A modal for better authentication using hybrid biometrics by adding a side face with an ear

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Abstract: Customer support in digital environment is most important by facilitating secure authentication and verification for both customer and retail stores. Ear and side face as hybrid biometric is effective and efficient method for authentication and recognition in biometrics. Many researchers reported that ear can be a biometric trait and has sufficient potential to be considered as biometric characteristic and same for the face it has been proved. In this research paper we investigated, with help of MATLAB tool. Idea of multiple traits of ear and side face biometric technique in retail stores for authorization and identification of customers in digital environment which is need of today

I. INTRODUCTION

As a human, identification becomes a very important issue in the current economical transactional environment. Most of the traditional identification methods, which are widely used in the commercial systems, have very many disadvantages. Like the theft of cards and forgetting the PIN number and passwords. The other drawback is the lack of security, as the passwords can be cracked as more and more technological virus attacker comes into existence as the number of hacking experts increase day by day. These are the main issues, due to which biometrical interference over the business increases.

Few human traits can be used as a biometric either in first category whose impression retains for longer time or in second category like finger-print, human-signature, facial-geometry, face-of-human, retina of human, hand-geometry, finger-geometry, structure of hand veins, vocal system, odor-of-human, keyboard-strokes, shape of ear [1].

Biometric [3] mechanism play a crucial part in almost all the areas where security at highest priority. These said biometrical traits are proven to be sufficiently unique enough to be treated as live passwords and cannot be stolen [3], unless they get damage physically which is effective solution over passwords and personal identity number.

These biometrics, by researchers, has been proved that they posse's different properties which are time invariant and can be used for authentication purposes for giving them access rights and privileges for certain domain of work system. Although manual working domain is there but due to the digitalization in every field, automated access granting mechanism and authorization gets popularity and having tremendous area of exploration. Since technical boundaries get narrow, it becomes easy for researcher to get the benefits of technical aspects and explore the new domain of authentication level using biometrics.

II. LITERATURE REVIEW

Face as a Biometrics and Review

Pioneers of automated face recognition include Woody Bledsoe, Helen Chan Wolf, and Charles Bisson. During 1964 and 1965, Bledsoe, along with Helen Chan and Charles Bisson, worked on using the computer to recognize human faces (Bledsoe 1966a, 1966b; Bledsoe and Chan 1965). [43]

A facial recognition system is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source by taking face into consideration. There are so many methods in which facial recognition systems work, but in general, they work by comparing selected facial features from given image with faces within a database. It is also described as a Biometric Artificial Intelligence based application

that can uniquely identify a person by analysing patterns based on the person's facial textures and shape.

Based on the available references, it was revealed that the Bledsoe's initial approach involved the manual marking of various landmarks on the face such as the eye centers, mouth, etc., and these were mathematically rotated by computer to compensate for pose variation. He distances between landmarks were also automatically computed and compared between images to determine identity.

All face recognition algorithms consistent of two major parts:

1. Face detection and normalization and
2. Face identification.

Algorithms that consist of both parts are referred to as fully automatic algorithms and those that consist of only the second part are called partially automatic algorithms. Partially automatic algorithms are given a facial image and the coordinates of the center of the eyes. Fully automatic algorithms are only given facial images.[43]

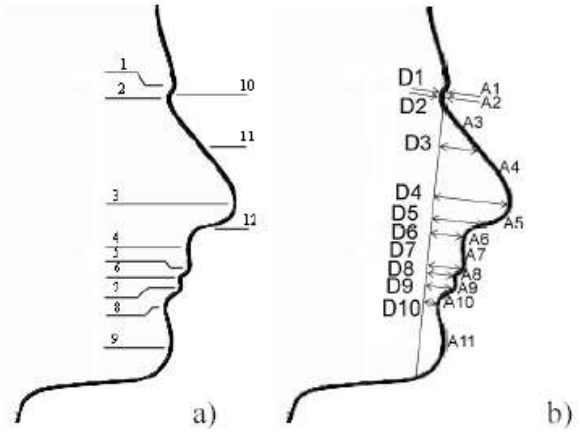

Image 1. a) The twelve fiducial points of interest for face recognition; b) Feature vector has 21 components; ten distances D1-D10 (normalized with /(D4+D5)) and eleven profile arcs A1-A11 (normalized with /(A5+A6)) [45]. (Courtesy of Z. Liposcak and S. Loncaric)

