International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 4, April 2015

A Novel Face Recognition System for Uncontrolled Environments

Veena K, Manju Thomas

***Abstract*—Face recognition system is an application that is used to identifying or verifying a person from an input image , which can be done by comparing selected features from the image and the facial database. But face recognition is a challenging technology , because its application is limited to controlled settings, i.e limited to pose changes, illumination changes, head orientations, expression variations etc. This paper present a novel face recognition approach for uncontrolled pose and illumination changes. Here normalization ("correction") procedure is used for correct pose and illumination variations and identification and decision making is perform using Eigenface approach. This method provide an accuracy of above 90%.**

***Index Terms*—Face recognition, Pose and illumination changes, Image quality index, Normalization, Eigenface**

I. INTRODUCTION

Real-World face recognition is an important vision task with many practical applications such as biometrics, video surveillance, image retrieval, security and human computer interaction etc. The major issue in face recognition system is how to ensure the recognition rate for a large dataset captured in various conditions, Because face learning can be successfully applied only if input face images are given in controlled conditions i.e static background, neural frontal face etc. In uncontrolled settings face recognition become difficult because of the disturbing factors like expression, occlusion, pose variations, varying lighting conditions [2] etc. In general face recognition mainly consists of five steps:

1. ***Acquiring the Image of an Individuals Face***
   There are two ways to acquire an image by digitally scan an existing photograph or acquire a live picture of a subject .
2. ***Perform pre-processing steps to the Face***
   Pre-processing improve the recognition performance of the system. It includes filtering , normalization etc.
3. ***Feature extraction***
   Compute the feature vector that is well enough to represent the face image.
4. ***Classification***
   Extracted features of the input face image is compared with the ones stored in face database using a pattern classifier.
5. ***Match Or No Match***
   Perform decision making task to check whether or not any comparisons from step 4 are close enough to declare a possible match.

We know that skin color in humans varies by individual. But intensity is the main distinguishing characteristic in humans. Therefore, recognition stage typically uses an intensity (grayscale) representation of the image for further processing. This grayscale version contains intensity values for skin pixels.

II. RELATED WORK

There are a large number of face recognition system have been developed in last decades [5]. The early work related to face recognition technology mainly includes PCA, SVM, LDA, ICA , LBP, neural networks etc.

Principal Component Analysis (PCA) is the one of the generally used face recognition system [4]. This c is also known as Eigenface method or Karhunen-Loeve method for face recognition. Kirby and Sirovich introduce PCA to effectively characterize geometry of face [4]. The advantage of this method is that it reduces the dimensionality of the original dataspace. But it requires large computation and provide poor discriminating power.

The Linear Discriminant Analysis (LDA) is an another method for face recognition [6]. This method is the most dominant method for feature selection in appearance based methods. But its recognition rate become poor when there occur variation in pose and illumination within same images.

Support Vector Machines (SVM) are one of the classification technique used fro face recognition system [7]. This method can apply to both verification and identification applications[8]. The advantage of SVM classifier is that SVMs can achieve better generalization performance.

The neural networks are the nonlinear solution to the face recognition problem and also it is used in many other pattern recognition problems[9]. This method is more reliable as compared to linear methods like PCA, LDA etc. By using neural networks , it is possible to reduce misclassifications among the neighbourhood classes. But neural networks based approaches encounter problems when the number of classes increases. Therefore, neural networks are not good for large data set and not an ideal approach for single face image recognition.

It is possible to represent shape and texture information to represent face images using Local binary pattern (LBP) [10]. In LBP the face area is first divided into small regions and then, histograms are extracted and concatenated into a single feature vector. This vector forms an efficient representation of the face image and is used to measure similarities between images [11].

The face recognition problems occur due to varied pose, expression, lighting conditions, facial aging on the images. Among them Pose and illumination variation are the great challenges for robust face recognition.

ISSN: 2278 – 909X

III. PROPOSED FACE RECOGNITION SYSTEM

This paper is an extension for eigenface basis face recognition system [3]. Eigenface basis face recognition system uses a set of eigenvectors when they are used in the computer vision problem of human face recognition. But the eigenface basis face recognition system have the following limitations ;

- Sensitive to head scale
- Applicable only to front view
- Good performance under controlled background (not including natural scenes)

