Independent Component Analysis Based Feature Level Extraction of Ear and Thumb Fusion

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***Abstract*— Fusion of multiple ears and fingerprint matchers based on different biometrics for personal authentication has been investigated in the last years. However, the performance achievable when the expected subject cooperation degree is different from the real one has not yet been sufficiently studied. In this paper, we propose a method based on ICA and Minutia Extraction for ear feature extraction and fingerprint feature extraction respectively. In the end FAR, FRR and accuracy has been evaluated for proposed algorithm. Results show that proposed fusion method allows increasing the robustness of the system under strong changes of the subject's cooperation degree**

***Index Terms*— Thumbprint, Ear, Biometric Multimodal, ICA, Neural Network**

I. INTRODUCTION

Biometrics is the science and technology used for measuring, analyzing the biological data. In information technology, biometrics usually refers for measuring and analyzing human body characteristics such as thumb, eye retinas and irises, tone patterns, facial patterns, and hand capacity, particularly for authentication purposes. Biometric is used for extracting a feature set from the acquired data, and comparing this set against to the template set in the database.Biometric fusion can be defined as the use of multiple types of biometric data for improving the performance of biometric systems. A perfect biometric should be unique, universal, and permanent over time that is easy to measure also cheap in costs, and have high user acceptance. No single biometric can fulfill all these requirements simultaneously. For example, fingerprints and retina are known to be extremely sole, but they require devoted sensors and are not user friendly. On the other give voice and facial geometry are not as unique, but they require only a cheap microphone or a camera as a sensor, and they are unobtrusive. Therefore combination of several complementary biometrics can provide higher recognition accuracy than any individual biometric alone [1]. Multi-modal biometric systems perform better than uni-modal biometric systems as it remove the confines of single biometric system. Multimodal biometric system can be constructed using more than one physiological or behavioral characteristic for identification and verification purposes. These types of system are urbanized for safety purposes in various fields like crime study, e-commerce and martial purposes. Multimodal biometric system developed using fingerprint, hand geometry, they required the concerned human to make physical contact with a sensing device.

Most of the obtainable biometric systems urbanized were based on single biometric facial appearance (fingerprint, ear, face, iris and so on). Each biometric mannerism has its own strength and weakness. Fig. 1-1 shows the different biometric traits popular recently.

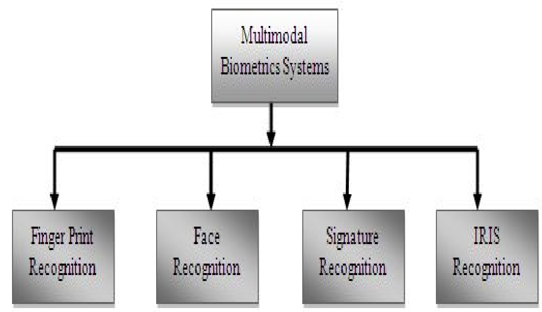

Figure 1: Biometric Traits

II. MULTIMODAL FUSION

Use of multiple biometrics indicators for identifying individuals is known as multimodal biometrics. Evidence obtained from different modalities can be combined by using an effective fusion technique for improving the overall accuracy of the biometrics system, as multimodal biometric system can reduce the FAR/FRR rates [2] and provide more resistance. Multimodal biometric system is more dependable than any other single biometric system.

2.1 Various levels of the fusions are:

1. Data-sensor level
2. Feature-extraction level
3. Matching-score level
4. Decision level

The multimodal biometric system can implemented on these fusion schemes to improve the Performance of the system.

Usually a classification of the biometric featuresis made: physiological that consist of fingerprint, face shape, iris, retina etc. and behavioral i.e. voice, gait, writing style etc. In practice, all biometric verifiers may be considered combinations of physiological and behavioral characteristics due to the interaction mode between the user and the system, which puts its mark over the characteristic.