A method for face recognition using profile images based on the scale-space filtering is resented in this paper. A grey-level image of profile is thresholded to produce a binary, black and white image, the black corresponding to face region. A pre-processing step then extracts the outline curve of the front portion of the silhouette that bounds the face image. From this curve, a set of twelve fiducial marks is automatically identified using scale space filtering with varying the scale parameter. A set of twenty-one feature characteristics is derived from these fiducial marks. After normalizing the feature characteristics using two selected fiducial marks, the Euclidean distance measure is used for measuring the similarity of the feature vectors derived from the outline profiles. Experiments were performed on a total of 150 profiles of thirty persons. [45].

There are at least three methods for ear picturing:

(i) Taking a photo of an ear,
(ii) Taking "earmarks" by pushing an ear against a flat glass and
(iii) Taking thermo-gram pictures of the ear.

The most interesting parts of the ear are the outer ear and ear lope, but the whole ear structure and shape can be used. The structure of ear does not change over the time. The medical literature reports [24] that ear growth after the first four months of the birth is highly linear i.e. proportional. The anatomy used for different parts of the ear is shown in the image 2. Taking photo of the ear is the most commonly used method in research. The photo is taken and it is combined with previous taken photos for identifying a person. The earmarks are used mainly in crime solving. Even though some judgments are made based on the earmarks, currently they are not accepted in courts. The thermo-gram pictures could be one solution for solving the problem with e.g. hair of hat.

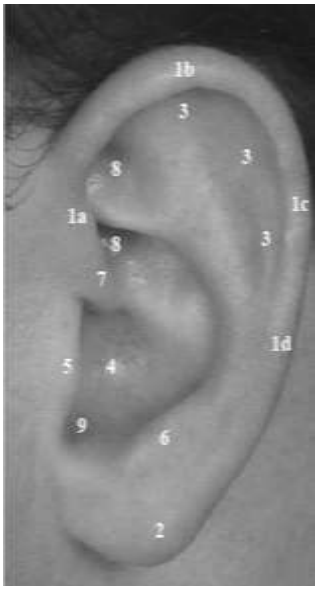

Image 1 Anatomy of the ear [24]

1. Helix Rim
2. Lobule
3. Anthelix
4. Concha
5. Tragus
6. Antitragus
7. Crus of Helix
8. Triangular Fossa
9. Incisure Intertregic

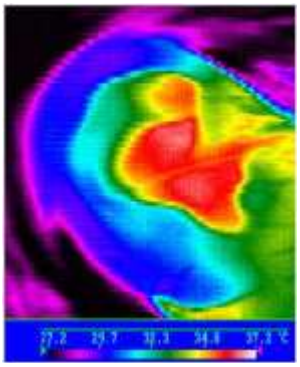

Image 3. Thermogram of an ear. Image provided by Brent Griffith, Infrared Thermography Laboratory, Lawrence Berkeley, National Laboratory. (Burge et al., 1998)

Alphonse Bertillon, a French criminologist, was the first person who identified, ear can be used as a biometric for authentication [8]. The first wide scale research on ear bio- metric has been done by an American police officer Alfred Iannarelli during early 1949 [24]. In his first study, more than 10000 ear images are compared and 12 biological characteristics are determined for uniquely recognize a person. While Iannarelli investigated to identify different anthro pometric measurements of ear in 1989, on continued path on the research, Zhou and Zaferiou [41] has presented deformable model for ear alignment and recognition in 2017 Although Iannarelli's research did not bear complete theoretical basis, the structure of outer ear image is considered to be unique. In 1997, Burge and Burger [10] demonstrated the viability of proposed ear biometric system theoretically in terms of uniqueness and measurability over time. Through further investigation [11], they constructed Voronoi diagram of the ear to represent each ear as an adjacency graph. But the underlying challenge was to accurately classify between graphs from ear and non-ear curves. Moreno et al. [30] have proposed a new multiple identification method for human recognition using outer ear image, which combines the neural classifier and macro features extracted by compression network. Herly et al. [23] have proposed a new feature extraction technique based on force field transformation, where images act as the sources of force fields. Although this work has been experimented on small database, but the results were found to be very promising. Choras [15] proposed a feature extraction technique based on geometric shape of the ear using contour detection, but faced the problem of erroneous curve detection. Victor et al. [38] have used principle component analysis approach to test the viability between face and ear-biometric. According to their results, face is proven more reliable biometric than ear. In their next work, Chang et al.[14] have done the same experiment on larger dataset, but no significant difference has been found between face and ear. Although the overall result has been significantly improved when the face and ear have been used as multimodal recognition system. Zhang et al. [40] have proposed a hybrid system of Independent Component Analysis (ICA) and Radial Basis Function (RBF) network for ear classification, which performed better than Principal Component Analysis (PCA). The major disadvantage of this method is that it works well only when images are captured in control environment and properly registered. Sana et al. [37] have proposed a new ear biometric system for human recognition based on Haar wavelet transform. This approach needs only two training images for database preparation. As a result the testing time significantly reduced. As it assumes ear shape to be elliptical, the detection may fail due to non elliptical shape of ear. Prakash et al. [35] have proposed template based matching for ear detection. These techniques may fail if side face contains non facial skin. Attrachi et al. [3] have proposed an ear segmentation approach based on ear geometry. Firstly, edges have been detected using Canny edge detector, then the longest edge has been considered as the outer boundary of the ear. A triangle has been formed using the top, bottom and left points on the detected boundary. Further using bary center of the triangle and predefined window size ear is extracted. Prakash and Gupta [35] have proposed efficient ear recognition techniques which would be illumination and pose invariant.

