A Robust Embedded Ear Recognition System

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Abstract: In contemporary society, there is a need to identify a person for safety and security. There are so many ways to recognize a person uniquely based on his/her behavioral attributes like fingerprints, iris, ear, etc. Recognizing a person based on the ear has gained attention because of its stable features with age. A sample ear database of 40 persons was created by video recording the ears of persons of different genders at different angles and at different illumination conditions using a HI-Focus Digital CCTV camera of 1MP resolution. From the video recordings, frames are extracted and cropped the ear part. The ear biometric system is developed using DM6437 in which PCA is applied on ear database, and achieved a recognition rate of 100%. From the recognition performance, it is opinioned that an embedded ear biometric system can be implemented in real time for large database.

***Index Terms* – Principal Component Analysis, Recognition Rate, Equal Error Rate.**

I. INTRODUCTION

The human body is an entity with amazing features that run from head to toe. The characteristics of the human body always help to design modern recognition systems for identification of the individual. We can identify a person based on facial features, fingerprints, iris, ear etc. We have been using face recognition and fingerprint biometric systems to identify a person from the past few decades, but these systems have certain drawbacks as the facial features and finger impressions are subject to changes as per the age**.** As the age increases, the lines of the fingerprints may disappear and the facial features change and even the close family members may not able to recognize if not seen for few years. Similarly, the iris recognition system has also certain disadvantages as it needs active cooperation of the person being recognized.

Human ear recognition system is a new technology in the field of biometrics. Identification of a human by ear biometrics is effective because it resembles other recognition systems. Ear has standard features which does not have expression changes, makeup effects and its color is constant. In Biometrics, they are two methods invasive and non-invasive. In invasive method, pre-recorded information is needed in the form of datasets which is used for human feature comparison. Non-invasive method is a process of capturing data from the subject under test without cooperation. For iris scanning and finger print scanning high quality of cameras and scanners are required. Ear pattern recognition is also come under non-invasive biometric system like face pattern recognition and do not require high quality data.

Ears play a significant role in forensic science for many years, an ear classification system based on manual measurements has been developed by Iannarelli [1]. Principal component analysis (PCA) algorithm is widely used by many researchers to extract features from ear image [2-5].

Chang *et al.* [3] compared ear recognition and face recognition using a standard PCA technique on face and ear images, and reported accuracies of 71.6% and 70.5% for ear and face recognition, respectively. They also presented results with varying lighting conditions which resulted in lower recognition accuracies of 64.9% and 68.5% for face and ear images, respectively. Principle component analysis can be considered as a most popular multivariate technique in statistics and recognition patterns. PCA is a statistical technique employed to reduce the dimensions of the image and it is also used to analyze the data having many variables in related subjects and can find scatters between those variables such as similarities and differences. Since it is difficult to analyze or represent data with higher dimensions, PCA can also be used to reduce the dimensionality. The PCA is applied to all the input images to produce characteristic features that classify input images. The characteristic features are obtained by projecting the input image on to eigen space. The principal eigenvectors having considerable eigen values only, are used to project each image onto eigen-space to reduce the dimensionality.

II. PRINCIPLE COMPONENT ANALYSIS WITH DIFFERENT DISTANCE MEASURES

The following are the important steps while applying the Principal Component Analysis for images:

- Acquiring initial set of data.
- The efficiency of PCA is improved by subtracting the average or mean of the particular dimension from its components. E.g., dimension x becomes x – x!!, where x!! is the mean.
- The next step involves calculating the covariance matrix which is a representation of the relations between two dimensions.
- Finally, eigenvector and eigenvalues are calculated from the covariance matrix. The eigenvectors are then arranged according to descending eigenvalues and usually the top few eigenvectors are chosen as principal components.

The process to compare test image is as follows:

- Subtract the mean of the image dimensions from themselves.

- Scalar multiplication of the image matrix with the matrix comprising of the principal components resulting in the weight matrix.
- To match two images (one test image with another from the database), the Euclidean distance between the two weight matrices of the images is calculated.
- The above mentioned distance is known as the *score*. Lower the score more are the similarities between the two images.
- A test run of the system is used to set a threshold below which the person is accepted as a valid user. This is combined with variation in threshold to obtain genuine and imposter scores resulting in the ROC curve.