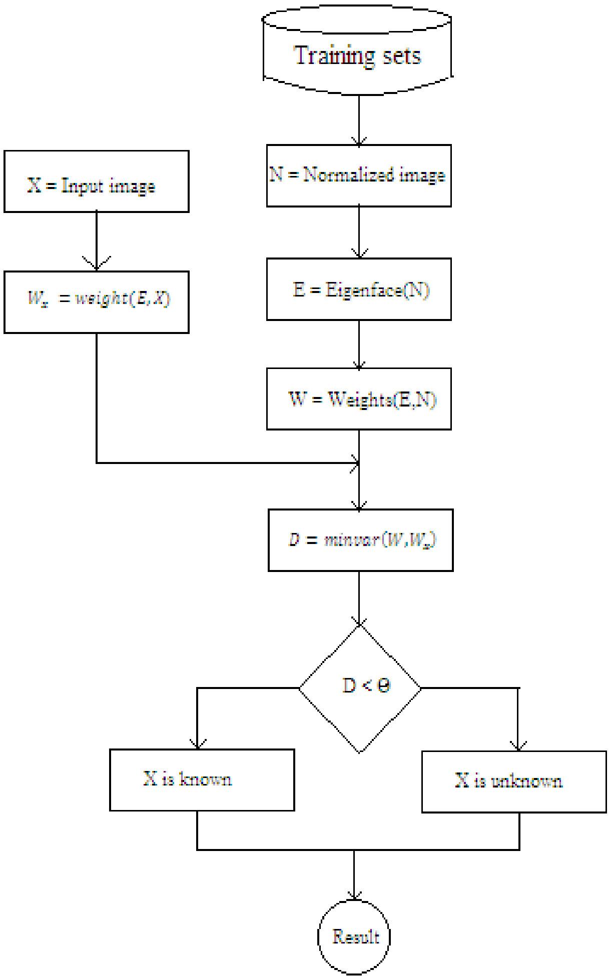


Fig 1.Block Diagram of proposed system

So, to overcome these limitations of eigenface face recognition, we propose a novel real-time face recognition system for uncontrolled pose and illumination variations . The pose and illumination variations are the crucial factors that affect the performance of face recognition system. Fig 1 shows the block diagram of the proposed face recognition system. Here, to correct the pose and illumination variations , first we calculated distortions in face image and then perform normalization procedure [1]. After normalization procedure the mean vector all images are calculated and subtracted from all the vectors, corresponding to the original face image. Then, the covariance matrix is computed to extract a limited number of eigenvectors, that represents the greatest eigenvalues. This eigenvector is known as eigenface of the face image which represent how much the images in the training set vary from the mean image in that direction. Once eigenface is obtained, weight vector is constructed with the help of the eigenfaces. After obtaining the weight vector, it is compared with the weight vector of every face image in the trainingsets and perform decision making according to the threshold value.

IV. FACE DETECTION AND NORMALIZATION

This section describes the face and landmark detection techniques and normalization process suitable for pose and illumination variations.

A. *Face Detection*

The first step in a face recognition system is the detection of one or more faces from the input image. For this, the input image is first submitted into a global face detector. In this paper, Viola-Jones face detector is used for face detection [12]. Viola-Jones face detector is a global object detector within the computer vision tool box containing a function vision.CascadeObjectDetector for face detection.

After detecting the face region from the input image, its characteristic points ("landmarks") are located using the extended Active Shape Model (STASM) algorithm [13],[15]. Face landmarking is defined as the detection and localization of characteristics points on the face. The STASM algorithm

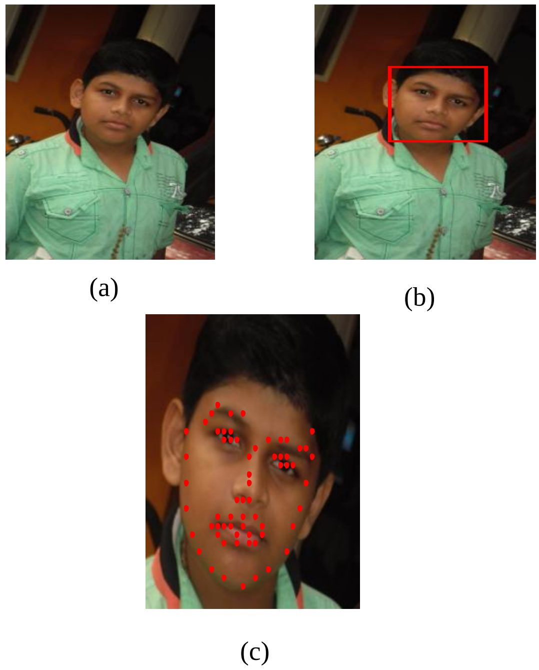


Fig 2 . (a) Input Image, (b) Face detected Image, (c) Characteristics points

automatically locating landmark points by minimizing the global distance between image points, which is pre-computed over wide range of training images. This algorithm locates 68 interest points [Fig. 2(c)]. The precision of the landmarking procedure depends on the amount of face distortion. When modeling a face, characteristic points consists of points that are lie along the shape boundaries of facial features such as eyes , lips, nose, mouth, and eyebrows.

B. *Normalization*

In image processing, normalization is the process that changes the range of intensity values. In face recognition

ISSN: 2278 – 909X

algorithm it often employed to improve classification accuracy.