Work	Method for Feature Extraction	Database	#Subjects	#Images	Accuracy (%)
Burge and Burger (1996) [9]	Adjacency graphs of Voronoi diagrams	Own	NA	NA	NA
Moreno et al. (1999) [30]	Geometric features — morphological description	Own	48	188	43 — 83
Mu et al. (2004) [31]	Geometrical measures on edge images	USTB II	77	308	85
Choras and Choras (2006) [17]	Geometrical approach on longest ear contours	Own	NA	NA	100
Devi and Yahagi (2006) [19]	SIFT	CP	17	102	78.8
Kumar and Zhang (2007) [27]	Log-Gabor wavelets	UND	113	450	90
Arbab-Zavar et al. (2007) [2]	SIFT point from ear model	XM2VTS	63	252	91.5

Rahman et al. (2007) [36]	Geometric features	Own	100	350	87
Choras (2008) [26]	Geometry of ear outline	Own	188	376	86.2
Guo and Xu (2008) [20]	Local Binary Pattern and CNN	USTB II	77	308	93.3
Arbab-Zavar and Nixon (2008) [1]	Log-Gabor filters	XM2VTS	63	252	85.7
Hai-Long and Zhi-Chun (2009) [21]	Wavelet transformation	USTB II	77	308	85.7
		USTB III	79	1501	97.2
Badrinath and Gupta (2009) [4]	SIFT landmarks from ear model	IITK	106	1060	95.32
Kisku et al. (2009) [25]	SIFT from different Color Segments	IITK	400	800	96.93
Nanni and Lumini (2009) [32]	Gabor filters	UND	114	464	84
Xiaoyun and Weiqi (2009) [39]	Block partitioning and Gabor transform	USTB I	60	180	100
Bustard et al. (2010) [12]	SIFT Point Matches	XM2VTS	63	252	96
De Marisco et al. (2010) [18]	Partitioned Iterated Function System (PIFS)	UND	114	228	61
Kumar et al. (2011) [28]	Log Gabor and SIFT	IITD	100	700	85 and 95
Chan and Kumar (2012) [13]	2D quadrature filter	IITD I	125	471	96.53
		IITD II	221	793	95.17
Kumar and Wu (2012) [26]	Phase encoding with Log Gabor filters	IITD II	221	753	95.93
Prakash and Gupta (2013) [35]	SURF and NN classifier	IITK	300	2066	97.75
Basit and Shoaib (2014) [5]	Non-Linear curvelet features	IITD II	221	754	96.2
Benzaoui et al. (2014) [6]	BSIF	IITD II	221	754	97.3
Pflug et al. (2014) [33]	LPQ	Several	555	2432	93.1
Pflug et al. (2014) [34]	LPQ, BSIF, LBP and HOG - all with LDA	UND-J2	158	790	98.7
Benzaoui et al. (2015) [7]	BSIF	IITD I	125	471	96.7
		IITD II	221	754	97.3
Bourouba et al. (2015) [22]	Multi-bags-of-features histogram	IITD I	125	471	96.3
Meraoumia et al. (2015) [29]	Gabor filters	IITD II	221	754	92.4

