Facial Image Based Security System Using PCA

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Abstract—**Security is one of the utmost requirements of homes and businesses which requires biometric identification. This paper aims to identify a person through face recognition. Face recognition is very complex and multidimensional problem. A MATLAB based Principal Component Analysis is used for face matching decision. The system is designed in MATLAB which converts facial images to feature characteristics of initial training database images. Facial features are extracted from the face and eigenvalues are calculated and represented as a eigen vector. Comparison of unknown face image and database image is done using Euclidian distance method. The recognized facial image has minimum Euclidian distance with the database images. When face is recognized by MATLAB Code it will provide the signal to ARM7 to open Gate and System will send SMS to the authorized person using GSM module. Security system using MATLAB and Embedded system design is cost effective, reliable and highly accurate.**

Keywords—Eigenvector; Eigen value; Face Recognition; GSM Module; PCA; MATLAB; ARM7 LPC2138.

I. INTRODUCTION

Most systems that control access to secured locations, financial transactions or computer networks identify authorized or permissible persons by recognizing passwords or Personal Identification Numbers (PIN). The weakness or disadvantages of these systems is that dishonest or unauthorized persons can discover others passwords and numbers easily and use that without detection to user. A Biometric Identification (BioID) system uses physical features for checking a person's identity and ensures much can be stored in a credit or debit card microchip. If the card is stolen and someone tries to use that card then the impostor's biometric features will prevent the false transaction without matching.

There is need to develop Biometrical Identification (BioID) system that uses biometrical feature face to identify people. Biometrical Identification (BioID) achieves much greater accuracy than other systems. Facial image leads to an accurate identification. Face recognition system provides a timely solution to the security problem. Face recognition is advantages for users to be focused on their current work without extra effort for hands or eyes and without extra learning time [3]. The face recognition is possible using the principal component analysis algorithm which uses eigenface approach. Once the face is recognized, the entrance gate

operated using the DC motor and send recognition result to the authorized person with the help of GSM Module. This paper aim is to develop a low cost software application for many industrial, national security and automation with flexible and reliable environments [4].

II. LITERATURE SURVEY

A biometric is a unique, measurable parameter of a human being. This can be used to automatically recognize an individual or verify an individual's identity. Physiological and behavioral characteristics of human being can be measured with the help of biometrics. It includes Finger-scan, Facial Recognition, Iris-scan, Retina-scan, Hand-scan etc. Behavioral biometrics include: Voice-scan, Signature-scan etc. A "biometric system" refers to the integrated hardware and software used to conduct biometric identification or verification [2]. Principal Component Analysis Algorithm with the classifier euclidian distance, normalized correlation and neural networks is used for the face recognition. This system use one physiological biometric (face) parameter for the more security purpose also GSM Module send recognition result in the form of SMS to the authorized person which increases the efficiency of Security.

III. PCA ALGORITHM

Principal Component Analysis is a dimension reducing method used to resolve recognition issues of face. It also called eigen space Projection. In this technique the image is converted into small sets of characteristics. This characteristics has the large difference with the other facial images; based on this difference the recognition result is more dependent. The transformation obtained from the output components is orthogonal or uncorrelated. While describing the original vector the mean square error can be small if compared with output components. Feature extraction can be performed on PCA, which is capturing the most different and unique data component from the image; this can be used while recognition. The PCA is used for image processing, System analysis, computational reduction etc. Major applications for which the PCA is more useful is the minimum dimensional representation for all database images [5]. These representations are linear combinations of all images or eigenvectors. The detailed procedure of PCA algorithm is first to builds a training database of human face. Second, represents each image of the database in the form of vector. The average face vector is to be

calculated and then subtracted from the average face vector of each face image vector. Third, is to calculate eigenface vector, space and project the training faces into eigenface space. By these calculations coordinate coefficients are to be obtained. Finally, by calculating the Euclidean distance between coordinate coefficients of test image and images in the database, the test image is classified by using the nearest Euclidean distance. After all these orthogonal transformations and vector calculations the test image which has minimum Euclidean distance declared as recognized face. PCA used for recognition of face is also called eigenface method [7].