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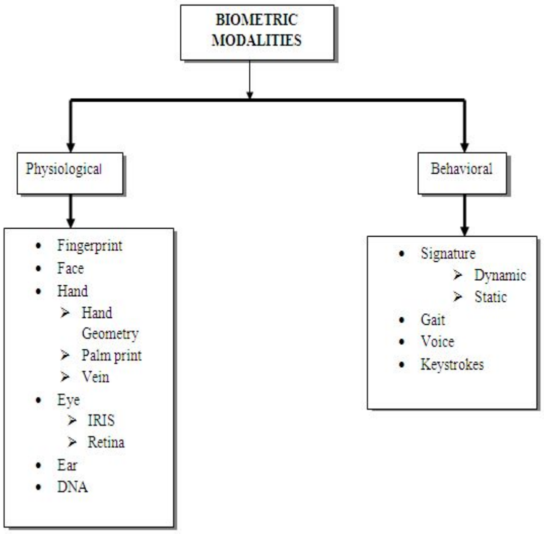

Figure 2: Biometric modalities

Any physiological or behavioral feature may be used as a biometric verifier as long as it satisfies the following requirements:

- Universality: every person must own characteristic.
- Distinctiveness: two persons having same characteristic does not exist.
- Permanence: the characteristic must be invariant for a time period as long as possible.
- Collectability: It indicates the fact that biometric may be quantitatively measured.
- Performance: refers to the accuracy of the tangible recognition, speed, robustness, as well as the prerequisites for touching a certain level of performance.
- Acceptability – indicates the degree in which the given biometric characteristic is accepted by the users.

III. THUMB RECOGNITION

The study of the fingerprints came into the existence in the 18th century. Fingerprint matching is one of the oldest forms of the biometric technologies that are being used so extensively. Father of fingerprint matching technique is Francis Galton. Combination of patterns called ridges and valley develop the fingerprints. Single arched section is known the ridges whereas part between two adjoining ridges is known as valley and ridge termination is known as minutiae. For fingerprint matching mainly two [3] features of minutiae are used:

1. Ridge ending
2. Ridge bifurcation.

The fundamentals of phase base fingerprint matching are described on the basis of phase only correlation (POC) functions. By considering $N \times N$ images, the function $f(n_1, n_2)$ and $g(n_1, n_2)$ in the index ranges are $n_1 = -M_1 \ldots. M_1 (M_1 > 0)$ and $n_2 = -M_2 \ldots. M_2 (M_2 > 0)$. Let $F(k_1, k_2)$ and $G(k_1, k_2)$ represents the 2D DFT's of the two images. $F(k_1, k_2)$ is shown by

$$F(k_1, k_2) = \sum_{n_1, n_2} f(n_1, n_2) W_{N_1}^{k_1 n_1} W_{N_2}^{k_2 n_2}$$

$$- A_F(k_1, k_2) e^{j\theta F(k_1, k_2)}$$

The cross-phase spectrum $R_{FG}(k_1, k_2)$ is given by

$$R_{FG}(k_1, k_2) = \frac{F(k_1, k_2)\overline{G(k_1, k_2)}}{\left|F(k_1, k_2)\overline{G(k_1, k_2)}\right|} = e^{j\theta(k_1, k_2)}$$

BLPOC (Band limited Phase only correlation) is used for finger print matching tasks. It is defined by:

$$r_{fg}^{K_1, K_2}(n_1, n_2) = \frac{1}{L_1 L_2} \sum_{K_1, K_2}^{\prime} R_{FG}(K_1, K_2) W_{l_1}^{-k_1 n_1} W_{l_2}^{-k_2 n_2}$$

Where $n_1 = K_1 \ldots. K_1, n_2 = K_2 \ldots. K_2$

Fingerprint matching is very crucial and essential step in biometric technology. Fingerprint matching based on minutiae method is a very popular approach.

A fingerprint frequently seen like a series of dark lines to symbolize the high, peaking portion of the resistance ridge skin, whereas the valley among these ridges appears as white space plus low, thin bit of the resistance edge skin. Fingerprint recognition depends mainly on the minutiae or else the place and route of the ridge endings and bifurcations next to a ridge path.