Table 1 Ear feature extraction using local descriptors

Partha Pratim Sarangai, B.S.P. Mishra and Schidananda Dehuri proposed a multimodal biometric system based on two modalities that is ear and profile face based on KDCV approach for identification and recognition of a person [46]. Also Susan EN, Ayman Abaza and Thirimachos Bourlai give the studied idea on human recognition using auricle and side view [47]. Mostafa Akhaavasaffar, Ali Nakhaei, Mostafa Mokhtari Ardakan also provide a multimodal biometric authentication system using ear and face, using practical Swarm Optimization algorithm[48]. Another work based on profile face for identification is there by Iacopo Masi, Fing-ju Chan , Jongmoo Choi, Shai Harel, Jungyeon Kim, KangGeon Kim, Jatuporn Leksut, Stephen Rawls, Yue Wu, Tal Hassner, Wael AbdAlmageed, Gerard Medioni, Louis-Philippe Morency, Prem Natarajan, Ram Nevatia, with approach is agnostic to the underlying CNN architecture used [49].

Cubic B-splines are used to extract the interesting points (turning points) and a total of six interesting points are extracted. From the five curve segments determined by these interesting points 24 features are extracted and used for the recognition. Eighteen people, typically representing most faces here, were tried for the learning and the recognition test [50].Another study based on side face is there which describe the challenges faced by taking side face as biometric. In the paper, Threshold value of the picture along with the tangential points is calculated accurately to train the dataset properly and low error ratio and accuracy and

validation ratio must be maximum clear images along with particular application of algorithms and methods must be done to resolve the conflicts in Side-view facial recognition [51].

Ear and face combined multimodal recognition method and a Full-space Linear Discriminant Analysis (FSLDA) are proposed. The rank one recognition rate of multimodal biometric using face and ear can reach 98.7% on the USBT ear database and ORL face database[52].

The multimodal system of face profile and ear achieved the best recognition performance 97.98% compared to other techniques in the literature such as PCA 94.44%, FSLDA 97.62% or KFDA 96.84%, given that we used the largest database[53].

III. IMAGE PROCESSING TOOL

We have so many image tools for enhancement and to normalize them for further investigation. Among them we have MATLAB. With the help of MATLAB, we can fetch the image and we can compare the two different images. For the experiment point of view, it has been proved that using various technical algorithms we can prove the identity of a person based on ear biometrics. Among these technical aspects one is PCA i.e. Principal Component Analyzer [10]. It is a mathematical process to compare set of data based on Eigen space and Eigen constraints.

Using MATLAB below is the image which is taken into consideration for comparing data set with stored data set