IV. MATHAMATICAL STEPS FOR FACE RECOGNITION

At the start to get a Set (S) which includes (K) face images; Every single image is transformed to the vector of magnitude (N) then training set is made which has (K) faces by;

$$S = \{ \Gamma_1, \Gamma_2, \Gamma_3, \ldots\ldots\ldots\ldots \Gamma_n\} \qquad (1)$$

The obtained Mean of database images as

$$\Psi = \frac{1}{M}\sum_{n=1}^{M} \Gamma n \qquad (2)$$

Then mean is deducted from the real time face as

$$\Phi i = \Gamma i - \Psi \qquad (3)$$

Eigen vectors are finding such that

$$\lambda_k = \frac{1}{M}\sum_{n=1}^{M}(u_k^T \Phi_i)^2 \qquad (4)$$

Where, u_k - eigen vector & λ_k - eigen value
Covariance matrix is calculated as

$$C = \frac{1}{M}\sum_{n=1}^{M} \Phi_n \Phi_n^T \qquad (5)$$

Real time facial image converted into Eigenface components

$$\omega_k = u_k^T (\Gamma - \Psi) \qquad (6)$$

Then the weight vector is formed by

$$\Omega^T = [\omega_1, \omega_2, \omega_3, \ldots\ldots \omega_m] \qquad (7)$$

Euclidian distance among two facial images given by;

$$d(xi, xj) = \sqrt{\sum_{r=1}^{n}\big(ar(x_i) - ar(x_j)\big)^2} \qquad (8)$$

Then find the Euclidian distance among real time facial image and training faces is given by,

$$\varepsilon_k = |\Omega - \Omega_k| \qquad (9)$$

The threshold level in the particular range is declared as the known face; if the threshold level is not in the range then it is the unknown face [6].

V. SYSTEM DESIGN FLOW

Face Recognition is the complex multidimensional problem. The System design flow explains the stepwise solution to the face recognition problem. After only observation of this flow gets the how the facial image based security system works.

A. Face Recognition Flow Chart

In Principal Component Analysis Training set created by capturing facial images. The eigen-vectors of every captured facial images are designed or calculated. The "eigenfaces" are linear combination of eigen-vectors.

Eigenface means the principal component of the stored data sets for the face images. By considering mathematically

eigenvectors of covariance matrix of stored database are eigenfaces. These eigenvectors or eigenfaces represents the significant changes of the face images which help to recognize facial image. For classification of different facial images, weights of the eigenvectors are calculated. The Euclidian distance among new entered face and the database face are approximately matched, new face has to be recognized. They are further classified as known or unknown face [8]. Face Recognition flowchart is shown in Fig. 1.
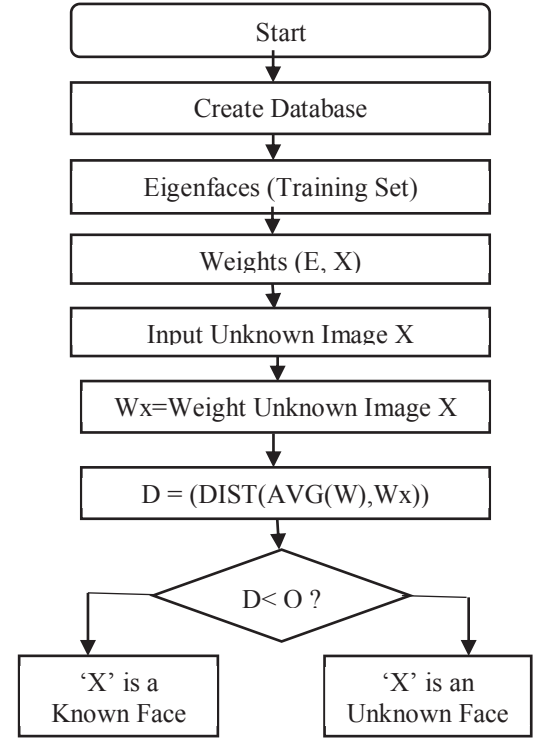

