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Ear Biometric: Sex, Bilateral and Ethnic Differences Among Brahmin and Yadav Communities of Bundelkhand Region using PCA Technique

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Abstract— In present investigation we have presented a passive biometric technique for detection and identification of human ear with the development of a biometric system using 2D ear image. The proposed work uses the extracted ear images to develop the respective features for identification of sex, bilateral and ethnic differences among Brahmins and Yadavs community of Bundelkhand region Via the PCA technique. 800 subjects (400 from Yadavs and 400 from Brahmins) were employed for developing the dataset. Now we approach all 800 samples for measurements of distance of 8 predetermine points on ear geometrical model. In order to test the robustness and variability of ear biometrics, and the accuracy achieved was found to be around 93.31% of Yadavs male &93.38% of Yadavs female and 94.22% of Brahmins male &93.75% of Brahmins Female for right and left ear and overall accuracy achieved by using the proposed method is 93.66%.Percentage of variance and cumulative match score was also analyzed for ear symmetry determination.

Index Terms— Biometric, 2D ear images, PCA, Features extraction, Computer vision, image analysis, and pattern recognition.

INTRODUCTION

The use of Biometrics has been traced back as far as the Egyptians, who measured people to identify them. Alphonse Bertillon, Chief of the criminal identification division of police department in Paris, developed and practiced the idea of using a number of body measurements to identify criminals in the mid-19th century. These measurements were written on cards that could be sorted by height, length of arm or any other parameter. After this, the use of fingerprints, ears, face etc. starts by many law enforcement agencies to determine the identity of the criminals. Biometrics is a method of identifying or verifying the identity of an individual based on the physiological and behavioral characteristics. Physiological biometricsis based on data derived from direct measurement of a part of the human body. Fingerprint, iris-scan, DNA fingerprinting, retina scan, hand geometry, ear recognition and facial recognition are leading physiological biometrics.

The biometric of ear is a very interesting issue in biometric identification systems. Although a newcomer in the biometrics field, ears have long been used as a means of human identification in the forensic field. A traditional and manual method for description of ear features and ear identification has been developed for more than 10 years. During crime scene investigation, ear marks are often used for identification in the absence of (valid) fingerprints. Ear Biometric is to positively identify an individual using comparative analysis of the human ear and its morphology. Ears are a part of physical biometric. Figure 3 (below) shows the main morphological features of the human ear which are used in ear biometrics and earprint analysis to positively identify an individual.The Ear is divided into three parts: 1) External Ear 2) Middle Ear 3) Internal Ear But, in the field of Forensic Science in the respect of individual identification and authentication on, we concern only with the external ear structure.

In order to understand the anthropometry of external ear, it is necessary to acquaint oneself with its anatomy. The external ear are also known as the Pinna or Auricle, is attached to the outside wall of the skull, with its centre positioned approximately halfway between the top of the head and the chin on the vertical axis, and the eye and the nose of the face on the horizontal axis. The external ear varies from the most minute to the greatest degree in reference to Size, Shape, Design and Anatomical distance between various different features like helix rim, anti-helix, tragus, antitragus, triangular fossa, crus of helix, concha, Incisure Intertragica, lobule and overall size (length and width) of ear etc. which are present in all people and provide variances in which each ear is set apart from any other.

REVIEW

There are many possible data sources for human identification systems, but the physiological biometrics seem to have many advantages over methods based on human behavior. The most interesting human anatomical parts for such passive, physiological biometrics systems based on images acquired from cameras are face and ear. Ear biometrics are often compared with face biometrics (Chang set al., 2003; Victor et al., 2002; Hurley et al., 2000). Ears have several advantages

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over complete faces: reduced spatial resolution, a more uniform distribution of color, and less variability with expressions and orientation of the face. In face recognition there can be problems with e.g. changing lightning, and different head positions of the person (Moreno et al., 1999). There are same kinds of the problems with the ear, but the image of the ear is smaller than the image of the face, which can be an advantage. Face can also change due to cosmetics, facial hair and hair styling. Face changes due to emotions and expresses different states of mind like sadness, happiness, fear or surprise. In contrast, ear features are relatively fixed and unchangeable. Moreover, the color distribution is more uniform in ear than in human face, iris or retina (Choras, 2005).

