Effect of Illumination Variation on Face Detection and Recognition using Skin Color Segmentation and Eigen Faces

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ABSTRACT

Computerized security systems are gaining significant importance from identification and authentication point of view in various areas like entrance control in buildings; access control for computers in general or in the prominent field of criminal investigation. This has resulted in an increased interest in biometric systems which enables automatic, i.e. quick with little or no human intervention, identification and authentication of an individual by physical characteristics. Illumination variation is a known problem in such systems affecting the error rate of the entire system. A GUI (Graphical User Interface) system for face detection and recognition based on Principal Components is designed and the effect of varying surrounding illumination is studied in this paper. The person to be recognized is subjected to different light levels, measured using a standard Light Lux Meter.

Keywords: GUI (Graphical User Interface), ROI (region of interest), Principal component analysis, eigen vectors.

1. INTRODUCTION

The scope of image processing has widened to nearly all modern applications one of them being biometrics for face recognition which can be further used in HMI (Human Machine Interaction)[4] like applications. There are also object recognition applications for surveillance related jobs that demand heavy image processing. Feature extraction forms the basis of every algorithm used in the above mentioned applications.

Illumination variation pose problems in feature extraction and hence in object detection applications. This paper describes implementation of a GUI based face detection and recognition system for biometric application and the effect of surrounding illumination on the designed system.

2. LITERATURE SURVEY

A general face recognition system consists of the blocks shown in figure 1. Image can be acquired from a integrated webcam or a readily available USB webcam. Face detection has various approaches like Facial feature extraction [1], where facial features like eyes, nose, mouth, chin etc are detected to find human faces. This can be done using filters for edge detection or using haar transforms to find haar like features in the image. Skin color segmentation can also be used for face detection[2] [3], as skin color is unique from the rest of the colors and it does not even change with respect to pose. Template matching is also one of the methods to approach the problem, wherein the image is scanned to find a match for the face template and hence face is detected [4]. Also for recognition, classifiers, neural networks[5], Principal component[6][7] analysis can be used. Also a combination of these can be used for efficient, smooth, fast and reliable implementation of the system. A quick review of the system designed for face detection is provided in the next section, i.e. section III. Section IV explains the implementation of the recognition block

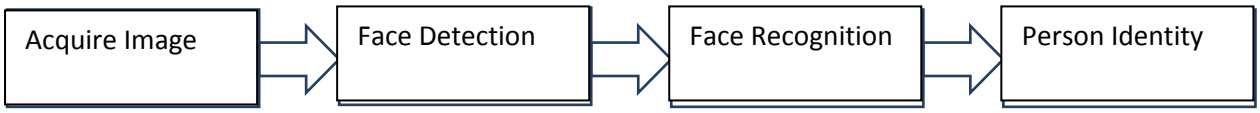


Figure 1: Flow diagram of face recognition system

3. SYSTEM DESIGN

Face Detection:

A number of preprocessing operations have been carried for promising results of Face detection. Figure 2 gives a detailed overview of the same.

Conversion of the captured RGB image into its HSV equivalent is accomplished using the inbuilt MATLAB function rgb2hsv.

The captured image is also converted into YCbCr using the relation given in equation(1) from [3].

$$\left.\begin{aligned} Y &= 0.257*R+0.504*G+0.098*B+16 \\ Cb &= 0.148*R-0.291*G+0.439*B+128 \\ Cr &= 0.439*R-0.368*G-0.071*B+128 \end{aligned}\right\} \quad (1)$$

The obtained images are thresholded for performing skin color segmentation using the relation in equation 2 from [3] & [4] to obtain a binary image.

$$\left.\begin{aligned} &120<=Cr<=195 \\ &140<=Cb<=195 \\ &0.01<=hue<=0.1 \end{aligned}\right\} \quad \text{----------(2)}$$

The discontinuities in the obtained image are treated with a series of morphological operations. . A structural element of size 30-by-30 is used for the closing operation. The morphological close operation is a dilation followed by an erosion, using the same structuring element for both operations. This image is logically ANDed with the original image to extract the required face region. MSER (Maximally Stable Extremal Regions) features are detected to serve two purposes Area thresholding is done for 6000 to 14000 pixels and it also gives the centroid of the so detected face region. The region is then cropped with respect to the centroid.