Fig. 2 Image of ear

After reading the image in MATLAB tool we get

Fig. 3 After applying MATLAB too Image of ear

Now for the following image

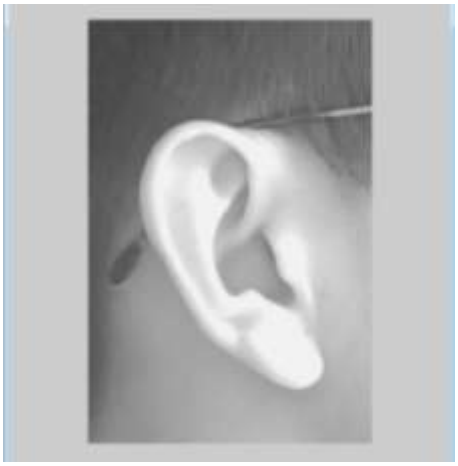

Fig. 4 Image which is to compare with fig.2 image

We have following histogram

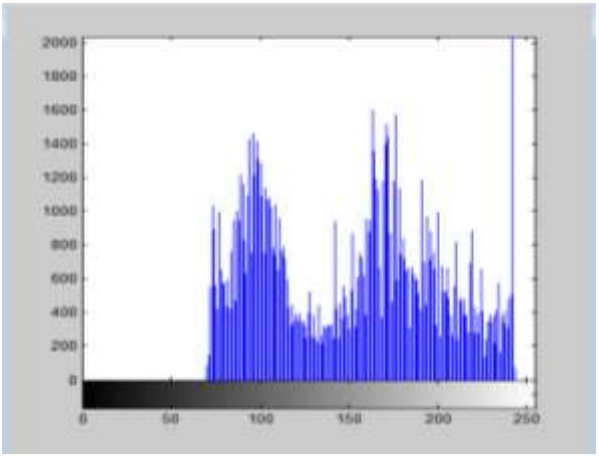

Fig. 4 Histogram for image at fig.3

Now the difference between these two histograms using MATLAB

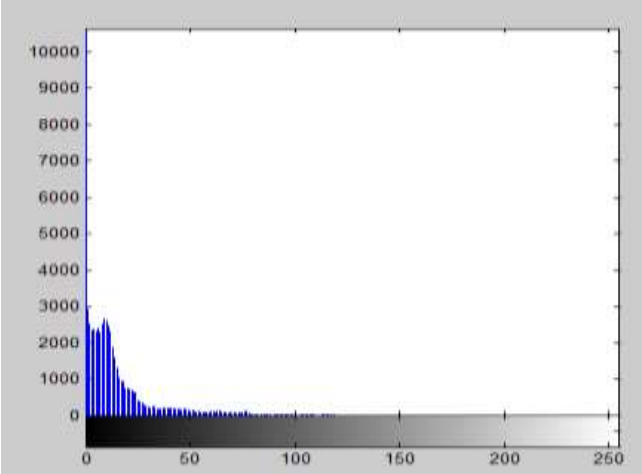

Fig. 5 Histogram difference between fig. 2 and fig. 4

It clearly reflects blue lines which reflect that these two images are not identical. For the identical image there should not appear any blue line in this histogram.

IV. PROPOSED METHODOLOGY

On the bases of paper reviewed from different researchers, it is observed that image processing tool just like Matlab/Python play a vital role. In Matlab/Python different algorithms were implemented to extract features of images and after filtering the various features, results were produced. We will also work on Matlab/Python for feature extraction and filtration to perform practical work. Also we will use high end digital camera for self clicked image sets for future work although we have standard data set from different sources.

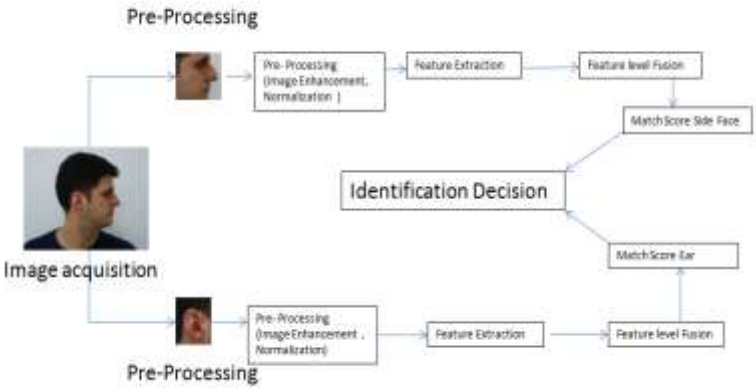

Image 5: Proposed Research Methodology

CONCLUSIONS

After studying various articles and research papers it has been discovered that ear biometric feature is quite applicable in certain areas for recognition of a person and if side view of face considered then the results will be more prominent. There are several cases where we can use this modal for surveillance. For example, by mounting the cameras side-wise, like during the entrance of the gate, to take side pose of a person. That will give us target's key points for identification and authorization as said above.

The applications where our research on Hybrid Biometric Verification Model for Human Auricle can be implemented as follows:
Access Control
Business
Attendance
Surveillance

References

1. Arbab-Zavar, B., and Nixon, M., Robust log-Gabor filter for ear biometrics. In: 19th International Conference on Pattern Recognition, pp. 1–4, 2008. https://doi.org/10.1109/ICPR.2008. 4761843.
2. Arbab-Zavar, B., Nixon, M., and Hurley, D., On model-based analysis of ear biometrics. In: First IEEE International Confer- ence on Biometrics: Theory Applications, and Systems, pp. 1–5, 2007. https://doi.org/10.1109/BTAS.2007.4401937.
3. Attarchi, S., Faez, K., and Rafiei, A., A new segmentation approach for ear recognition. In: International Conference on Advanced Concepts for Intelligent Vision Systems, pp. 1030– 1037, 2008. https://doi.org/10.1007/978-3-540-88458-3 93.
4. Badrinath, G., and Gupta, P., Feature level fused ear biometric system. In: Seventh International Conference on Advances in Pattern Recognition (ICPR), pp. 197–200, 2009. https://doi.org/10.1109/ICAPR.2009.27.
5. Basit, A., and Shoaib, M., A human ear recognition method using nonlinear curvelet feature subspace. Int. J. Comput. Math. 91(3):616–624, 2014. https://doi.org/10.1080/00207160.2013. 800194.
6. Benzaoui, A., Hadid, A., and Boukrouche, A., Ear biometric recognition using local texture descriptors. J. Electron. Imaging 23(5):053,008–053,008, 2014. https://doi.org/10.1117/ 1.JEI.23.5.053008.
7. Benzaoui, A., Hezil, N., and Boukrouche, A., Identity recognition based on the external shape of the human ear. In: International Conference on Applied Research in Computer Science and Engineering,