Shailaja and Phalguni (2006) discussed the biometric systems based on human traits which, unlike passwords or pins, cannot be lost, stolen or forgotten. One such trait is ear. With the initial doubts on uniqueness of ear, ear biometrics could not attract much attention. But after it has been said that it is almost impossible to find two ears with all the parts identical, ear biometrics has gained its pace. Introduced a simple scale and rotation invariant two-stage geometric approach which is based on the concept of max-line, the longest line that has both its end-points on the edges of the ear.Purkait (2007) described that Personal identification had been an age-old problem for the law enforcement organizations and Forensic Scientists. The advent of sophisticated electronic gadgets though on one hand has multiplied the problem manifold, on the other, had introduced new techniques for surveillance and monitoring crime. Biometric was one such tool which used human characteristics for personal identification. Ear biometrics, a relatively new class of biometric trait for personal identification had been discussed in this paper. A brief introduction to the field and review of leading works including those appearing in the research world lately are discussed.

Is this the person who he or she claims to be? Nowadays this question arises incessantly. In different organizations like financial services, e-commerce, telecommunication, government, traffic, health care the security issues are more and more important. It is important to verify that people are allowed to pass some points or use some resources. The security issues are arisen quickly after some crude abuses in Indian subcontinent. For these reasons, organizations are interested in taking automated identity authentication systems, which will improve customer satisfaction and operating efficiency. The authentication systems will also save costs and be more accurate that a human being. A reliable solution is required to fill the loopholes of the conventional personal identification methods.

PCA is a useful statistical technique that has found application in fields such as face, Ear recognition and image compression, which is a common technique for finding patterns in data of high dimension. PCA involves a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. Dewiet. al. (2006) described various approaches, such as Principal Component Analysis (PCA) and force field transformation, had already been researched for ear photo recognition. Force field transformation was invariable to scale and rotation. However, the number of extracted features was considerably insufficient for recognition.

The aims of the present study were to access the sex, bilateral and ethnic differences among the Yadav and Brahmin communities of Bundelkhand region leading to the development of Ear based biometric system for personal identification by determining the patterns using PCA technique.

MATERIALS AND METHODOLOGY

In the present research work, an attempt has been made to study the various aspects of sex, bilateral and ethnic differences through ear biometric among the Brahmin and Yadav communities of Bundelkhand region, India. The study focused on the various components that make up the external ear structure and how they vary.

Subjects: In the present research work the subjects were selected from the various places of Bundelkhand region

Samplesize: total 800 subjects were photographed for ear biometrics which included 400 Yadavs (200 male and 200 female) and 400 Brahmins (200 male and 200 female). All the subjects belonged to both "Brahmins" and "Yadavs" communities of Bundelkhand Region of India, in the age group of 18-40 years.

Methodology: Photography of both right and left ears of 800 individuals were done by using "Canon Power Shot-A470" under the same lighting conditions, with no illumination changes. Setting of the camera was same throughout the collection of photographs. The camera was setup on a tripod at same height as the headrest of the chair. The light was placed on either side of the tripod facing the chair. The photographs of both right and left external ear of all the subjects has been taken from the angles perpendicular to the head with a fixed distance of 15 cm between ear and the camera.