The test image features are compared with the database images using Euclidean and City Block distances. The Euclidean distance between p^{th} and q^{th} feature vectors with length 'l' is given by ED_{pq}.

$$ED_{pq} = \sqrt{\sum_{j=1}^{l} \left(M_{pj} - M_{qj}\right)^2} \quad (1)$$

The City Block distance between p^{th} and q^{th} feature vectors with length 'l' is given by CD_{pq}.

$$CD_{pq} = \sum_{j=1}^{l} \left|M_{pj} - M_{qj}\right| \quad (2)$$

III. DATABASE CREATION

This database consists of the ear images collected from the persons of age ranging between 9 to 40 years. All the images are acquired from a distance using the simple imaging setup and the imaging is performed in the indoor environment. The current available database is acquired from 40 different subjects and each subject has at least three ear images. This database is created by extracting frames from the video that we have recorded from the camera through DSP processor. All the subjects in the database are in the age group of 9-40 years. The sample ear images are shown below:

Fig. 1: Sample Ear images of database

IV. IMPLEMENTATION

The PCA algorithm is applied to the database created. An embedded ear recognition system was developed using SIMULINK, CCS and DM6437. The input to the embedded system is given in real time. The features of the input subject's ear are extracted using Principle Component Analysis and the obtained feature vector is compared with those feature vectors in the database. Based on the correlation of the feature vectors, a decision is made on the input test ear image and declared it as "authorized" or "Unauthorized".

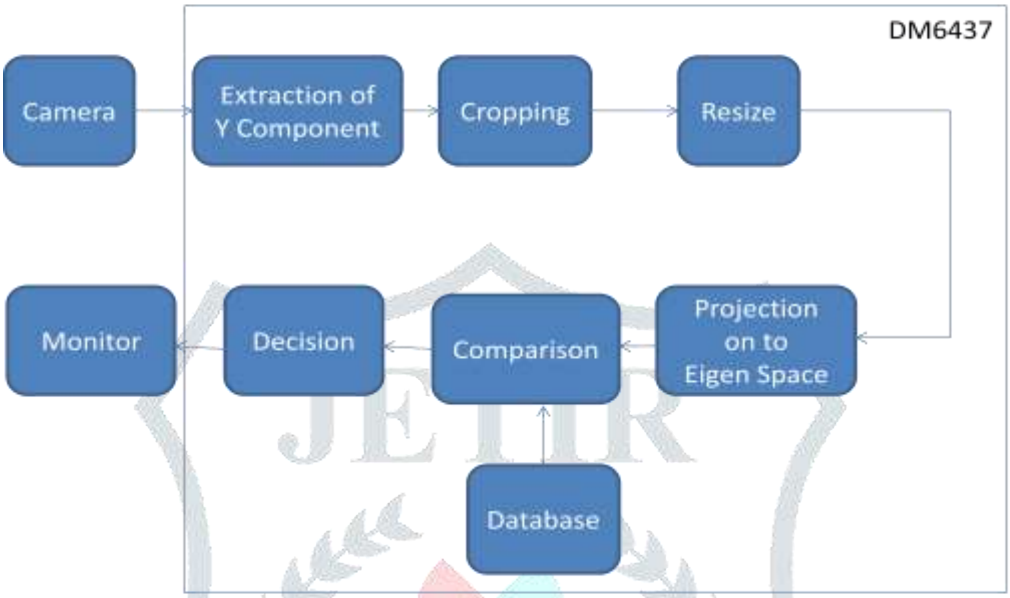

Fig. 2: Block Diagram

V. RESULTS AND DISCUSSION

PCA with Euclidean and City-Block distance measures is applied on created database has achieved a recognition rate of 100% and it is shown in fig. 3. An equal error rate of 5.0% is obtained in case of Euclidean distance measure and 3.8% in case of city block distance measure. This is evident from the plots shown in figures 4 and 5.

An embedded system was tested by giving input test samples of genuine person and imposter. It recognizes genuine persons as authorized and imposters as unauthorized and it is evident from figures 6 and 7.