Fig. 1. Face Recognition Flowchart

B. Flow of Security System

The system operation starts with the user face recognition. In Face Recognition the real time image is captured using the Web Camera. The Security system flow is shown in Fig. 2. The Captured image will be pre-processed and the facial area is extracted from the captured image. For this purpose the motion detection concept is used. For example a person is doing some others activities like lifting hands up, blinking eyes, looking here and there, moving eyebrows or sitting down. In these cases also our system will track or capture human head position. This motion detection and tracking system uses spatiotemporal filters followed by nonlinear accentuates or highlights image positions that change in intensity with respect to time so the moving person "lights up" in this image. After this the binary motion image is produced this image analyse the "motion blobs" which decide the head position [9]. Face detection, comparison and recognition using MATLAB and Principal component Analysis. To display the recognition result the Euclidian distance formula is used which finds the difference between mean image and unknown

image. The smallest Euclidian distance image is verified as the recognized face because this image has the minimum variance with the other database images but below the threshold level. When face is recognized then access will be granted and ARM7 will drive the Gate using L293D and GSM Module will send recognition result through SMS and the recognition result will be displayed.
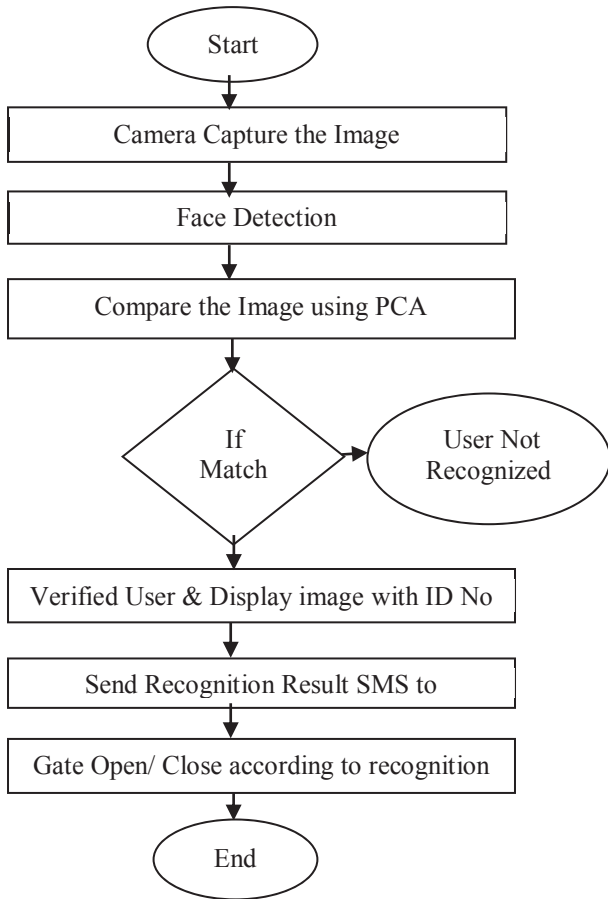

Fig. 2. Security System Flow

VI. HARDWARE IMPLEMENTATION

Hardware implementation of the system is shows in Fig. 3. It consists of ARM LPC 2138, GSM Module, Liquid Crystal Display (LCD) and DC Motor to drive the Gate, the input for the ARM LPC 2138 is the face recognition result which is received from the Matlab software program which uses PCA for face recognition the GSM Module will send the recognition SMS the detected face is known or unknown to the authorized person. LCD displays the current status of the hardware these are Sending SMS, Face recognizing, Known or unknown person etc. The DC Motor Driver L293D is used to drive the DC Motor. According to the recognition result the DC Motor drives the Gate Connected to it.
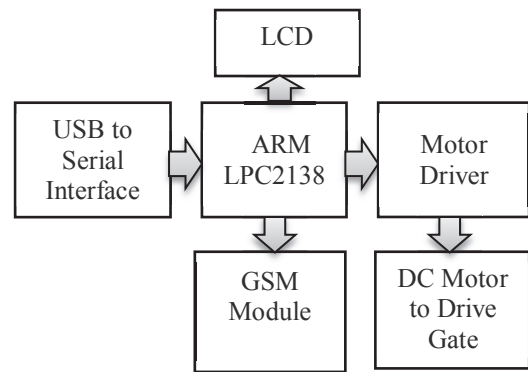