Basic methodology presented in the following flow chart was used to generate the required data from various subjects is presented in Fig. 1

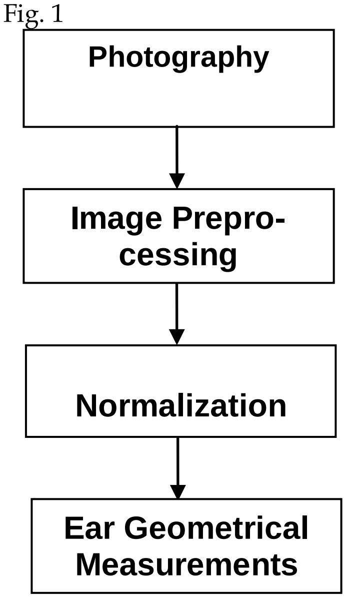

Fig.1Major steps of the approach for ear recognition

In order to maintain reproducibility of the **photographs**, the

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setting of the camera was kept constant. In image **preprocessing**, each image has gone through the following steps: 1. Ear image was cropped manually from the side face image of a person 2. Cropped ear image was resized 3. Coloured image was converted to grayscale image.The sizes of cropped ear images were different. In order to find same number of features from each ear image, resizing the images to unique fixed size of 220x380 pixels were made. Figure 26 demonstrates the output at the end of preprocessing step. Figure 2(a) shows the original image in the database, Figure 2(b) cropped image, Figure 2(c) resized image and Figure 2(d) grayscale image.

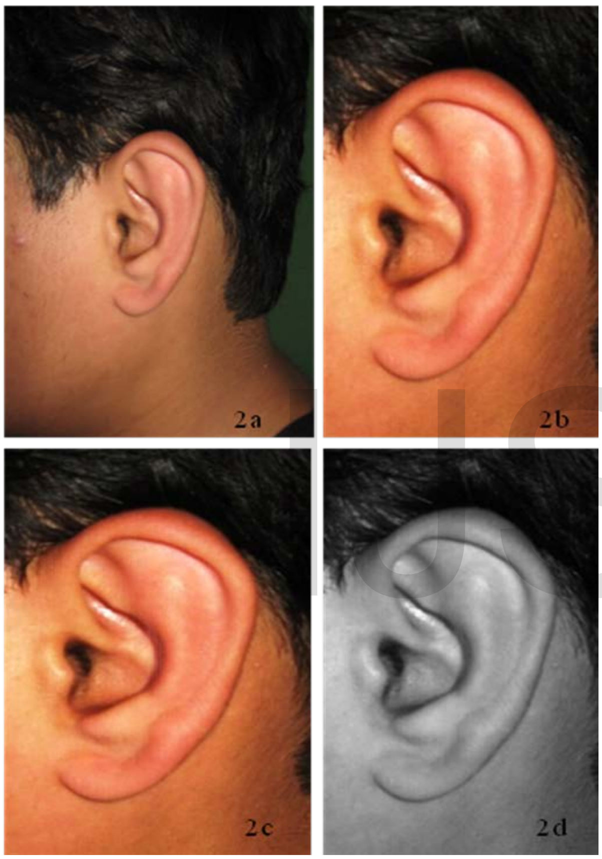

Fig. 2 a) Original image b) Cropped ear image c) Resized image and d) Grayscale image

NORMALIZATION

The photograph of the external ear was placed on a development easel and geometrically aligned such that the lower tip of a standardized vertical guide on the development easel touches the upper flesh line of the concha area while the upper tip touches the outline of the antitragus. The crus of helix was then detected and used as the origin. Vertical, horizontal, diagonal, and anti-diagonal lines were drawn from the origin to intersect with the internal and external edges present in the pinna resulting in 8 geometric measurements. These measurements have been used to distinguish individuals. (Figure 3)

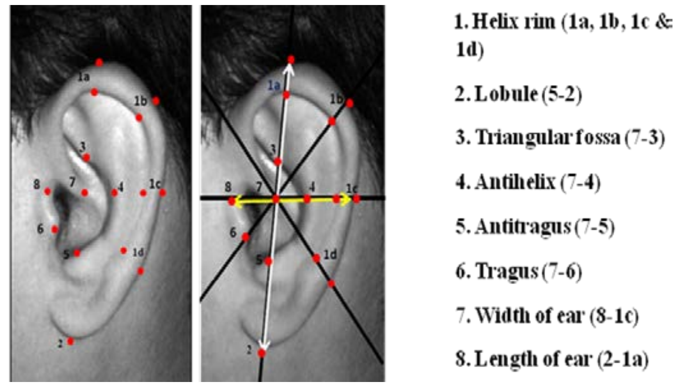

Fig. 3 Overview of geometrical measurements points of external ear used in ear measurements.

