Probabilistic PCA Human Ear Recognition System

[1]Diksha Kumari, [2]Satnam Singh, [3]Bhanu Gupta

[1]PG Student, [2]Assistant Professor and Head of Department, [3]Assistant Professor
Department of ECE,
SSCET (IKGPTU), Pathankot (Punjab) , India

***Abstract*: The human ear is a perfect source of data for passive person identification in many applications. In a growing need for security in various public places, ear biometrics seems to be a good solution, since ears are visible and their images can be easily taken, even without the examined person's knowledge. Human ears have been used as major feature in forensic science for many years (for example in airplane crashes). Ear prints, found on the crime scene, have been used as a proof in over few hundred cases in the Europe and the United States. Nowadays, police and forensic specialists use ear prints as a standard proof of identity. There are many advantages of using the ear as a source of data for human identification. Firstly, the ear is one of the most stable human anatomical features. It does not change considerably during human life. Furthermore, the ear is one of our sensors, therefore it is usually visible (not hidden underneath anything) to enable good hearing. Reliability in personal authentication is a key to the stringent security requirements in many application domains ranging from airport surveillance to electronic banking. Many physiological characteristics of humans, *i.e.*, biometrics, are typically invariant over time, easy to acquire, and unique to each individual. The first step of ear recognition is the segmentation of ear image from the profile face. Ear images taken at different time can vary significantly due to changes in hair length and color. Due to this variation many false point matches may occur and this reduce the accuracy of image distance measurement significantly. The proposed system is to be developed in MATLAB and tested on a available Human Ear Database.**

***Index Terms*: Ear Recognition, CPD, Probabilistic PCA, MATLAB.**

I. Introduction

The Ear Biometrics is latest trend in biometrics technology. Ear Biometrics has attracted attention of many researchers in recent years. Ear Biometrics is a technique of identifying, verifying and comparison of person on the basis of typical physiological structure of ear. Ear biometrics is used in human identification and verification. There are three ways of ear biometrics: recognition using ear photographs, ear prints and thermograph picture of ear image. Common method of biometrics is by taking photographs of ear image. Ear biometrics is preferred over face biometrics as shape and outer structure of ear is unique for each individual, outer structure of ear is permanent i.e. it does not change with age. Ear is small in size so image processing work is less compared to object in large size. Ear has a uniform distribution of color. There is less variability of structure of ear with expressions and orientation of the face. Morphology of outer ear is simple compared to texture of iris or the distribution of minutiae in fingerprint identification. Features of ear are fixed causes less image processing work and saves time in processing. Out of these four steps Image pre-processing and Ear feature extraction are major steps. Ear Recognition system has to face problems due improper capture of images. Blurred image does not give good results. Noise generated due to hair occlusion and improper lighting is also the problem.

The various application areas of Ear Biometrics

1. Ear Biometrics will be applied to:
2. Security purposes in banks, ATM or for getting access in highly secure areas.
3. For any active identification.
4. In forensics to solve a crime if there is picture of ear in the tape of CCTV camera.
5. Class attendance system.

Structure of Human Ear

To develop a system for ear biometrics it is required to understand first the structure of human ear. The Human ear features are shown in the figure below [1]. Human ear consists of parts like helix, concha, tragus, lobe and antitragus. Helix is the most important part of outer structure of ear shape. Helix again has three more parts as superior, anterior and posterior helix. This feature is different from individual to individual, that is why outer structure of ear is considered as a valuable measure for human identification by criminal investigation. The French criminologist Alphonse Bertillon was first person to study the outer shape of ear for human identification system. This structure is used mostly in biometrics for security. The proposed system here will use a probabilistic approach in combination with principal component analysis for human ear recognition. In general Ear Biometrics system is consists of following steps:

1. Ear Sample Capture and Preprocessing
2. Feature extraction of Ear
3. Feature Data Storage
4. Comparison of Ear shapes
5. Testing of Human Ear Recognition according to availability of database [1].