Fingerprint features are shown by the examples below:

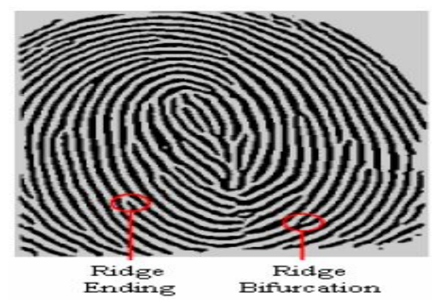

Figure 3: Two types of Minutiae

$S_{minutiae} (0 \leq S_{minutiae} \leq 1)$ is defined as:

$$S_{minutiae} = \frac{(\neq \text{of corresponding minutiae pairs})^2}{M'^f \times M'^g}$$

Figure 4: Other fingerprint characteristics

For the reason of huge fingerprint recognition, automaticsystem depends on special hardware and software has been executed, called Automated FingerprintIdentification Systems (AFIS)

Figure 5 details the automatic procedure in detail with its essential elements:

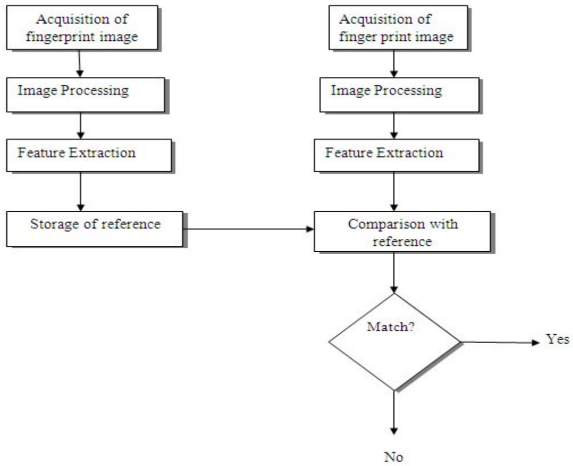

Figure 5: Thumb Recognition Process

Acquisition of fingerprint image is a method in which a fingertip is located on the speciallyconsidered scanner and an image of the finger impression is created. These methods typically agree to only for flat fingerprints as the fingertip needs to be reserved comparatively at rest.

In number of cases, the first step is to get rid of low gap effects for improvisation of the difference among ridge lines and the space in-between. For this purpose, image processing techniques are used.

Feature extraction typically starts with finding the ridge lines in order to follow them till it ends or bifurcations are originated.

The evaluation of two templates following feature extraction is the mainly vendor needy division of the procedure and is depend on matching algorithm. The common property of each algorithm is the information to determine a comparison score among the two fingerprints to be compared.

To select the match threshold is a very responsive task. It can be determine by two statistical measures that are FAR (false Acceptance Rate) and FRR (False rejection rate)

IV. EAR RECOGNIGITION/BIOMETRICS

A present is an ever increasing need to repeatedly validate individuals; biometrics has been an active old of investigate over the way of the last decade. An established means of automatic recognition, such as passwords or ID cards, can be stolen, fake, or beyond. Biometric individuality, on the additional hand, is widespread, sole, lasting, and quantifiable.The feature exterior of the human outer ear is formed by the outer helix, the antihelix, the lobe, the tragus, the antitragi's, and the Concho. The many ridges and valley on the outer ear's surface serve as acoustic resonators. For low frequencies the pinna reects the acoustic signal towards the ear canal. For high frequencies it reects the sound influence and causes neighboring frequencies to be drop. Also the outer ear enables human to perceive the source do a sound. The shape of the outer ear evolves through the developing state from six growth nodules. Its structure, therefore, is not entirely random, but still subject to cell segmentation. The innocence of random factors on the ear's exterior can best be experimental by compare the left and the right ear of the same person. Even though the left and the right ear show some similarity, they are not symmetric [4].