EAR GEOMETRICAL MEASUREMENTS

First of all, we had observed the overall shape of the external ear and categorized the ear shape into oval, rectangular, round and triangular. Now, we had measured the distance between each geometrical points of both right and left external ear respectively and assigned an integer distance value. The eight geometrical measurements for the right and left ear of a single subject were illustrated in Fig. 4.

When all the measurements have been taken, values for the each measurement was tabulated and analyzed by SPSS Statistical Software 17 Version/PC. These measurements, along with information on sex, bilateral and ethnic differences among Yadav and Brahmin communities of Bundelkhand Region, were then used for identification.

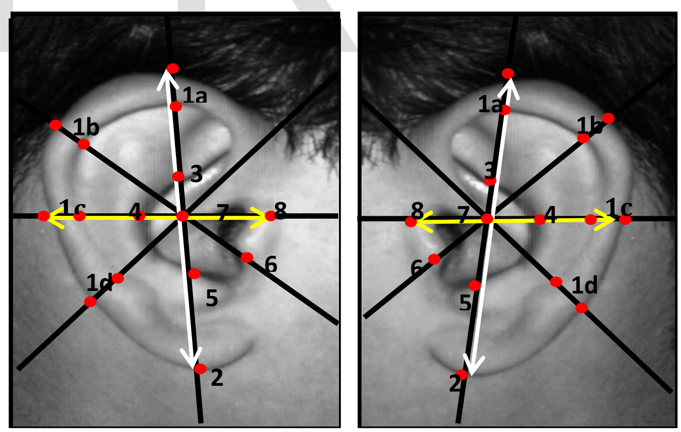

Fig. 4 the eight geometrical measurements for the right and left ears of a single subject

Assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Yadavs Male (right & left) ear of Bundelkhand Region through Extraction Method: Principal Component Analysis is presented in Table.1a& Fig 5a:

TABLE 1a- presents the data for assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Yadavs Male (right & left) ear. It has been observed from the table that the length of ear (LE) show the highest value of cumulative match score (99.31%) with (0.69%) variance and the length of tragus (LT) show the lowest value of cumulative match score (95.07%) with (4.93%) variance. (Fig. 5a)The present table further reveals that the total cumulative% match score for different ear dimensions among Yadavs male (right & left) ear is 97.47%.

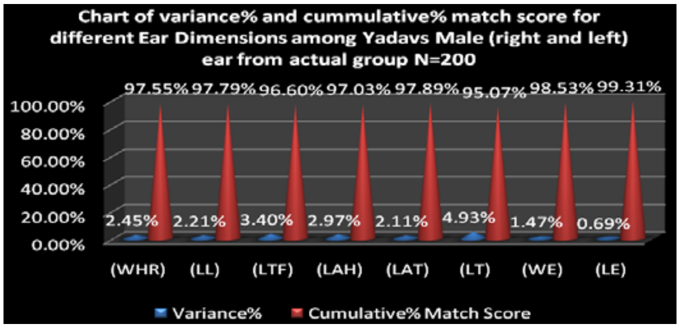

Fig. 5a

Assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Yadavs Female (right & left)ear of Bundelkhand Region through Extraction Method: Principal Component Analysis is presented in Table.1b & Fig. 5b:

S. No.	Ear Dimensions	Variance%	Cumulative% Match Score
1	WIDTH OF HELIX RIM (WHR)	2.63%	97.37%
2	LENGTH OF LOBULE (LL)	2.29%	97.71%
3	LENGTH OF TRIANGULAR FOSSA (LTF)	3.75%	96.25%
4	LENGHT OF ANTIHELIX (LAH)	3.19%	96.81%
5	LENGTH OF ANTITRAGUS (LAT)	4.59%	95.41%
6	LENGHT OF TRAGUS (LT)	3.39%	96.61%
7	WIDTH OF EAR (WE)	1.78%	98.22%
8	LENGTH OF EAR (LE)	1.02%	98.98%
	TOTAL CUMULATIVE% MATCH SCORE		**97.17%**

TABLE 1b- presents the data for assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Yadavs Female (right & left) ear. It has been observed from the table that the length of ear (LE) show the highest value of cumulative match score (98.98%) with (1.02%) variance and the length of antitragus (LAT) show the lowest value of cumulative match score (95.41%) with (4.59%) variance [show in fig. 5b]. The present table further reveals that the total cumulative% match score for different ear dimensions among Yadavs female (right & left) ear is 97.17%.

S. No.	Ear Dimensions	Variance%	Cumulative% Match Score
1	WIDTH OF HELIX RIM (WHR)	2.45%	97.55%
2	LENGTH OF LOBULE (LL)	2.21%	97.79%
3	LENGTH OF TRIANGULAR FOSSA (LTF)	3.40%	96.60%
4	LENGHT OF ANTIHELIX (LAH)	2.97%	97.03%
5	LENGTH OF ANTITRAGUS (LAT)	2.11%	97.89%
6	LENGHT OF TRAGUS (LT)	4.93%	95.07%
7	WIDTH OF EAR (WE)	1.47%	98.53%
8	LENGTH OF EAR (LE)	0.69%	99.31%
	TOTAL CUMULATIVE% MATCH SCORE		97.47%

Table 1a

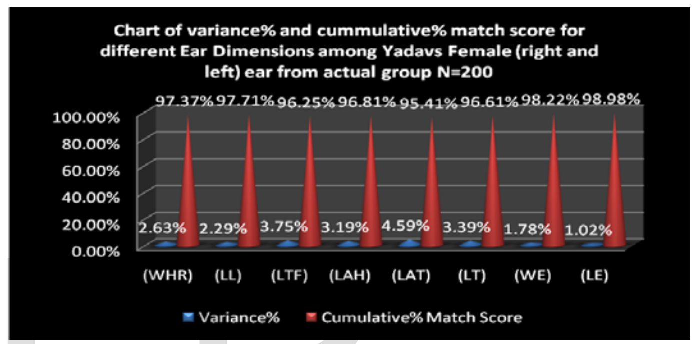

Fig. 5b

Assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Brahmins Male (right & left) earof Bundelkhand Region through Extraction Method: Principal Component Analysis is presented below in table. 2a & Fig. 6a:

S. No.	Ear Dimensions	Variance%	Cumulative% Match Score
1	WIDTH OF HELIX RIM (WHR)	2.94%	97.06%
2	LENGTH OF LOBULE (LL)	3.67%	96.33%
3	LENGTH OF TRIANGULAR FOSSA (LTF)	3.49%	96.51%
4	LENGHT OF ANTIHELIX (LAH)	3.95%	96.05%
5	LENGTH OF ANTITRAGUS (LAT)	2.69%	97.31%
6	LENGHT OF TRAGUS (LT)	2.49%	97.51%
7	WIDTH OF EAR (WE)	1.43%	98.57%
8	LENGTH OF EAR (LE)	0.30%	99.70%
	TOTAL CUMULATIVE% MATCH SCORE		**97.38%**

TABLE 2a- presents the data for assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Brahmins Male (right & left) ear. It has been observed from the table that the length of ear (LE) show the highest value of cumulative match score (99.70%) with (0.30%) variance and the length of antihelix (LAH) show the lowest value of cumulative match score (96.05%) with (3.95%) variance [show in fig. 6a]. The present table further reveals that the total cumulative% match score for different ear dimensions among Brahmins male (right & left) ear is 97.38%.