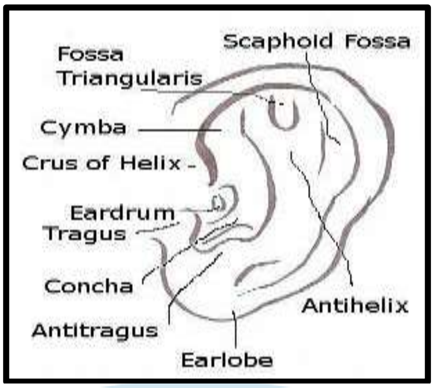

Fig. 1 Human Ear Features [1]

Ear is remarkably consistent and does not change its shape under different expressions like face. Moreover, ear has uniform color distribution. Changes in the ear shape happen only before the age of 8 years and after that of 70 years. Shape of the ear is very much stable for the rest of the life. Like face, handling background is a challenging issue and often it requires data to be captured under controlled environment. However, in case of ear, background is predictable as an ear always remains fixed at the middle of the side face. Size of the ear is larger than fingerprint, iris, retina etc. and smaller than face, and hence ear can be acquired easily. Ear is a good example of passive biometrics and does not need much cooperation from user. Ear data can be captured even without the knowledge of the users from the far distance.

In the proposed system, used a CPD-PCA method to analyze and finding similarities and differences between the dataset images.

1. To acquire ear image from database.
2. To convert to grayscale (if color).
3. To apply binaraization operator to obtain binary image.
4. To achieve feature extraction using PCA
5. To apply PPCA i.e. Coherent Point Drift to principal features obtained in above to retrieve probabilistically enhanced features.
6. To establish a coordination system for key points to calculate biometric comparator
7. To calculate the biometric comparator as matching matrix for identification
8. To test the system on an available Ear Lobe Database according to availability for example USTB Ear Image Databases.

II. LITERATURE REVIEW

In the past decade palmprints has been investigated by various researchers. Some of the recent researches are referred here.

Rasika B. Naik et. al. (2018) proposes that automatic person identification becomes essential in surveillance systems. A class of biometrics based on ear detection and recognition is used in a passive identification system. The main goal is to identify a person using ear. The system has used Principal Component Analysis (PCA) algorithm which is implemented in MATLAB [1].

H. Dai et. al. (2018) publishes that morphable models are useful shape priors for biometric recognition tasks. Here we present an iterative process of refinement for 3D Morphable Model (3DMM) of the human ear that employs data augmentation. The process employs the following stages 1) landmark-based 3DMM fitting; 2) 3D template deformation to overcome noisy over-fitting; 3) 3D mesh editing, to improve the fit to manual 2D landmarks. These processes are wrapped in an iterative procedure that is able to bootstrap a weak, approximate model into a significantly better model. Evaluations using several performance metrics verify the improvement of our model using the proposed algorithm. We use this new 3DMM model-booting algorithm to generate a refined 3D morphable model of the human ear, and we make this new model and our augmented training dataset public [2].

S. Bharath et. al. (2018) use image processing approach and Watershed Segmentation algorithm, to segment an image into regions for better results. The input ear image is pre-processed and segmented, based on the matching percentage attendance is marked for that concerned user and displayed as output. This paper provides good future prospects for the upcoming researchers in the field of ear recognition. For the purpose of result and analysis, experimental MATLAB tool is very useful for result oriented works [3].

Sajal Kumar Goel et. al. (2017) present a more systematic, coherent and methodical way for ear identification using GLCM algorithm which has overcome the limitations of other successful algorithms like ICP and PCA. GLCM elucidates the texture of an image through a matrix formed by considering the number of occurrences of two pixels which are horizontally adjacent to each other in row and column. Pre-processing techniques and algorithms will be discussed and a step-by-step procedure to implement the system will be stated [4].

K. Mohanapriya et. al. (2017) explores the use of an Ear Visual Biometric as a measure of identification unit for the Teaching Management System in Universities and Colleges. It is significantly reduces the workload of teachers' teaching process and improved the credibility and controllability of data by the data acquisition equipment and the whole system. Ear detection and recognition is achieved through the use of Feature Extraction approaches like Force Field Transformation and Chord Point Detection Algorithm is used for better performance than the method to other algorithm [5].

Swati Newale et. al. represents the computer vision application which can be used in underdeveloped country. In underdeveloped country this app can be used to keep medical record. Author represent smart phone app for image based ear biometric. This app is not only used in medical application but it has found several different applications. The research started in 1890 by criminologist. First Ear biometric is used to detect criminal. Author represents the overview of image based ear biometric smart phone app. It also describes about methods used for image processing. Author also describes why we should go for ear biometric as nowadays there are so many options available to use as biometric. [6].