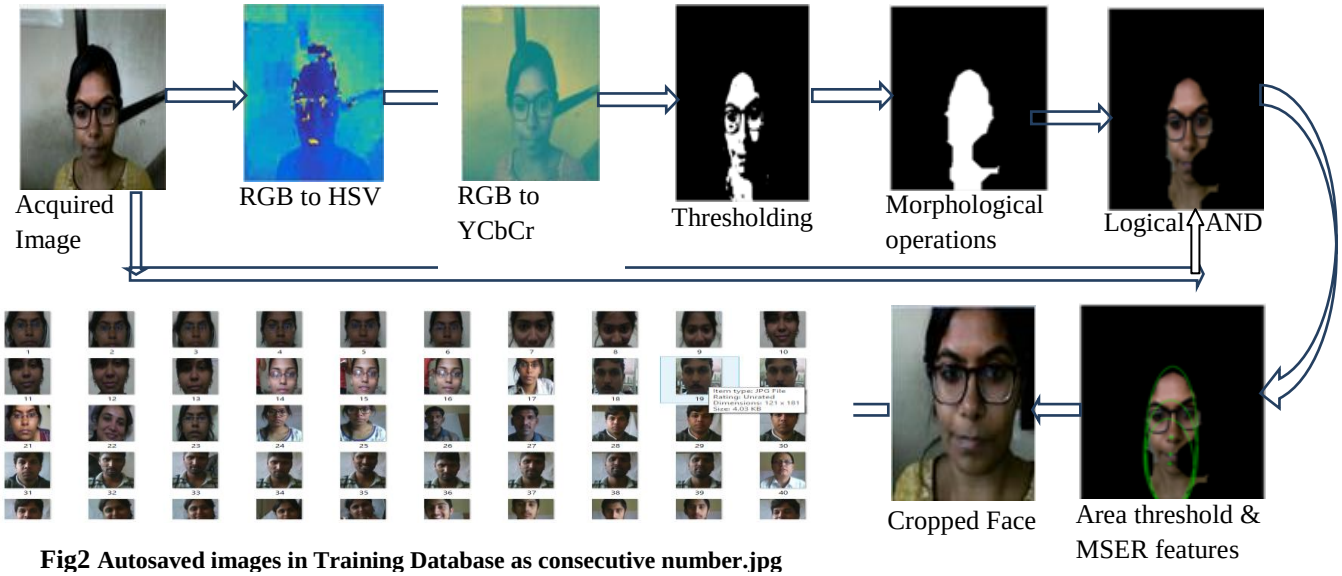


Fig2 Autosaved images in Training Database as consecutive number.jpg

A region of size 180-by-120 is cropped and it can be used for training or for testing (recognition purpose) depending on the user
input from GUI. If user selects it to be a training image, a copy of this cropped image is automatically saved in the train database with the consecutive serial number.jpg as its name, (for example 50.jpg if the last image saved was 49.jpg) or else this image is provided to the algorithm explained in the next section

Face Recognition
The detected face now needs to be identified, and this part is called face recognition. Various methods as discussed in the literature survey, can be used to accomplish the task. In this work we choose information theory based approach due to its simplicity and reliability. This approach involves the steps as shown in figure 3