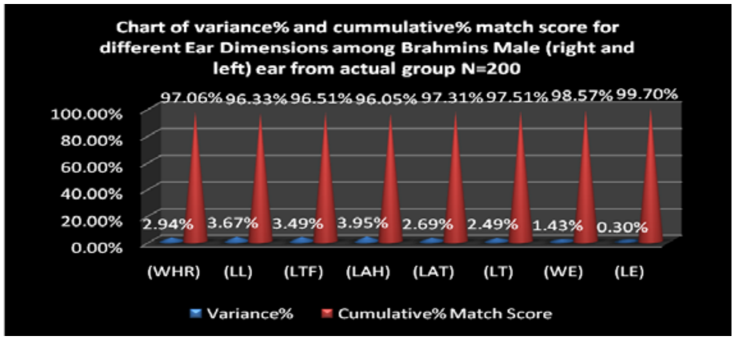

Fig. 6a

Assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Brahmins Female (right & left) ear of Bundelkhand Region through Extraction Method: Principal Component Analysis is presented below in table 2b & Fig 6b:

S. No.	Ear Dimensions	Variance%	Cumulative% Match Score
1	WIDTH OF HELIX RIM (WHR)	2.19%	97.81%
2	LENGTH OF LOBULE (LL)	2.44%	97.56%
3	LENGTH OF TRIANGULAR FOSSA (LTF)	2.89%	97.11%
4	LENGHT OF ANTIHELIX (LAH)	1.62%	98.38%
5	LENGTH OF ANTITRAGUS (LAT)	3.54%	96.46%
6	LENGHT OF TRAGUS (LT)	1.30%	98.70%
7	WIDTH OF EAR (WE)	2.13%	97.87%
8	LENGTH OF EAR (LE)	1.29%	98.71%
	TOTAL CUMULATIVE% MATCH SCORE		**97.83%**

TABLE 2b- presents the data for assessment of Variance% and Cumulative% Match Score for different Ear Dimensions among Brahmins Female (right & left) ear. It has been observed from the table that the length of ear (LE) show the highest value of cumulative match score (98.71%) with (1.29%) variance. The present table further reveals that the length of antitragus (LAT) show the lowest value of cumulative match score (96.46%) with (3.54%) variance [show in fig. 6b]. The present table further reveals that the total cumulative% match score for different ear dimensions among Brahmins female (right & left) ear is 97.83%.

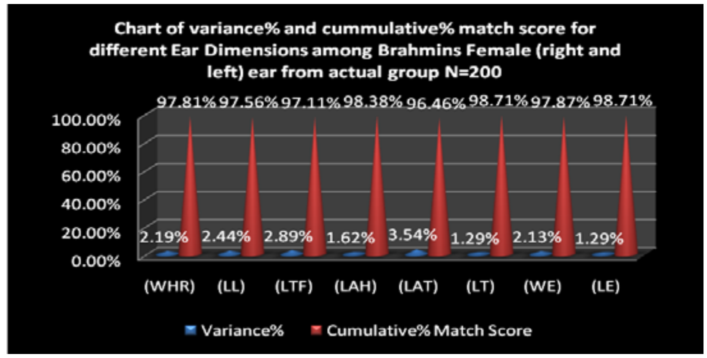

Fig. 6b

Assessment of Overall Cumulative% match score for different Ear Dimensions among both communities Yadavs and Brahmins (Male & Female) of Bundelkhand Region (N=200) was also analyzed for which data is presented in table 3:

Ear Dimensions	Yadavas Cumulative% Match Score		Brahmins Cumulative% Match Score		Overall Cumulative Match Score of both communities
	Male (N=200)	Female (N=200)	Male (N=200)	Female (N=200)	
All Ear Dimensions	97.47%	97.17%	97.38%	97.83%	97.46%

Table 3- Data presented in table reveals the Overall Cumulative% Match Score is 97.46% for different Ear Dimensions among both communities Yadavs and Brahmins (male & female) of Bundelkhand region (N=200). (Aggregate)