Pose normalization procedure starting from set of 68 characteristics points that are located using STASM. Here, for pose normalization only 13 of them uses [Fig 3(d)]. The head rolling can be approximated as the angle θ between line passing through the centers of eyes and *x* axis [Fig.3(a)]. The values of d_l and d_r allows the better exposed half of the face, where d_l and d_r are the distance between external corners of the left and right eyes and the tip of the nose [Fig 3(b)]. When $d_r > d_l$, image is left unchanged. Therefore , we reconstruct the left half of the face using right half one [1] [Fig 3(e)]. The points in the Fig 3(c) shows the line marks for the boundary between the right and left half of the face.

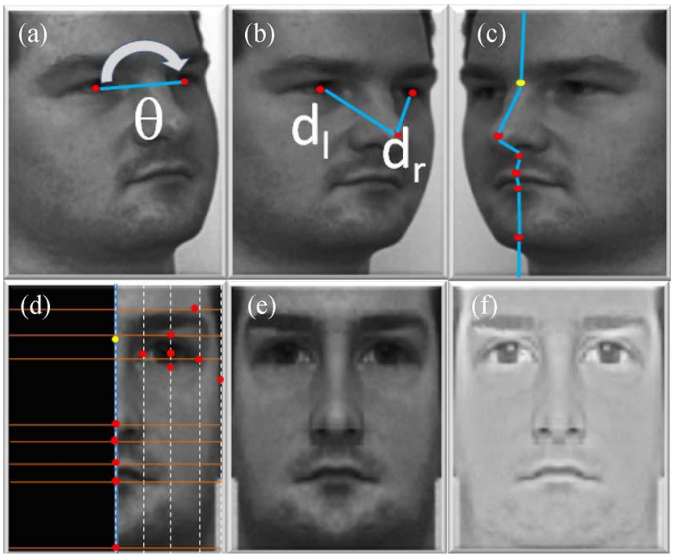


Fig 3.Six main steps of the pose and illumination normalization.[1]

General face recognition algorithm work under normal or good illumination. If the illumination gets 'bad', the recognition rate decreases. Therefore, after completing pose normalization , it undergoes illumination normalization. Here SQI algorithm[14] is used to perform illumination normalization. In SQI algorithm the value of each image pixel is divided by the mean of the values in its neighborhood, represented by a square mask.

V. FACE RECOGNITION BY EIGENFACE BASIS

Eigenface basis face recognition system is a powerful solution to the face recognition dilemma. Eigenfaces are fundamentally basis vectors for real face faces. The eigenface basis face recognition system can be divided into two modules: Building of the eigenface basis and Recognition of new face.

A. Building of the eigenface basis

For creating eigenfaces, we need to collect set of known face images [Fig 4]. Here, the database of known face images are the pre-processed image, i.e pose and illumination normalized image. All face images should be the same size for our purposes. The major steps for creating eigenfaces are;

1. Each face image in the trainingsets are converted into a vector Γ_n of length ***N.*** This collection of faces is known as "face space".
2. Calculate the mean face in face space using

$$\psi = \frac{1}{M}\sum_{n=1}^{M}\Gamma_n \qquad (1)$$

Here M is the number of faces in trainingsets.

3. Subtract the mean image from each image vector.

$$\Phi_i = \Gamma_i - \psi \qquad (2)$$

4. Compute the covariance matrix (C) for our dataset.

$$C = \frac{1}{M}\sum_{n=1}^{M}\Phi_n\Phi_n^T$$

$$= \frac{1}{M}\sum_{n=1}^{M}\begin{bmatrix} var(p1) & \cdots & cov(p1,pN) \\ \vdots & \ddots & \vdots \\ cov(pN,p1) & \cdots & var(pN) \end{bmatrix}$$

$$= AA^T \qquad (3)$$

Where **N** is the number of pixels in face images.

5. Now, we can reduce the number of eigenvectors in covariance matrix from **N** to **M,** i.e number of pixels in our images to number of face images in our datasets, by using the technique Principal Component Analysis (PCA) [4].

.

This new vector with size MxM represents the orthonormal vectors which are associated with highest eigenvalues of covariance matrix..

B.Face Recognition

The face recognition can be executed as ,

- ✓ Calculate eigenface components of input face.
- ✓ Calculate a difference between mean-face and the input face image.
- ✓ weight vector is constructed with the help of the eigenfaces of datasets.
- ✓ Choose a best matched face compared with weight vector of every face image in the trainingsets according to the threshold value.