Fig. 3. Hardware Implementation of System

VII. SOME TERMS USED IN FACE RECOGNITION

A. Eigen Valuess and Eigen Vectors

Mathematically, The eigenvectors are the non_zero vectors. The results gets scalar multiple of operator when operated by operator. Scalar also known as the eigen value (λ) related to the eigen vector (Y). The Vector which is scaled by the linear transformation is called eigenvector. When matrix is applied on it the direction of vector is not altered but magnitude of vector is altered.

$$BY = \lambda Y \tag{10}$$
Where, B is function of vector

$$(B - \lambda I)Y = 0 \tag{11}$$
Where, I is Identity of Matrix

By observing the equation it is found that this is a Homogeneous equation.
If, 'Determinant (B-λI) =0'   (12)
Then the solution is non_trivial.
After evaluation a degree 'm' of polynomial becomes B's characteristics polynomial. When 'B' has 'M×M' then there are 'm' results or 'm' roots of characteristics polynomial. Therefore there are 'm' eigen values of 'B' which satisfies the equation given below.

$$BY_i = \lambda_i Y_i \tag{13}$$
For, i=1, 2, 3, 4, 5,…m
When Eigen values are completely different then their 'm' number of related linearly independent eigenvector [6].

B. Training Set

By capturing and combining different face images, a training set is formed. The facial images of every person are together in the set known as training set. These images are taken by real time webcam or pre-recorded video. The images can be captured from video camera or can be taken from face image database. The captured facial images should have variations in the expression, illumination and pose etc. These variations help to get the system efficiency under different surroundings [6].

A user interface is a graphical display which has one or more windows. It contains components that support a user to perform co-operative tasks. When the user is verified then the The Fig. 6 GUI showing verified user is displayed. The user is not required to create a script or type instructions at the command line to complete the tasks. To accomplish tasks, the user doesn't need to know the details of how the tasks are accomplished. User Interface (UI) components consist of toolbars, push buttons, radio buttons, list boxes, menus and sliders. UIs created using MATLAB tools can also perform any type of computation, read and write data files, communicate with other user interfaces and display data as tables or as plots [3].
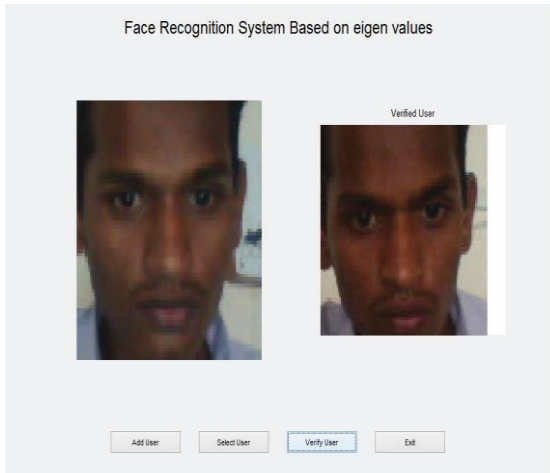