Assessment of Overall Accuracy% for different Ear Dimensions among both communities Yadavs and Brahmins (Male & Female) of Bundelkhand Region (N=800) were also determined which is presented in table 4:

Ear Dimensions	YADAVS ACCURACY%		BRAHMINS ACCURACY%		OVERALL ACCURACY% OF BOTH COMMUNITIES (N=800)
	Male (N=200)	Female (N=200)	Male (N=200)	Female (N=200)	
All Ear Dimensions	93.31%	93.38%	94.22%	93.75%	93.66%

Table.4- Reveals the Overall Accuracy is 93.66% for different Ear Dimensions among both communities Yadavs and Brahmins (male & female) of Bundelkhand region. (Show in Fig. 7)

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Fig. 7

Discussion

In the present study, 8 ear dimensions were taken on 800 subjects including 400 Yadavs (200 male & 200 female) and 400 Brahmins (200 male & 200 female) under the age group of 18-40 among Yadavs and Brahmins communities of Bundelkhand region. An overall accuracy achieved through all significant ear dimensions was 93.66%.Followed by the findings of Dewiet. al. (2006)who has also used PCA in his studies.The result of the present study shows similarity with the 94% rank one recognition rates by Saleh M. I. (2007).The results were also confirmed by the findings ofDarwish(2009)study and the system was tested on several databases and gave an overall accuracy of 92.24% which shows that our accuracy is better than Darwish by using the same methods. Sana et. al. (2006) proposed that ear biometrics system for human recognition based on discrete Haar wavelet transform. In the proposed approach the ear were detected from a row image using template matching technique. Haar wavelet transform were used to decompose the detected image and compute coefficient matrices of the wavelet which was clustered in its feature template. Decision was made by matching one test image with 'n' trained images using Hamming distance approach. It had been implemented and tested on two image databases pertaining to 600 individuals from IITK and 350 individuals from SaugorUniversity, India. Accuracy of the system was more than 96% which also supports our findings achieved through PCA technique(93.66%). Ali M. et al. (2007) employed various methods for ear recognition to improve the performance and making the results comparable with other existing methods. In continuation to these efforts, a new ear recognition method was proposed. Ear images were cropped manually from the side head images. After that wavelet transform was used for feature extraction and matching was carried out using Euclidean distance. Results achieved by using the proposed method were up to 94.3% which is also about equal to our value generated through PCA Method. Overall data shows the efficacy of PCA technique in study of ear biometrics correctly.

Conclusions

The current advances in ear identification methods show that alternate and reliable methods for positive human identification are available and can be used. Further tests in validating these methods are still required. Ear biometrics seems to be a good solution, since ears are visible and its images can be easily taken, even without the knowledge of the examined person. Due to its advantages, ear biometrics seems to be a good choice to support well known methods like voice, hand or face identification. Ear biometrics is viable and promising new passive approach to automated human identification. Data presented in various tables and graphs show that there are remarkable personal identification differences in ear biometrics between the Yadavs & Brahmin communities of Bundelkhand region in terms of Sex, Bilateral & ethnicity. Study concluded that the data can be used for criminal identification, mass disaster, civil causes, including armed robberies and stalking cases etc.