VI. EXPERIMENTAL RESULTS

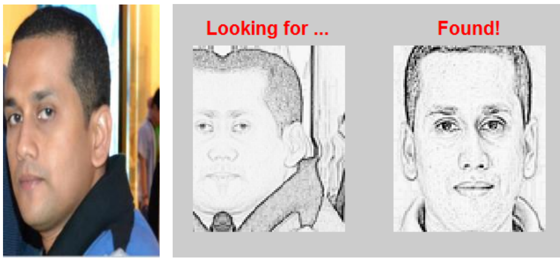
The face recognition algorithm used in this paper is the combination of FACE [1] and Eigenface [3] face recognition methods. Here, we used 400 ORL face images and 50 real world face images for the implementation of this paper and it provide an accuracy of above 90%.

ISSN: 2278 – 909X

Fig 4. Real-world Inputs

Fig 5. ORL face images

while processing the input face images, we created pose and illumination corrected eigenfaces and these images were stored as training sets. After that , using this eigenfaces, a new unknown face recognized using the approach that discussed here.



(a) (b)

Fig 6. Result of face recognition system
(a) Input face image (b) pose and illumination corrected image and best matched face from datasets

VII. CONCLUSION

This paper presents a novel face recognition method. The most noteworthy feature of the algorithm is that this face recognition method can use in both pose and illumination changed image in real-world. The experimental results shows above 90 % of accuracy with pose and illumination changed images.

ACKNOWLEDGMENT

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my project work to complete it successfully. First of all I would like to acknowledge with much appreciation the Pivotal role of the Principal of this institution, Prof. Shine P. James, who gave his full support to complete my work. At this moment of accomplishment, I pay homage to myguide,Asst.Prof.Manju Thomas(Electronics and Communication Engineering). This work would not have been possible without her guidance, support and encouragement. Under her guidance I successfully overcame many difficulties and learned a lot.

REFERENCES

[1] Maria De Marsico, *Member, IEEE*, Michele Nappi, Daniel Riccio, and Harry Wechsler, *Fellow, IEEE* ”Robust Face Recognition for Uncontrolled Pose and Illumination Changes” vol. 43, no. 1, january 2013

[2] T. Ahonen, A. Hadid, and M. Pietikainen, “Face recognition with local binary patterns,” in *Proc. 8th ECCV*, N. Sebe, M. S. Lew, and T. S. Hua ng, Eds., 2004, pp. 469–481.

[3] Jon Krueger Marshall B. Robinson, Doug Kochelek, Matthew Escarra, ‘Obtaining the Eigenface Basis’, .. OpenStax-CNX module: m12531

[4] L. Sirovich and M. Kirby, ’Low-Dimensional Procedure for Characterization of Human Faces,’ J. Optical Soc. Am., vol. 4, pp. 519-524, 1987.

[5] E. Hjelmås, and B. K. Low, “Face detection: A survey”, Computer Vision and Image Understanding, Vol. 83, No. 3, Sept. 2001, pp. 236-274.

[6] D. L. Swets and J. J. Weng, "Using discriminant eigenfeatures for image retrieval", *IEEE Trans. PAMI.*, vol. 18, No. 8, 831-836, 1996.

[7] Vapnik. *Statistical Learning Theory*. JohnWiley and Sons, New York, 1998.

[8] ISVM for Face Recognition Sisodia, D. ; Shrivastava, S.K.: Jain, R.C. Computational Intelligence and Communication Networks (CICN), 2010

[9] Baudat, G. and F. Anouar, 2000. Generalized discriminant analysis using a kernel approach. Neural Comput., 12: 2385-2404.

[10] T. Ojala, M. Pietikainen and D. Harwood, “A comparative study of texture measures with classification based on feature distributions” Pattern Recognition vol. 29, 1996

[11] Global Journal of Computer Science and Technology Graphics & Vision Volume 13 Issue 4 Version 1.0 Year 2013

[12] Rapid Object Detection using a Boosted Cascade of Simple Features”, Paul Viola and Michael Jones ,*on Computer vision and pattern recognition* 2001

[13] S. Milborrow and F. Nicolls, “Locating facial features with an extended active shape model,” *in Proc. Eur. Conf. Comput. Vis*., 2008

[14] T. Riklin-Raviv and A. Shashua. “The Quotient image: Class based recognition and synthesis under varying illumination”. *In Proceedings of the 1999 Conference on Computer Vision and Pattern Recognition,pages* 566– 571, Fort Collins, CO, 1999.

[15] Peter N. Belhumeur, David W. Jacobs,David J. Kriegman and Neeraj Kumar*,” Localizing Parts of Faces Using a Consensus of Exemplars”*.

Veena K received the degree in Electronics and Communication Engineering from Cochin University Of Science And Technology (CUSAT) , Kerala , India.

Manju Thomas received the graduation in Electronics and Communication Engineering from MG university, kerala, india and post graduation in Signal Processing from Cochin University Of Science And Technology (CUSAT) , Kerala , India. She now works as an assistant professor at CUSAT.