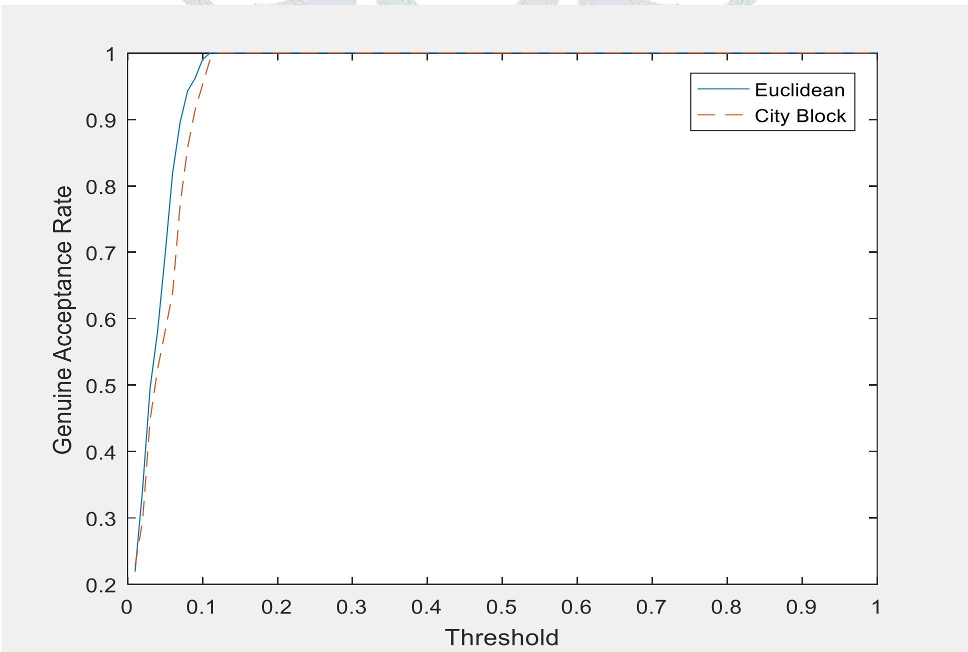

Fig. 3: Genuine Acceptance Rate with different distance measures

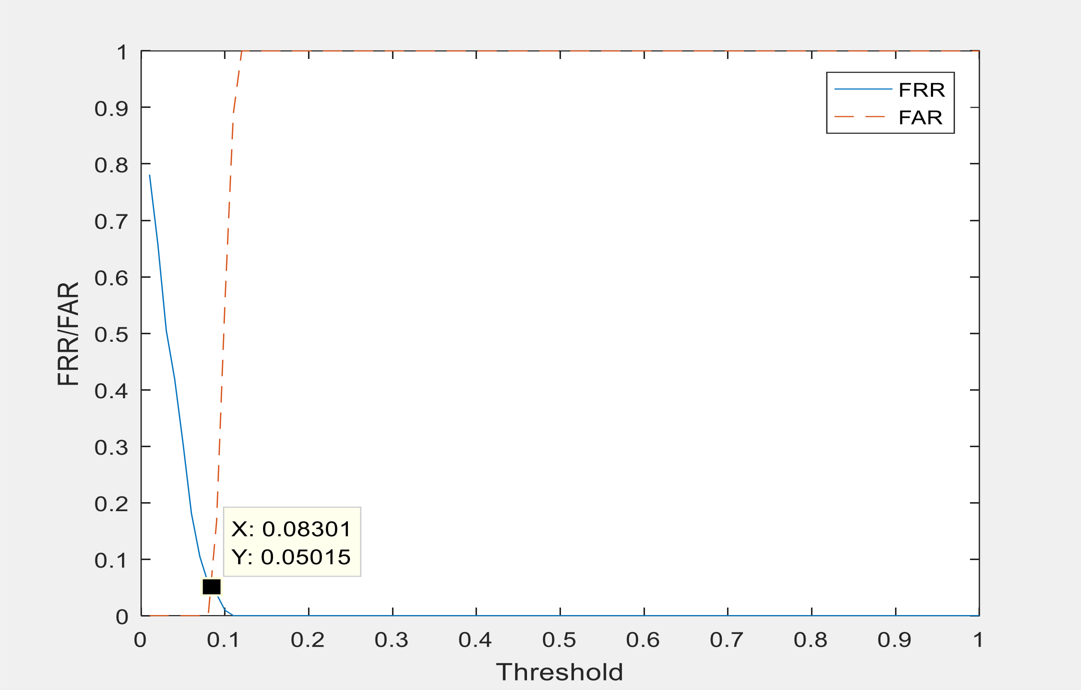

Fig. 4: FRR/FAR with Euclidean distance measure

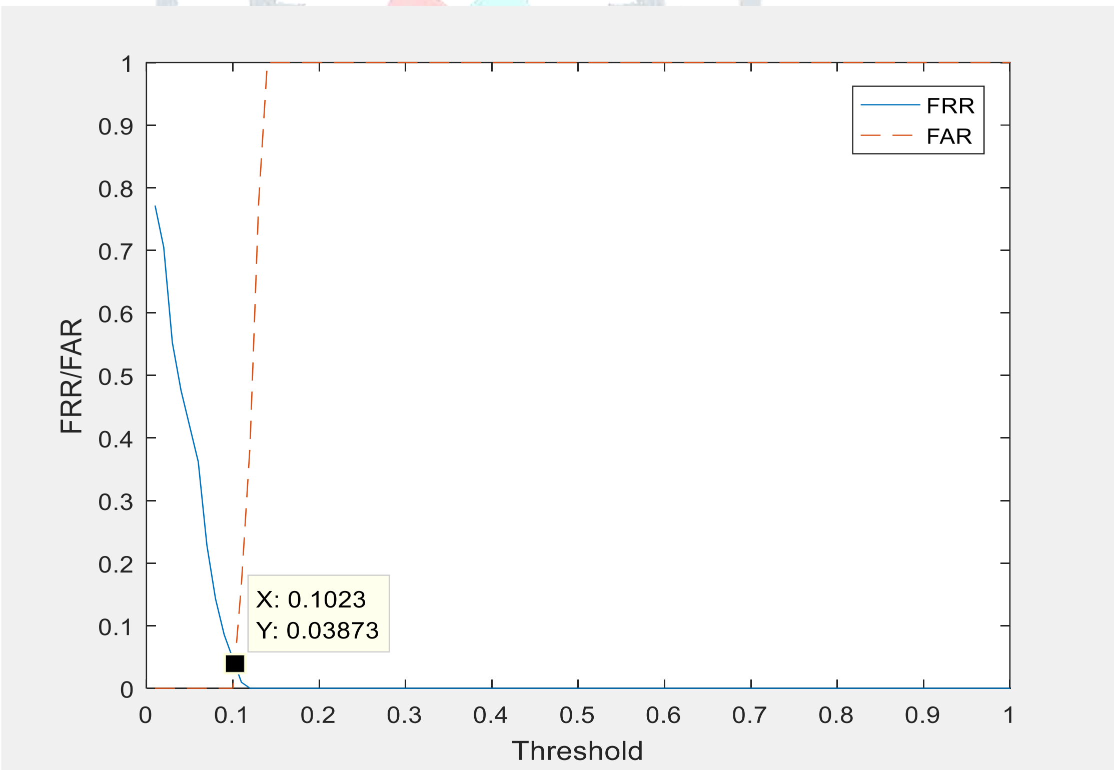

Fig. 5: FRR/FAR with city-block distance measure

The embedded ear biometric system is verified for its accuracy under different test conditions. Light intensity of the room is varied and the input to the camera is given with different pose variations from different angles etc. A sample result given by the system declaring the unauthorized person is shown in fig. 6 and an authorized person declaration is shown in fig. 7.