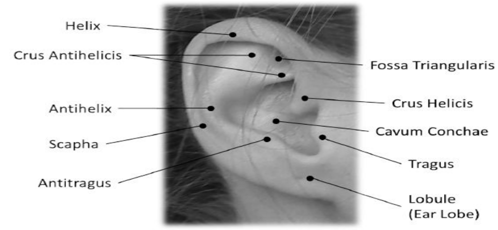

Figure 6: Characteristics of the human ear

Vector quantization is applied for the segmentation of pixels in the ear images based on the probabilities of the spaces of the color for clustering the pixels. It is a fitting model represented by conditional density functions. Gaussian mixture models are used for fitting the data which is contained in vector quantization framework.

This is represented as:

$$f(D) = \sum_{i-1}^{N} P_i f(D/i)$$

In the above equation, N is the number of clusters in ear image. $P_i$is the prior cluster probability i and $f_i(D)$ is t density function of cluster i.

$f_i(D)$ Is shown as:

$$f\left(\frac{D}{i}\right) = \frac{\exp(-\frac{1}{2}(D-m_i)\Sigma_i^{-1}(D-m_i)}{(2\pi^{\frac{p}{2}})/\Sigma_i \frac{1}{2}}$$

Where $D\varepsilon R^P$ and m_i and Σ_i are the mean and covariance matrix of cluster i.

When the Gaussian mixture model are found for the color pixels in the cropped ear images. K-L divergence is based on keeping the color consistency in the areas correspondingly.

Normally, KullbackLeibler divergence or comparative entropy depend on measuring the difference among two probability density functions $(PDF) P(D)$and $Q(D)$. K-L divergence can be expressed as

$$KL(P(D) :: Q(D) = E_{P(D)} \left\| \log \frac{P(D)}{Q(D)} \right\|$$

The KL convergence is always non- negative. If the two probability density function is same or not, then the K-L divergence would be zero.

Figure 7: Color segmented ear slice regions

V. RELATED WORK

M. Ali[6],2007 In this paper, ear is a new comer in biometric recognition method. A variety of methods have been working for ear detection to improve the presentation and making the consequences similar with other obtainable methods. In continuance to these pains, a new ear recognition method is planned. Ear images are crop physically from the side head imagery. After that wavelet transform is used for feature removal and matching is carried out using Euclidean distance. A consequences achieved by using the future method are up to 94.3%.

DakshinaRanjanKisku[7],2007 In this paper, ear biometric is measured as one of the most dependable and invariant biometrics individuality in line with iris and fingerprint individuality. In many cases, ear biometrics can be compare with face biometrics on the subject of many physiological and texture uniqueness. In this paper, a hearty and proficient ear recognition system is offered, which uses Scale Invariant Feature Transform as quality descriptor for structural symbol of ear images. In categorize to make it more strong to user verification, only the region having color probability in a certain ranges are considered for invariant SIFT feature extraction, where the K-L deviation is used for keeping color constancy. Ear skin color model is formed by Gaussian mixture model and cluster the ear color pattern using vector quantization.

Koichi Ito [8],2003 This article suggest an well-organized fingerprint recognition algorithm unite phase based image matching and characteristic based matching. The use of Fourier phase in order of fingerprint images makes likely to achieve robust recognition for faintly impressed, low-quality fingerprint images. A new evaluation using two different types of fingerprint image databases demonstrate efficient recognition performance of the proposed algorithm compare with typical minutiae based algorithm and the conservative phase based algorithm.

Fernando Alonso [9], 2004 In this described as, fingerprint recognition is obtainable, counting current issues and challenge. Fingerprint database and assessment campaign, are also summarized. This is follow by the description of the Bio Secure Benchmarking Framework for Fingerprints, using the NIST Fingerprint Image Software, the openly available MCYT-100 database, and two assessment protocols.

Andrew Ackerman [10], 2004 Fingerprint matching is the procedure used to conclude whether two sets of fingerprint ridge feature come from the same finger. There survive multiple algorithms that do fingerprint matching in many diverse ways. A several methods involve matching minutiae points between the two imagery, while others look for similarity in the bigger organization of the fingerprint.