References

1. Abaza, A. and Ross, A. (2010) "Towards understanding symmetry of human ears: A biometric perspective" Proceeding on 4th IEEE International conference on biometric: Theory, Application and systems (BTAS) (Washington DC, USA), Sep. 2010.
2. Ali, M.; Javed, M. Y. and Basit, A. (2007) "Ear recognition using wavelets" proceedings of image and nision computing New Zealand 2007, pp. 83-86, Hamilton New Zealand Dec. 2007.
3. Brucker, M.J.; Patel, J. and Sullivan, P.K. (2003) "A Morphometric study of the External Ear: age- and sex-related differences". Department of Plastic Surgery, Brown Medical School and Rhode Island Hospital, Providence, 02905, USA.
4. Chang, K.; Bowyer, K.W.; Sarkar, S. and Victor, B. (2003) "Comparison and combination of ear and face images in appearance-based biometrics". Analysis and Machine Intelligence, IEEE Transactions on pattern analysis and machine intelligence, 25:1160–1165.
5. Choras, M. (2005) "Ear Biometrics Based on Geometrical Feature Extraction". Electronic Letters on Computer Vision and Image Analysis 5(3):84-95, 2005.
6. Dewi, K. and Yahagi, T. (2006) "Ear Photo Recognition using Scale Invariant Keypoints". From Proceeding (523) Computational Intelligence - 2006.
7. Gentile, J.E. and Bowyer, K. (2005) "Specimen Degradation on 3-d Ear Biometrics" Tri-state University and University of Notre Dame, Biometrics research at the University of Notre Dame supported by the National Science Foundation under grant CNS-013089, pp-1-7.
8. Hurley, D.J.; Nixon, M.S. and Carter, J.N. (2000) "A New Force Field Transform for Ear and Face Recognition". In Proceedings of the IEEE 2000 International Conference on Image Processing ICIP, 25-28.
9. Iannarelli, A.F. (1989) "Ear Identification". Forensic Science Series, Paramont Publishing Company, California 1989.
10. Imhofer, R. (1906) "Die Bedeutung der OhrmuschelFiirFeststellung der Identitat". Archivfiir die Kriminologie, 26:150-163.
11. Kearney, B. (2003) "Variations of the External Ear in an Australian Population for the purposes of the identification" thesis for the award of Bachelor of Science (H) University of Adelaide.
12. Moreno, B.; Sanchez, A. and Velez, J.F. (1999) "On the use of outer ear images for personal identification insecurity applications". Proceedings. IEEE 33rd Annual 1999 International Carnahan Conference, 469-476.
13. Prakash, S.; Umarani, J. and Phalguni, G. (2008) "Ear localization from side face images using distance transform and template matching" Dept. of CSE IIT Kanpur, Proceeding of IEEE International work shop on image processing theory, tools and application, IPTA 2008, source, Tuniria pp. 1-8.
14. Prakash, S.; Umarani, J. and Phalguni, G. (2009) "Connected component based technique for automatic ear detection" Proceeding of the 16th IEEE International Conference on Image processing, cairo, Egypt pp. 2705-2708. C.S.E. IIT Kanpur.
15. Prakash, S.; Umarani, J. and Phalguni, G. (2009) "Skin colour and template based technique for automatic ear detection". Dept. of

C.S.E. IIT Kanpur, Proceeding of International Conf. on Advances in pattern recognition, ICAPR 09, PP. 213-216 Kolkata India. Feb. (2009).

16. Purkait, R. (2007) "Ear Biometric: An Aid to Personal Identification" Department of Anthropology, Saugor University, Saugor, M.P. India. Anthropologist Special Vol. 3. Pp. 215-218.
17. Radhika, V.B. (2009) "Biometric identification systems: Feature level clustering of large biometric data and DWT based hash coded ear biometric system" Dept. of C.S.E. national institute of technology (Deemed university) Rourkela.
18. Saleh, M.I. (2007) "Using Ears for Human Identification" Thesis Submitted to the faculty of Virginia Polytechnic Institute and State University, 311-314.
19. Shailaja, D. and Phalguni, G. (2006) "A simple Geometric approach for ear recognition" Indian Institute of Technology Kanpur, India, 9th International Conference on Information technology (ICIT) 0-7695-2635-7/06, 164-167.
20. Sana, A.; Phalguni, G. and Purkait, R. (2006) "Ear Biometrics: A New Approach" IIIK and Dept. of Anthropology Saugor University, WSPC-Proceeding (ICAPR 2007), pp.1-5, sep-2006.
21. Victor, B.; Bowyer, K. and Sarkar, S. (2002) "An Evaluation of Face and Ear Biometrics". 16th International Conference on Pattern Recognition (ICPR'02), 1:10-429.

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