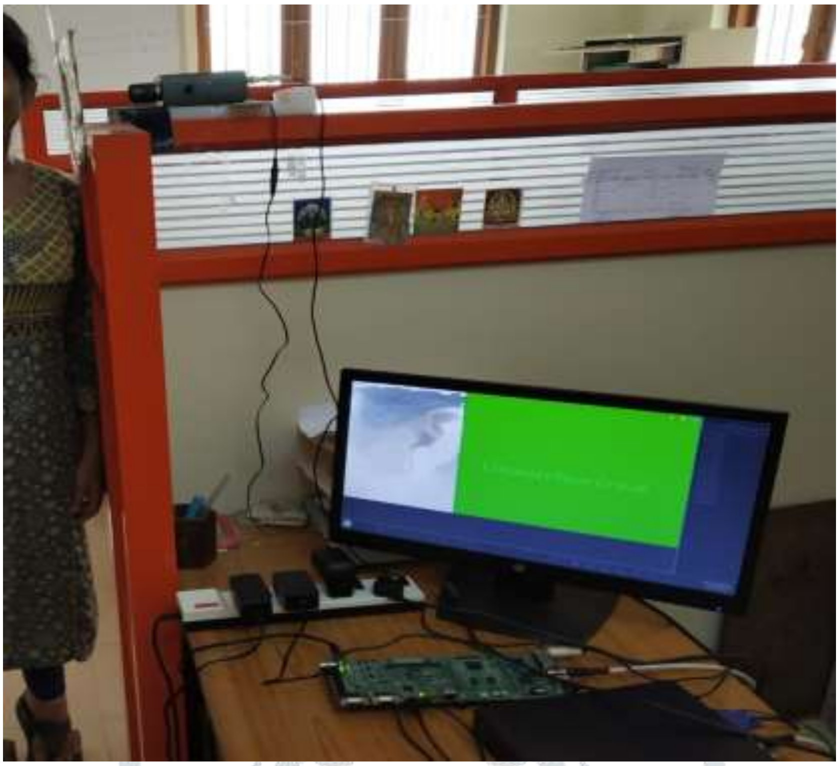

Fig. 6: An imposter is declared as unauthorized by the ear biometric system

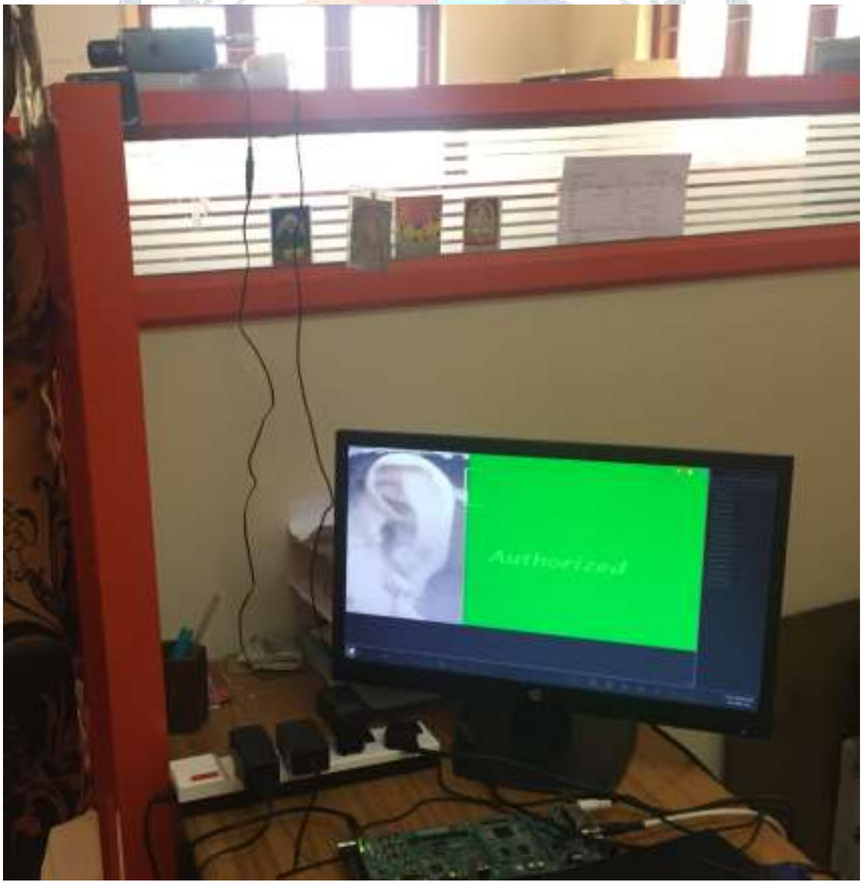

Fig. 7: Authorizing a genuine person by the ear biometric system

VI. ACKNOWLEDGMENT

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