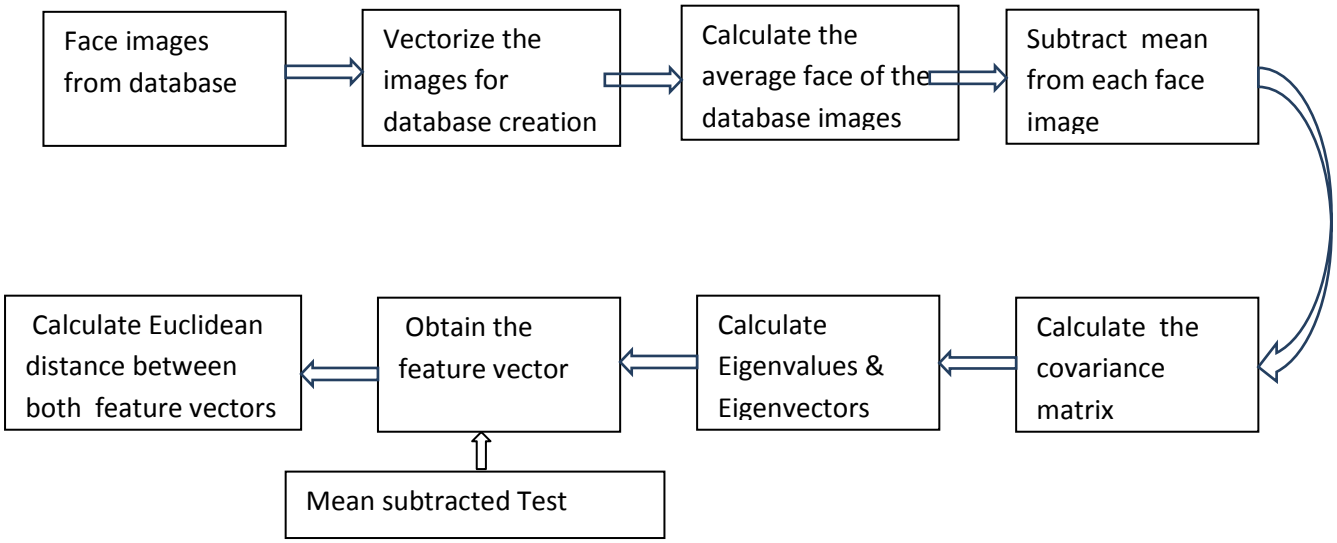


Figure 3 Flow diagram for face recognition

4. IMPLEMENTATION

MATLAB R2013a has been used to implement the algorithm described above. The implementationis as follows [6][7] :

The average face of this training set is calculated.

Let there be I_1, I_2, I_3,------ I_m images in the training set.

$$\Psi = \frac{1}{m}\sum_{n=1}^{m} I\, n$$

Figure 4 shows the average face of our training database.

The mean obtained above is subtracted from each image

$$\Phi_i = I_i - \psi$$

The covariance matrix of subtracted image matrix is calculated using

$$C = AA^T$$

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

Eigenvectors of the covariance matrix are obtained using the inbuilt function, which are further used to obtain Eigen faces as

Eigenfaces(**ω**) = A*V

Where again A=[Φ_1 ,Φ_2 ,Φ_3 ,……Φ_n] and V are the eigen vectors obtained using the inbuilt function. Sample Eigen Faces are shown in *Fig. 4*

The feature vector of the training database is obtained as

$$\mathbf{\Omega} = \boldsymbol{\omega}^T * A$$

For classification, mean is subtracted from the test image and the feature vector of it is obtained using

$$\mathbf{\Omega}_{test} = \boldsymbol{\omega}^T * A_{test}$$

Where $\boldsymbol{\omega}$ is obtained in step 5 and A_{test} is the mean subtracted test image.

Finally the euclidean distance between all columns of training database feature vectors and feature vector of test image is calculated. The minimum distance is a match.

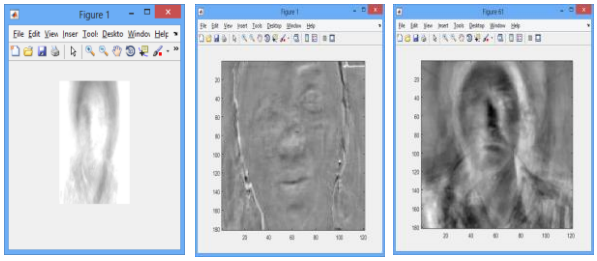
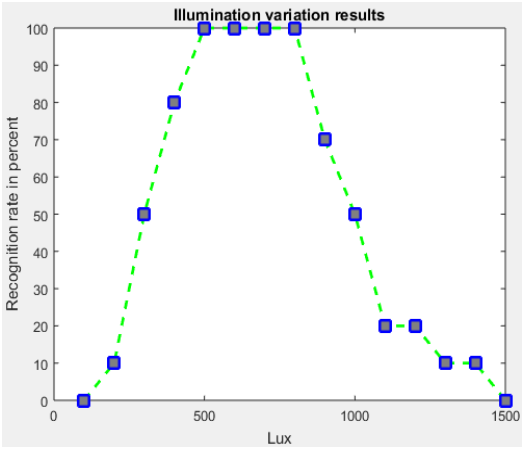
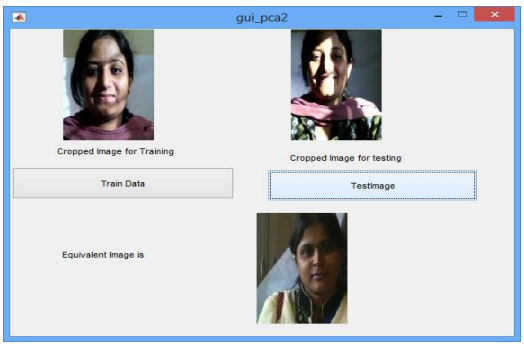
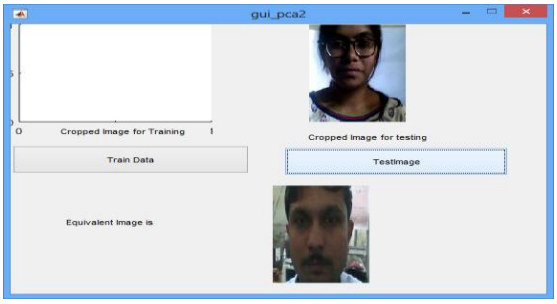