Trupti S. Indi [11],2012 A broad variety of systems require dependable and precise personal classification system. A main goal of such systems is to give access of an application to legal users only. Such a set of application include, but not imperfect to, banking applications, military applications, hospital applications, digital library. A preponderance of systems has started shifting towards biometric features of human beings for special unique identification. Most popular biometric characteristic used is Thumbprint or thumb impression. A Various researchers have come out with different solutions, albeit partially best, for personal recognition based on thumb impression. Though there exists no single solution that encompasses best of all & provides collectively a better answer. An attempt is made in this paper to perform exactly the same based on new setup, findings, & analysis. A facial appearance of biometric individuality of thumb print is extract and stored into the database in text format. The corresponding algorithm uses these text format features for identical purpose & identification.

Seiichi Ozawa[12],2001, Independent Component Analysis has been practical to not only harms of blind signal division, but also feature removal of images and sounds. But, it is not easy to obtain high presentation features from real data by using conservative ICA algorithms. This might be originating in the fact that class in order is not taken into consideration when feature extraction is carried out. It is measured that a preparation for this problem is to introduce a director into ICA.

VI. SIMULATION MODEL

Multimodal biometrics is the combination of two or more modalities such as ear and thumb modalities. In this proposed work an online ear verification system and thumb verification system are combined.Thumb recognition is the most popular physiological characteristic used to identify a person in biometric systems, because of feasibility, permanence, distinctiveness, reliability, accuracy, and acceptability. Ear recognition is the most popular behavioral characteristic used in biometric systems. Thus, we believe that the combination of these two methods will have a reliable and accurate result. We propose a weighted fusion scheme, which transforms the scores into a common range, assigned weights and combines them, giving the final fused score.As these modalities are widely accepted and natural to produce, although this combination of multimodal enhances security and accuracy, yet the complexity of the system increases due to increased number of features extracted out of the multiple samples and suffers from additional cost.

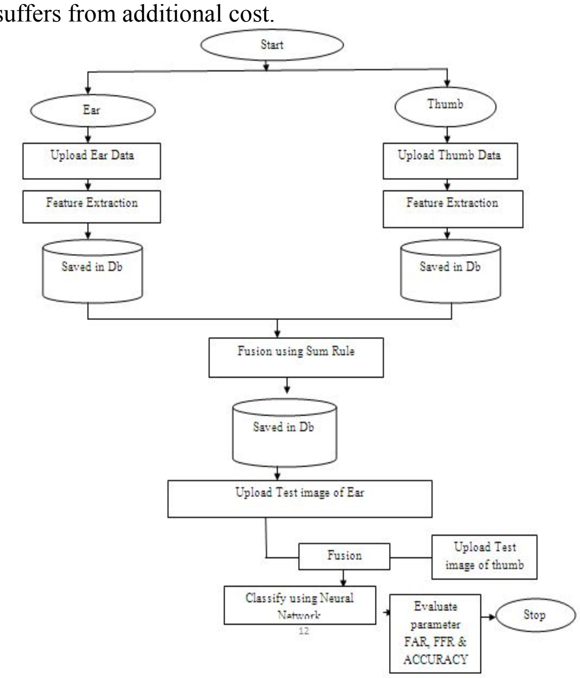

Figure 8: Simulation Flowchart

So these days the key issue is at what degree features are to be extracted and how the cost factor can be minimized, as the number of features increases the variability of the intra-personal samples. Increase in variability of the system will further increase FAR. Thus to resolve these issues an effective fusion level and fusion mode is required**.** The proposed work tires to present a novel user authentication system based on a combined acquisition of ear and thumb signals with high accuracy rate.

VII. RESULTS AND DISCUSSION

The whole implementation has been taken place in MATLAB 7.10. There are two sections first are training and next is testing for both fingerprint and ear. In proposed work left side ear as well as fingerprint database has been chosen and for fusion purpose.