pp. 1–5, 2015a. https://doi.org/10.1109/ARCSE. 2015.7338129.

8. Bertillon, A., La photographic judiciaries: avec un-appendicesur la classification et l'identification anthropome´triques, 1890.
9. Burge, M., and Burger, W., Ear biometrics. Biometrics: Personal Identification in Networked Society pp. 273–286, https://doi.org/10.1007/0-306-47044-6 13, 1996.
10. Burge, M., and Burger, W., Ear biometrics for machine vision. In: 21st Workshop of the Austrian Association for Pattern Recognition, pp. 275–282, 1997.
11. Burger, M., and Burger, W., Ear biometrics in computer vision. In: International Conference on Pattern Recognition, pp. 822– 826, 2000. https://doi.org/10.1109/ICPR.2000.906202.
12. Bustard, J., and Nixon, M., Toward unconstrained ear recognition from two-dimensional images. IEEE Trans. Syst. Man Cybern. Syst. Hum. 40(3):486–494, 2010. https://doi.org/10. 1109/TSMCA.2010.2041652.
13. Chan, T. S., and Kumar, A., Reliable ear identification using 2- D quadrature filters. Pattern Recogn. Lett. 33(14):1870–1881, 2012. https://doi.org/10.1016/j.patrec.2011.11.013.
14. Chang, K., Bowyer, K., Sarkar, S., and Victor, B., Comparison and combination of ear and face images in appearance-based biometrics. IEEE Trans. Pattern Anal. Mach. Intell. 25(9):1160–1165, 2003. https://doi.org/10.1109/TPAMI.2003.1227990.
15. Choras, M., Ear biometrics based on geometrical feature extrac- tion. ELCVIA Electron. Lett. Comput. Vision Image Anal. 5(3):84–95, 2005. https://doi.org/10.5565/rev/elcvia.108.
16. Choras, M., Perspective methods of human identification: ear biometrics. Opto-Electron. Rev. 16(1):85–96, 2008. https://doi.org/10.2478/s11772-007-0033-5.
17. Choras, M., and Choras, R., Geometrical algorithms of ear con- tour shape representation and feature extraction. In: Sixth Inter- national Conference on Intelligent Systems Design and Applica- tions (ISDA), Vol. 2, pp. 451-456, 2006. https://doi.org/10.1109/ ISDA.2006.253879.
18. De Marsico, M., Michele, N., and Riccio, D., HERO: human ear recognition against occlusions. In: IEEE Computer Society Conference on Computer Vision and Pat- tern Recognition Workshops (CVPRW), pp. 178–183, 2010. https://doi.org/10.1109/CVPRW.2010.5544623.
19. Dewi, K., and Yahagi, T., Ear photo recognition using scale invariant key points. In: Proceedings of the Second IASTED Inter- national Conference on Computational Intelligence, pp. 253– 258, 2006.
20. Guo, Y., and Xu, Z., Ear recognition using a new local matching approach. In: 15th IEEE International Conference on Image Processing, pp. 289–292, 2008. https://doi.org/10.1109/ ICIP.2008.4711748.
21. Hai-Long, Z., and Zhi-Chun, M., Combining wavelet trans- form and orthogonal centroid algorithm for ear recognition. In: 2nd IEEE International Conference on Computer Science and Information Technology (ICCSIT), pp. 228–231, 2009. https://doi.org/10.1109/ICCSIT.2009.5234392.
22. Houcine, B., Hakim, D., Amir, B., and Hani, B., Ear recognition based on multi-bags-of features histogram. In: 3Rd International Conference on Control, Engineering & Information Technology (CEIT), Vol. 2015, pp. 1–6, 2015. https://doi.org/10.1109/CEIT.2015.7232997.
23. Hurley, D. J., Nixon, M., and Carter, J., Force field energy functional for image feature extraction. Image Vis. Comput. 20(5-6):311–317, 2002. https://doi.org/10.1016/S0262- 8856(02)00003-3.
24. Iannarelli, A., Ear identification Paramont Publishing, ISBN: Paramont Publishing, 1989.
25. Kisku, D., Mehrotra, H., Gupta, P., and Sing, J., SIFT-based ear recognition by fusion of detected keypoints from color similarity slice regions. In: International Conference on Advances in Computational Tools for Engineering Applications, pp. 380–385, 2009. https://doi.org/10.1109/ACTEA.2009.5227958.
26. Kumar, A., and Wu, C., Automated human identification using ear imaging. Pattern Recogn. 45(3):956–968, 2012. https://doi.org/10.1016/j.patcog.2011.06.005.
27. Kumar, A., and Zhang, D., Ear authentication using log-Gabor wavelets. Defense and Security Symposium pp. 65,390A– 65,390A, https://doi.org/10.1117/12.720244, 2007.
28. Kumar, A., Hanmandlu, M., Kuldeep, M., and Gupta, H., Auto- matic ear detection for online biometric applications. In: Third National Conference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG), pp. 146–149, 2011. https://doi.org/10.1109/NCVPRIPG.2011.69.