Figure 4 Average face and Sample Eigen faces



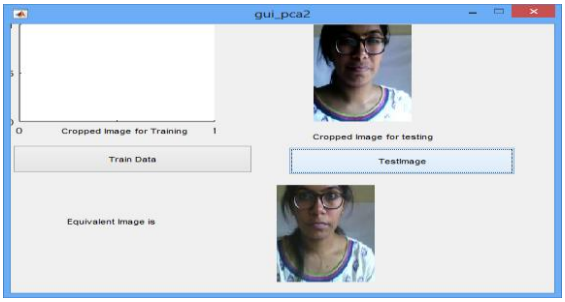




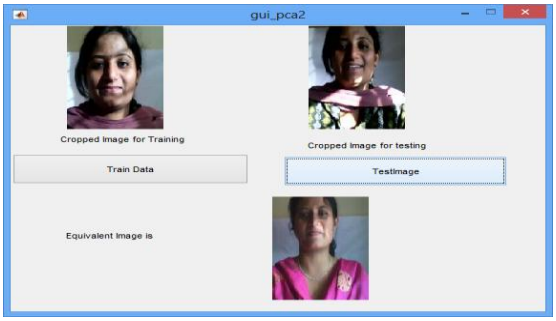
5. EXPERIMENTAL SETUP:

A GUI for recognition system has been built as shown in figure 5. Also a training database has been developed with a total of 70 face images of around 30 subjects all captured in bright daylight (illumination approx. between 200 lux to 1000 lux). Testing for illumination variation has been performed on 2 subjects with 10 samples of each subject taken at different lux levels.

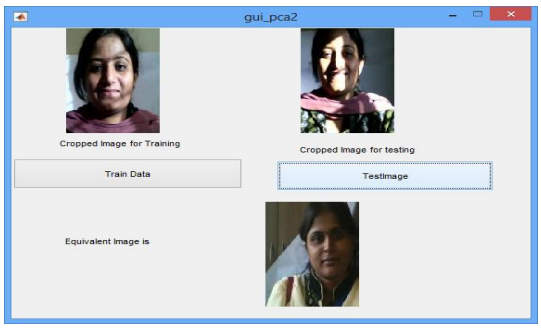
False recognition of test Image at illumination level 242 lux



True recognition of test Image at illumination level 400 lux



True recognition of test Image at illumination level 800 lux



False recognition of test Image at illumination level 1200 lux

Figure 5 Results of illumination variation

6. RESULTS:

The system was tested on intel's core i5, 1.6GHz processor with 6GB RAM and built in 2GB graphics card. A training dataset of 70 images and over 30 subjects was built, using a integrated webcam of 640-by-480 resolution. Images were taken in different illumination levels measured using a standard LUX meter with white background and the distance from camera was not more than 1 meter. The results obtained for various illumination levels are shown in figure 5. Figure 6 shows the corresponding graph of the observations.

7. OBSERVATIONS AND CONCLUSIONS:

Face recognition system is designed, implemented and tested for different illumination levels. Test results show that system has acceptable performance between the illumination levels from 300 Lux to 1000 Lux. Although there is still a scope for improvements like system is sensitive to illumination, distance from camera and background colors. While testing, certain precautions were taken like distance from the camera was not more than 1 meter and a white background was used.

8. REFERENCES

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