portion is surely a face portion.

So to detect face, the features that we have taken are Euler number and distance between two eyes.

IV. FEATURE EXTRACTION USING PCA

For the recognition purpose, the first and the foremost step is the feature extraction from the face images which are saved in the database. For this purpose, principal component analysis is used which can be used for both purposes: feature extraction and classification or recognition. It is one of the extensively used classifiers which has low time complexity. The algorithm steps are discussed below:

We use the eigenface method for feature extraction and classification. In the computer vision problem, eigenfaces are used as a set of eigenvectors for the recognition. These eigenvectors refer to an appearance-based approach to face recognition that seeks to capture the variation among the collection of face images and use this information to recognize the images of individual faces in a holistic manner. Specifically, for a distribution of faces, eigenfaces are referred as the principal components for the recognition purpose, or equivalently, the eigenvectors of the covariance matrix of the set of face images, where an image with M×M pixels is considered a point (or vector) in M^2-dimensional space.

Let a face inage be denoted by $I(x,y)$ be a 2-D M by N array of intensity values, or a vector of dimension $M \times N$. The Training set used for the analysis is of size 108×68, resulting in 7344 dimensional space. For simplicity the face images are assumed to be of size $N \times N$ resulting in a point in N^2 dimensional space. An ensemble of images, then, maps to a group of points in this huge space.

The main idea behind the use of principal component analysis is to find the vectors which best suit for the distribution of face images within the entire image space.

Let the training set be $X_1, X_2, X_3 \ldots\ldots X_M$.

The set of average face is given by:

$$\Psi = 1/M(\sum X_k), \qquad (4)$$

where k = 1,2,3,….M.

By subtracting the mean from each image, the expectation is made equal to zero and also, the deviation from the mean can be found out.

i.e. $\Phi_i = X_i - \Psi$.

This is of very large vectors which is then considered to principal component analysis and it seeks a set of M orthonormal vectors, u_k, which best describes the distribution of the data. The k^{th} vector is u_k chosen such that,

$$\lambda_k = 1/M(u^T_k \ \Phi_n)^2 \qquad (5)$$

In the covariance matrix, the vectors u_k and λ_k scalars are eigenvectors and eigenvalues respectively.

$$C = 1/M \sum^{M}_{n=1} \Phi.\Phi^T \qquad (6)$$
$$= A.\ A^T$$

Where, $A = [\Phi_1, \Phi_2, \Phi_3 \ldots\ldots \Phi_M]$

The matrix *C*, however, is $N^2 \times N^2$ by *N*, and the *N* eigenvectors and eigenvalues cannot be determined as it is intractable for typical image sizes.

To calculate these eigenvectors, a computationally feasible method is to be defined. If the number of data points in the image space is M ($M<N^2$), then the eigenvectors will be $(M - 1)$ instead of N^2. The eigenvectors can be determined by solving much smaller matrix of the order $M \times M$ which, reduces the computations from the order of N^2 to M, pixels.
Therefore we construct a matrix L, such that

$$L = A^T . A \qquad (7)$$

Where, $L_{mn} = \Phi^T{}_m . \Phi_n$

And we are required to find M eigenvectors μ_L of L, which determine the linear combination of the M training set face images to form the eigenfaces V_l ,

$$V_l = \sum u_{lk}.\ \Phi_k \qquad (8)$$

Where, l = 1,2……M.

.

V. CLASSIFICATION AND IDENTIFICATION

After the creation of eigenface, the next task is to go for the recognition purpose. The eigenfaces gives an N^2 dimensional subspace of the original image matrix A. The eigenvectors associated with the largest eigenvalues are chosen. In the test cases, based on $M = 6$ face images, $M' = 4$ eigenfaces were used. The number of eigenfaces to be used is chosen heuristically based on the eigenvalues. The equation given below gives a new face image (I), transformed into its eigenface components as,

$$\Omega_k = v_k^T (\Gamma_k - \Psi) \qquad (9)$$

Where k = 1…..M'

And the weight vector is $\Omega^T = [\Omega_1\ \Omega_2\ \Omega_{3 \ldots\ldots}\ \Omega_{M'}]$, that describes the contribution of each eigenface in representing the input face image, treating the eigenfaces as a basis set for face images.