29. Meraoumia, A., Chitroub, S., and Bouridane, A., An auto- mated ear identification system using Gabor filter responses. In: 13th International Conference on New Circuits and Systems (NEWCAS), pp. 1–4, 2015. https://doi.org/10.1109/NEWCAS. 2015.7182085.
30. Moreno, B., Sanchez, A., and Ve´lez, J., On the use of outer ear images for personal identification in security applications. In: 33rd Annual International Carnahan Conference on Security Technology, pp. 469–476, 1999. https://doi.org/10.1109/CCST. 1999.797956.
31. Mu, Z., Yuan, L., Xu, Z., Xi, D., and Qi, S., Shape and structural feature based ear recognition. In: Advances in Biometric Person Authentication, pp. 663–670, 2004. https://doi.org/10.1007/978- 3-540-30548-4 76.
32. Nanni, L., and Lumini, A., Fusion of color spaces for ear authentication. Pattern Recogn. Lett. 42(9):1906–1913, 2009. https://doi.org/10.1016/j.patcog.2008.10.016.
33. Pflug, A., Busch, C., and Ross, A., 2D ear classification based on unsupervised clustering. In: 2014 IEEE International Joint Conference on Biometrics (IJCB), pp. 1–8, 2014a. https://doi.org/10.1109/BTAS.2014.6996239.
34. Pflug, A., Paul, P., and Busch, C., A comparative study on texture and surface descriptors for ear biometrics. In: International Carnahan Conference on Security Technology (ICCST), pp. 1–6, 2014b. https://.
35. Prakash, S., and Gupta, P., An efficient ear recognition technique invariant to illumination and pose. Telecommun. Syst. 52(3):1435–1448, 2013. https://doi.org/10.1007/s11235- 011-9621-2.
36. Rahman, M., Islam, M. R., Bhuiyan, N., Ahmed, B., and Islam, A., Person identification using ear biometrics. Int. J. Comput. Integr. Manuf. 15(2):1–8, 2007.
37. Sana, A., Gupta, P., and Purkait, R., Ear biometrics: a new approach. Advances in Pattern Recognition pp. 46–50, https://doi.org/10.1142/9789812772381 0006, 2007.
38. Victor, B., Bowyer, K., and Sarkar, S., An evaluation of face and ear biometrics. In: 16Th International Conference on Pattern Recognition, Vol. 1, pp. 429–432, 2002. https://doi.org/10.1109/ ICPR.2002.1044746.
39. Xiaoyun, W., and Weiqi, Y., Human ear recognition based on block segmentation. In: International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, pp. 262–266, 2009. https://doi.org/10.1109/CYBERC.2009.5342143.
40. Zhang, H. J., Mu, Z. C., Qu, W., Liu, L. M., and Zhang, C. Y., A novel approach for ear recognition based on ICA and RBF network. In: 2005 International Conference on Machine Learning and Cybernetics, Vol. 7, pp. 4511–4515, 2005. https://doi.org/10.1109/ICMLC.2005.1527733.
41. Zhou, Y., and Zaferiou, S., Deformable models of ears in-the- wild for alignment and recognition. In: 12Th IEEE International Conference on Automatic Face & Gesture Recognition (FG 2017), pp. 626–633, 2017. https://doi.org/10.1109/FG.2017.79.
42. An introduction to Biometric Recognition, Anil K.Jain, Arun Ross, Salil Prabhakar, IEEE Transactions on Circuits And System For Video Technology, Vol 14, No. 1 Jan-2004
43. https://en.wikipedia.org/wiki/Facial_recognition_system , The History of Information Security, 1st Edition
44. A.S. Tolba, A.H. EL-Baz and A.A. El-Harby, Face Recognition: A Literature Review, International Journal of Signal Processing 2;2 2006, doi=10.1.1.307.5530
45. Z. Liposcak and S. Loncaric, "A scale-space approach to face recognition from profiles," in Proceedings of the 8th International Conference on Computer Analysis of Images and Patterns, Vol. 1689, Lecture Notes In Computer Science. London, UK: Springer- Verlag, 1999, pp.243-250 doi= 10.1007/3-540-48375-6_30
46. Multimodal Biometric Recognition using Human Ear and Profile Face Partha Pratim Sarangi, B. S. P Mishra†and Sachidanada Dehuri,School of Computer Engineering, KIIT University, Bhubaneswar, Odisha, India,Department of ICT, FM University, Balasore, Odisha, India. 4th Int'l Conf. on Recent Advances in Information Technology | RAIT-2018
47. A Study on Human Recognition Using Auricle and Side View Face Images Susan El-Naggar, Ayman Abaza and Thirimachos Bourlai Springer International Publishing AG 2018 P. Karampelas and T. Bourlai (eds.), Surveillance in Action, Advanced Sciences and Technologies for Security Applications, https://doi.org/10.1007/978-3-319-68533-5_4