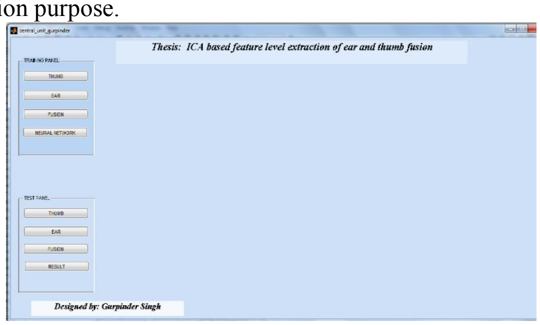

Figure 9: Main GUI

Above Figure represented the main window of left-fingerprint and left- ear fusion working. Here the button indicates the functionality of work containing two sections i.e. training and testing. This window also includes button for fusion of Fingerprint and Ear.

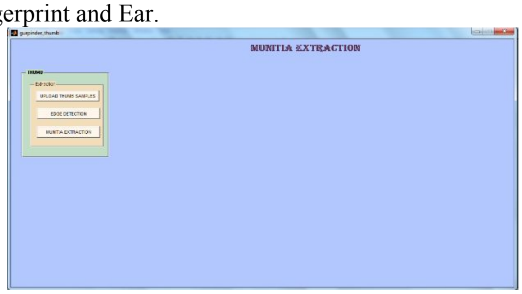

Figure 10: Fingerprint GUI

Above figure displays the fingerprint recognition process for fingerprint containing different buttons like edge detection and then minutia extraction. Combination of patterns called ridges and valley develop the fingerprints. Single arched section is known the ridges whereas part between two adjoining ridges is known as valley and ridge termination is known as minutiae. Every person has different values for minutia, so it is accurate for fingerprint recognition.

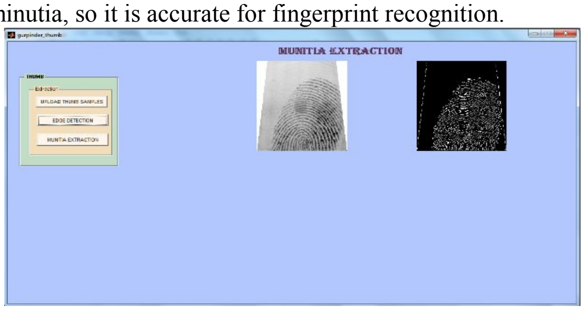

Figure 11: Upload fingerprint data sample and apply edge detection

Above window displays the uploading of the fingerprint sample for further processing. Uploaded sample must be of small size e.g. in few kbs otherwise time consumption will be there for pre-processing.The uploaded image is further converted into Gray Scale image.

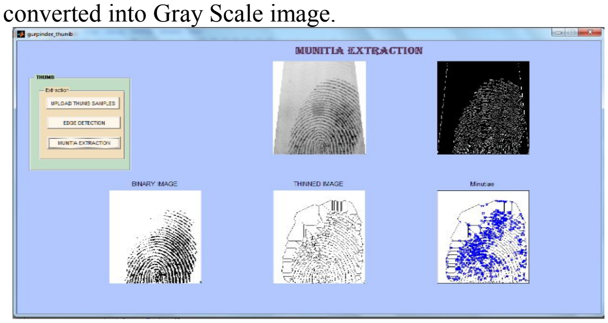

Figure 12: Apply minutia extraction

Above figure displays that after image uploading, binary image conversion is done then image is thinned using thinning morphological operator, then minutia are extracted. For Fingerprint matching mainly two features of minutiae are used 1. Ridge ending 2. Ridge bifurcation.

Figure 13: Graph of minutia features range

Above figure shows a graph, plotted between thin figure points and values which shows the minutia features range. When minutia is applied on uploaded fingerprint image it will extract some distinct features from the image and save it in database.