Fig. 6. GUI Showing Verified User

In this paper for handling captured facial images the Matlab Graphical User Interface (GUI) is used. When run the program the initial GUI window will be appearing on the Screen. Using GUI it is Possible to handle the captured or database image. This GUI has four push buttons add user, Select user, Verify user and Exit which are used for handling face image.
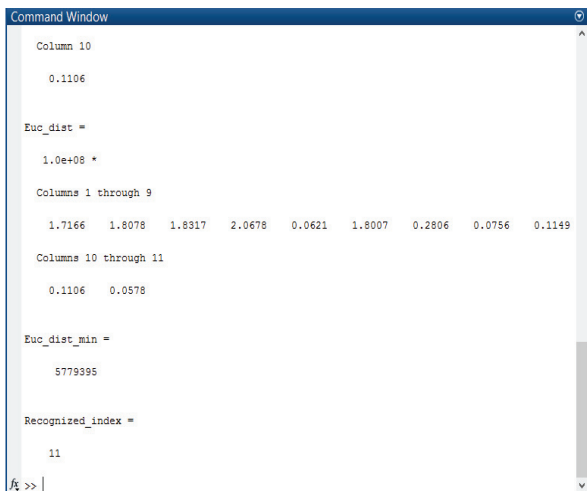

Fig. 7. Euclidian Distance for Verification

After comparing the Eigen Values of captured/unknown face image and database face image using Euclidian distance measurement technique. The Fig. 7 shows Euclidian distances for verification. The Euclidian distance is calculated among the just captured facial image and database facial images. Recognized face has the smallest Euclidian distance is known face and all remaining are unknown faces. The known face has Euclidian distance below threshold and unknown face has above threshold.

When the Euclidian distance is above threshold level then this can be considered as the unknown and the image "User Not Recognized" will be displayed on the GUI. This is shown in Fig. 8 GUI showing user not recognized.
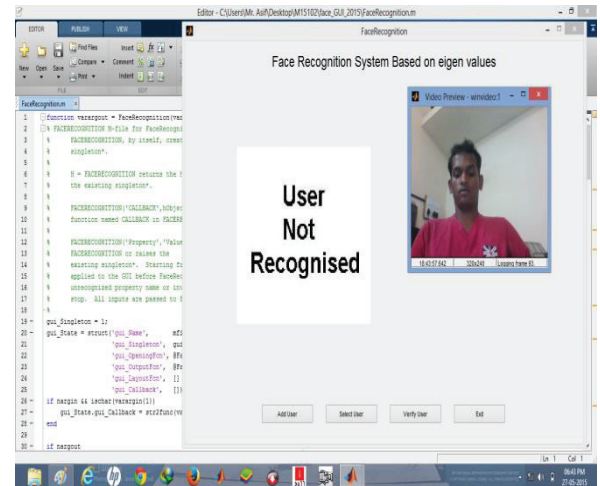

Fig. 8. GUI Showing User Not Recognized

TABLE I.   FACE RECOGNITION ANALYSIS

	Principle Component Analysis(PCA)		
	Algorithm and Classifier	*Recognition Rate*	*Error Rate*
1.	PCA and Euclidian Distance	86%	14%
2.	PCA and Normalized Correlation	75%	25%
3.	PCA and Neural Networks	70%	30%

Principle Component Analysis algorithm is used for the face recognition with the different classifiers that are euclidian distance, normalized coordination and neural networks. TABLE I. shows the Face Recognition Analysis; results obtained using various classifiers with PCA; Recognition results obtained using euclidian distance method is better than the normalized correlation and neural network classifier.

IX. CONCLUSION

A complete security for safeguarding to business offices, houses and banks are necessary due to the increase of thefts; as the security increases the cost of the security increases hence it is important that offices be secure and also security systems used should be cost effective. The natural

way to identify the person is through their face and this system designed with the combination of Matlab and Embedded system; by using this possible to provide complete security.

Face recognition is done using PCA which reduces the face features components for comparison called eigen values due to this the computation time and space required for calculation and comparison of eigen faces is reduced and system will work more faster. Face Recognition is done using PCA and recognition result SMS known or unknown person is sent using GSM module to the authorized person increases the level of security. Security system using Matlab and Embedded system provide cost effective, reliable and highly accurate response.

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