48. A Multimodal Biometric Authentication System Using Ear and Face Mostafa Akhavansaffar *, Ali Nakhaei , Mostafa Mokhtari Ardakan Department of ICT Engineering, Payame Noor Universtiy(PNU), Tehran, I. R of Iran Manuscript submitted August 2, 2017; accepted November 5, 2017. doi: 10.17706/jcp.13.7. 876-888
49. Learning Pose-Aware Models for Pose-Invariant Face Recognition in the Wild Iacopo Masi, Feng-ju Chan, Jongmoo Choi, Shai Harel, Jungyeon Kim, KangGeon Kim, Jatuporn Leksut, Stephen Rawls, Yue Wu, Tal Hassner, Wael AbdAlmageed, Gerard Medioni, Louis-Philippe Morency, Prem Natarajan, Ram Nevatia DOI 10.1109/TPAMI.2018.2792452, IEEE Transactions on Pattern Analysis and Machine Intelligence.
50. HUMAN FACE PROFILE RECOGNITION BY COMPUTER CHYUAN JY Wu and JUN S. HUANG* Pattern Recognition, Vol. 23, No. 3~4, pp. 255 259, 1990 Printed in Great Britain,
51. Side-View Facial Recognition: Major Issue in Face Recognition, Harshit Patel1, Ria Yadav2 1, 2 B. Tech (CSE), 4thYear (1503510033), BBDIT Ghaziabad (035), Dr. APJ Abdul Kalam Technical University, International Journal for Research in Applied Science & Engineering Technology (IJRASET) Volume 6 Issue XI, Nov 2018
52. MULTIMODAL RECOGNITION BASED ON FACE AND EAR,LI YUAN, ZHI-CHUN MU, XIAO-NA XU, School of Information Engineering, University of Science and Technology Beijing, Beijing, 100083, China,E-MAIL: yuanli64@hotmail.com, Proceedings of the 2007 International Conference on Wavelet Analysis and Pattern Recognition, Beijing, China, 2-4 Nov. 2007
53. Multimodal biometrics system based on face profile and ear Iman S. Youssef Ayman A. Abaza Mohamed E. Rasmy and Ahmed M. Badawi ,Systems and Biomedical Engineering, Cairo University, Egypt; West Virginia High Tech Foundation, Fairmont, USA