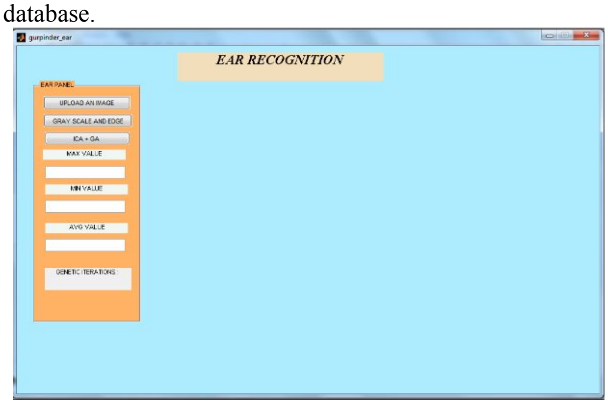

Figure 14: EAR GUI

Above Figure represented the main window of ear working. Here the button indicates the functionality of work. In ear recognition ICA has been used for feature extraction and GA has been used for optimization of obtained features. It shows the left ear database that has been chosen for ear recognition in proposed work. The ear database has been collected from UCI machine learning online website.

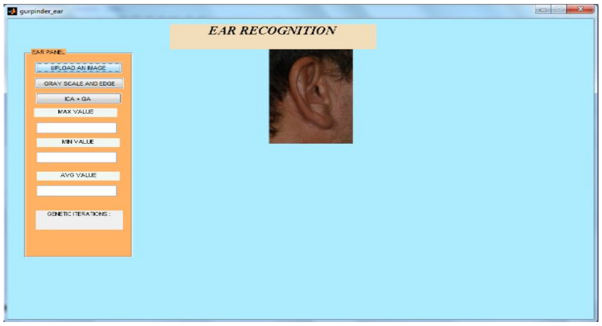

Figure 15: Upload Ear image sample

Above figure shows the left ear database that has been chosen for ear recognition in proposed work. The ear database has been collected from UCI machine learning online website.

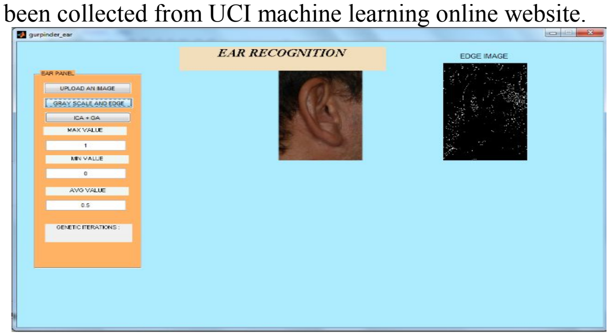

Figure 16: Change into Gray scale and find edges

Above figure shows the gray scale conversion of ear from RGB components using RGB2GRAY function and feature extraction using ICA. After that feature extraction ICA values will be saved in database and three features called min. value, max. value and average value has been calculated.

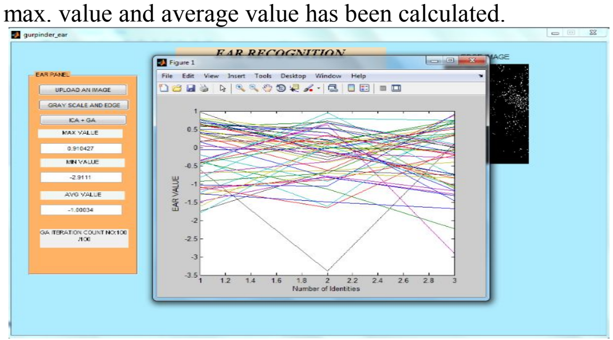

Figure 17: Apply ICA+ GA technique

Above Figure shows the score level values of ear that has been stored in db (database) for matching purpose. In this when we apply ICA for feature extraction and GA for feature reduction then graph will appear showing .