III. SYSTEM DESIGN & METHODOLOGY

The In this proposed work an ear geometry-based biometric verification system using PPCA Probabilistic (CPD) Principal Component Analysis will be modeled and evaluated. The figure below shows the proposed system.

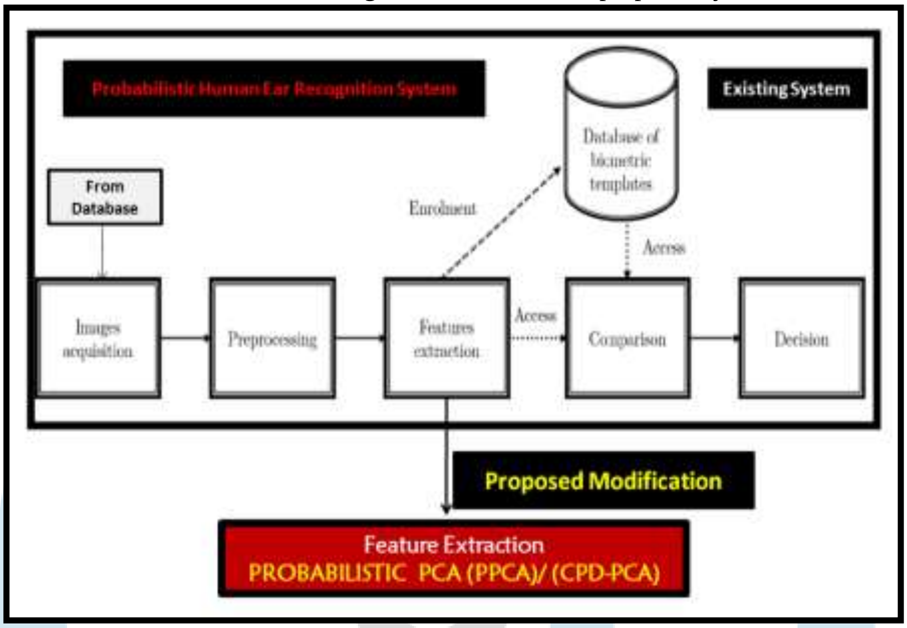

Fig. 2 Proposed System Block Diagram PPCA Human Ear Recognition

In a verification system, the user shows his/her identity when trying to access within the system and presents his/her biometric trait to the system. Then, a sample is given as input from Ear database and processed in order to extract the biometric features, which are compared against the user's template previously stored in the system. In that way, the system makes a one-to-one comparison between the sample and the pattern, resulting in a numerical value which indicates their degree of similarity. The decision module evaluates the result of this comparison and accepts or rejects the user identity depending on a threshold previously set on the system. The statistical method ***Probabilistic Principal Component Analysis (PPCA)*** has been selected as a feature extractor, and the matching of features is performed by a distance-based classifier including Euclidean and Eigen distances. The system has been designed following the typical structure of biometric verification systems and is composed of the following modules: images acquisition from database, images preprocessing, features extraction, database of biometric templates and comparison.

Pre-processing: A good preprocessing of the images is crucial to improve the system performance. To this end, it is necessary to remove those areas which do not contain information about the ear as well as to improve their quality and adapt them for the feature extraction step. Accordingly, those regions of the images including the ears have been manually cropped. Then, they have been converted to grayscale and normalized. In addition, aimed to reduce the computation time as well as to equate the size of the images, they have been resized to 80x45 pixels. Finally, as feature extraction is usually sensible against to rotations and translations, the left ear of each user has been flipped horizontally. This way, it is possible to evaluate the influence of the ear orientation in the system performance by comparing the results of the tests using the original orientation against those involving the flipped images.

Feature Extraction: In basic system the feature extracted using basic principal components which is modified using probabilistic principal component analysis. Principal Component Analysis (PCA) has been selected to extract the ear features from the image. Accordingly, the ear-space that provides the best representation of the ears belonging to the different individuals has been searched. This space is composed of vectors named principal components, which correspond to the most descriptive ear features, are uncorrelated and maximize the variance that the images present.

The ***proposed modification i.e. PPCA*** is technique in which features with high probability of occurring and importance for ear recognition are included in calculating the matching biometric comparator. This is done by application of probabilistic algorithm approach called Coherent Point Drift (CPD) applied to PCA features i.e. Eigen ears.