The vector is used to find which of a number of predefined face classes, if any, best describes the face. The simplest method for determining which face class provides the best description of an input face image is to find the face class *k* that minimizes the *Euclidean distance*

$$\boldsymbol{\varepsilon_k = \|\Omega - \Omega_k\|} \qquad (10)$$

where, $\boldsymbol{\Omega_k}$ is a vector describing the k_{th} face class.

A face is classified as belonging to class *k* when the minimum ε_k is below some chosen threshold θ_ε Otherwise the face is classified as "unknown".The distance threshold, θ_ε , is *half the largest distance between any two face images,* Mathematically can be expressed as,

$$\Theta\varepsilon = \tfrac{1}{2} \max\{\|\Omega - \Omega_k\|\} \qquad (11)$$

Where j,k = 1,2,3….M

If

$\varepsilon \geq \theta\varepsilon$ then input image is not a face

$\varepsilon<\theta\varepsilon$,ε $k\geq \theta\varepsilon$ then input image contains an unknown face

$\varepsilon < \theta$,$\varepsilon_{k'} = \min \{\varepsilon_k\} < \theta_\varepsilon$ then image contains face of individual *k'*.

VI. EXPERIMENTAL RESULTS

Around 50 images of 10 persons are used for training purpose of size 108×68 each. The programing background that we are using is Matlab2011a. In Matlab, using the Computer Vision Toolbox, the programming becomes flexible different functions can be used for different purposes.

In this section, we are showing some of the images of a person for the experimental evaluation. The running time of the algorithm is quite good.

A. Detection of faces from the entire image

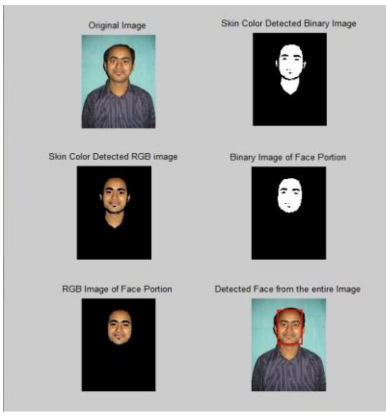

Figure 3: Extraction of face portion from the image

The face portion that is extracted from the entire image is saved as a database image. This process is done for all images. From each image, the face portion is extracted and saved. Now from this saved image, this image is converted into grayscale and principal component analysis is computed, from which eigenvalues and eigen vectors are calculated. The image below showing the eigen image of the face of the person in the above.

Figure 4: (i)Mean Calculated Image (ii) Gray image of the above image (iii) Eigenface image

From the eigenface image, the eigen values and eigen vectors are determined which further used for classification as discussed in the above section. If the right person is recognized, then recognition process is successful and further this can be used for the authentication purpose such as for attendance, for entry into a restricted area etc. There are some evaluation results mentioned in the tables below. The accuracy is good and the system is efficient.

TABLE I
DETECTION OF FACES FROM THE ENTIRE IMAGE

No. of Persons	Detected Persons	Accuracy
50	46	92%

TABLE II
ACCURACY OF FACE RECOGNITION

No. of Training Images	No. of Test Images	Recognized Images	Accuracy
50 5 img/person	10 Each/person	9	90%

We have also done the performance measurement using confusion matrix [17]. This performance evaluation is done for 5 persons each having 6 images. The table below shows the recognition of the 5 persons. Based on the values in the confusion matrix, different parameters such as True Negative Rate, True Positive Rate, G- Mean, Precision, Recall etc. are determined which give the performance measurement of the system.

TABLE III
RECOGNITION DATA SET

No. of Persons	**Per 1**	**Per 2**	**Per 3**	**Per 4**	**Per 5**
Per 1	5	0	1	0	0
Per 2	1	4	1	0	0
Per 3	0	0	6	0	0
Per 4	0	0	0	6	0
Per 5	0	1	0	0	5

TABLE IV: THE MAIN CONFUSION MATRIX

5.2 True Positive	0.8 False Negative
0.8 False Positive	23.2 True Negative

The above values are the average of all the respective values for all the 5 persons. From these values, we can find the parameters as given below:

True Negative Rate (Acc^-) = $\frac{TN}{TN + FP}$

True Positive Rate (Acc^+) = $\frac{TP}{TP+FN}$

G-mean = $(Acc^- \times Acc^+)^{1/2}$

Precision = $\frac{TP}{TP+FP}$

Recall = Acc^+

F-measure = $\frac{2 \times Precision \times Recall}{Precision + Recall}$

TABLE V
PARAMETERS AND VALUES FROM THE CONFUSION MATRIX

Parameters	Values
TNR	0.97
TPR	0.18
G- Mean	0.42
Precision	0.87
Recall	0.18
F - Measure	0.3

Acc^+ = High precision Accuracy over minority class
Acc^- = Reasonable Accuracy over majority class
Geometric mean (G-mean) = to access the performance of the method.
Precision, recall and *F*-measure are commonly used in the information retrieval area as performance measures.

VII. CONCLUSION

The algorithm that we have proposed for Face detection gives a good accuracy as it can be seen from the above table. We have proposed a novel algorithm for detecting the face portion from the entire image and also the recognition of the given input face with that of the database. We have found a good result in the experiment. Again from the performance measurement table, values for different parameters are obtained. These values show good performance of the algorithm. Our future scope is to design a system that incorporates both voice as well face recognition which can be further used for strict authentication purpose.

REFERENCES

[1] H. Wang, "Research on the Face Detection Based on YCbCr Skin Gaussian Model, Modern Electrical Technology", Vol. 22, March, 2008, pp. 102–105.
[2] R. Hassanpour, A. Shahbahrami, and S. Wong, "Adaptive Gaussian Mixture Model for Skin Color Segmentation", Proceedings Of World Academy Of Science, Engineering And Technology, Vol. 31, June, 2008 pp. 1307–6884.
[3] P. Saikia, G. Janam and M. Kaithing, "Face Detection using Skin Colour Model and distance between Eyes", IJCCN, Vol. 1, No. 3, pp. 102-105, 2012.
[4] L. Sirovich and M. Kirby, "Low-dimensional procedure for the characterization of human faces". Journal of the Optical Society of America A 4: 519–524, 1987.
[5] M.Turk and A. Pentland, "Eigenfaces for Recognition", *Journal of Cognitive Neuroscience,* March 1991.
[6] R. Brunelli and T. Poggio, "Face recognition: Features versus templates," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 15, No. 10, pp. 1042–1052, 1993.
[7] D. J. Beymer, "Face recognition under varying pose," A.I. Memo 1461, Center for Biological and Computational Learning, M.I.T., Cambridge, MA, 1993.
[8] L. Sirovich and M. Kirby, "Low-Dimensional procedure for the characterisation of human faces," *J. Optical Soc. of Am.*, vol. 4, pp. 519-524, 1987.
[9] M. Kirby and L. Sirovich, "Application of the Karhunen- Loève procedure for the characterisation of human faces," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 12, pp. 831-835, Dec. 1990.
[10] Yu-Ting Pai, Shanq-Jang Ruan, Mon-Chau Shie, Yi-Chi Liu, "A Simple and Accurate Color Face Detection Algorithm in Complex Background", International Conference on Multimedia and Expo, IEEE, 2006, pp. 1545 1548.
[11] Mohammad Saber Iraji, Ali Yavari, "Skin Color Segmentation in Fuzzy YCBCR Color Space with the Mamdani Inference, American Journal of Scientific Research", pp.131-137, July, 2011.
[12] Charles Poynton, Digital Video and HDTV, Chapter 24, pp. 291–292, Morgan Kaufman, 2003.

[13] Hideki Nodaa, Michiharu Niimia, "High Performance JPEG Steganography Using Quantization Index Modulation In DCT Domain", Elsevier Science, 2005.

[14] D. Chai and K. Ngan, "Face segmentation using Skin color map in Videophone Applications", IEEE transactions on Circuits and Systems for Video Technology.

[15] M. J. Jones, and J. M. Rehg, "Statistical Color Models with Application to Skin Color Detection", International Journal of Computer Vision, Vol. 46-1, pp. 81-96.

[16] Devendra Singh Raghuvanshi and Dheeraj Agrawal, "Human Face Detection by using Skin Color Segmentation, Face Features and Regions Properties", IJCA, January 2012, pp.14-17.

[17] C. Chen, A. Liaw and L. Breiman, Using Random Forest to Learn Imbalanced Data,