Distance Based Matching (Euclidean Distance): Distance-based matching has been selected to compare feature vectors due to it is one of the most extended methods in biometrics given its simplicity and low computational requirements. It provides a numeric value as a result, which represents the data dissimilarity. Accordingly, the decision policy established in the system is to consider the compared vectors as belonging to the same person if the computed distance is lower than a previously established threshold. The distance used as biometric comparator is Euclidean distance.

IV. RESULTS AND DISCUSSIONS

The snapshot of Application Graphical User Interface for CPD-PCA (PPCA) Human Ear Recognition System which was developed programmatically using MATLAB is shown in figure below. It consists of 08 buttons which have been assigned different functions to be performed by the application.

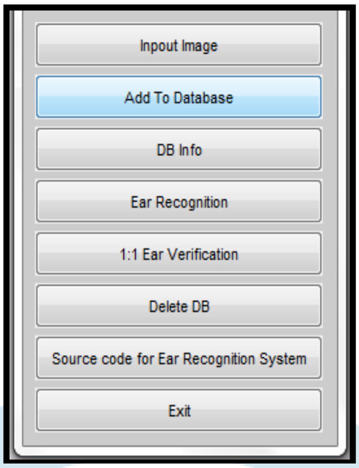

Fig.3 Human Ear Recognition GUI

Input Image: Select ear image. Region of Interest (ROI) will be segmented and feature vector will be encoded.
Add to Database: Selected ear image will be added to database. An ID is required. ID is a progressive non-negative integer number associated to palmprint.
Database Info: Show information about all images present in database and the corresponding IDs.
Ear Recognition (1: N Match): Selected image is compared with all ear images present in database. Code returns the ID of recognized image. Database has to include at least one image.
Ear Verification (1:1 Match): Just select two palmprint images. Selected images will be compared and code will return if they match or not.
Delete Database: Remove database and all saved images.
Get the Source Code: View the source code of the application in read only format.
Exit: Exit the Application GUI.

The color input image from database is converted to grayscale and opened in MATLAB. The snapshot of the image is shown below.

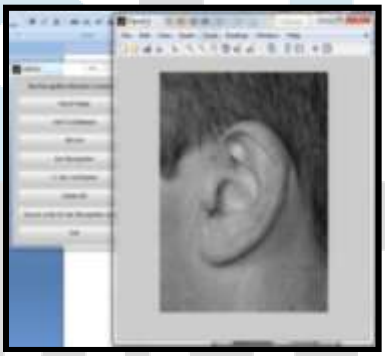

Fig.5 Ear Input Image after grayscale conversion operation in MATLAB

The MATLAB Command window showing ear recognition results with Nearest Class, Euclidean Distance, Distance from ear space values.

Fig.6 MATLAB Command Window: Ear Recognition (1:N) Result

The MATLAB Command window showing CPD based Ear Verification results.

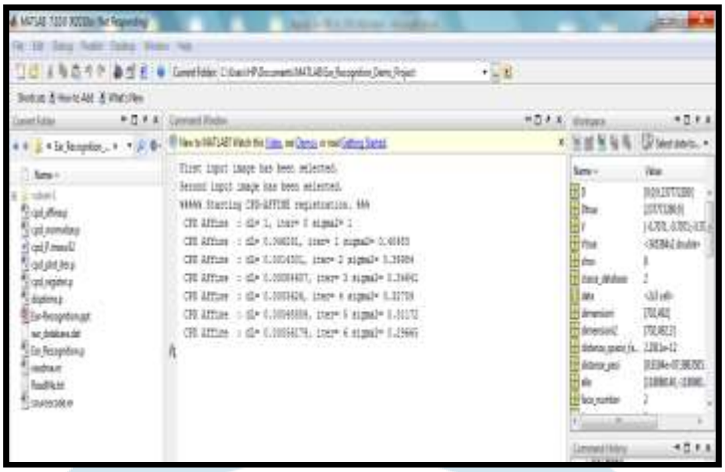

Fig.7 MATLAB Command Window: Ear Recognition (1:N) Result

V. CONCLUSION

The Application GUI for the CPD-PCA Ear Recognition System has been developed along with initial stages of Ear Image Acquisition, Ear Image Pre-processing and Ear Recognition and verification. The application is to be tested on database for accuracy and performance and analytical comparisons are to be made on basis of testing.

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