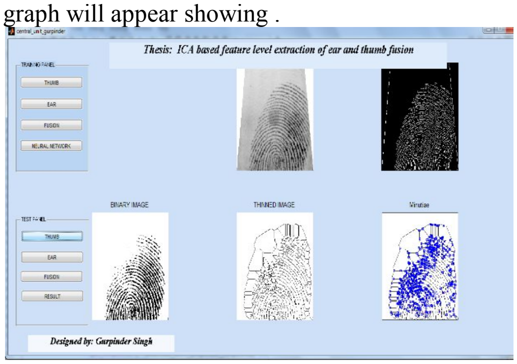

Figure 18: Testing for thumbprint panel

Above figure shows the testing part for the Fingerprint template using stored feature extraction values.

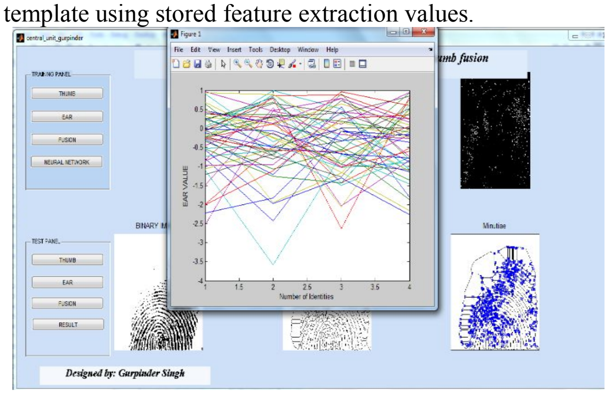

Figure 19: Testing for ear panel

In above figure we have shown features extracted from earthrough above shown graph.

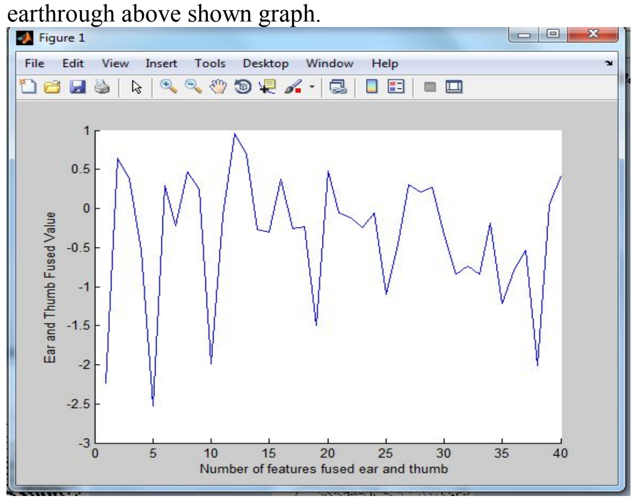

Figure 20: Fused Value

Above Figure shows the score level values that has been stored in db (database) for matching purpose of fingerprint and ear. It has been clearly seen that 40 feature values has been fused for proposed algorithm.

Figure 21: Evaluate Parameters

In above figure, we evaluate results using parameters such as FAR, FRR, RECALL, Accuracy, and Precision.

Table 1 Result values comparison table

Accuracy Values	Proposed Work	Base Work
Fingerprint	99.97	95
Ear	99.97	93.10

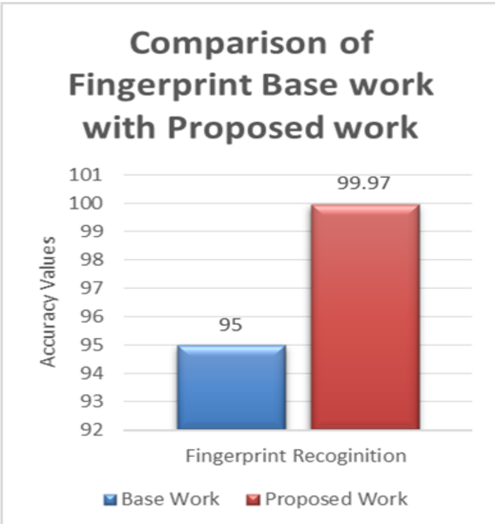

Figure 22: Comparison table of Fingerprint recognition Base work with proposed work

In above graph we have compared proposed work results using accuracy parameter with base work done by Harpreet Singh Brar [15]. This comparison shows our work done gives much better performance as given by single biometric identification system.

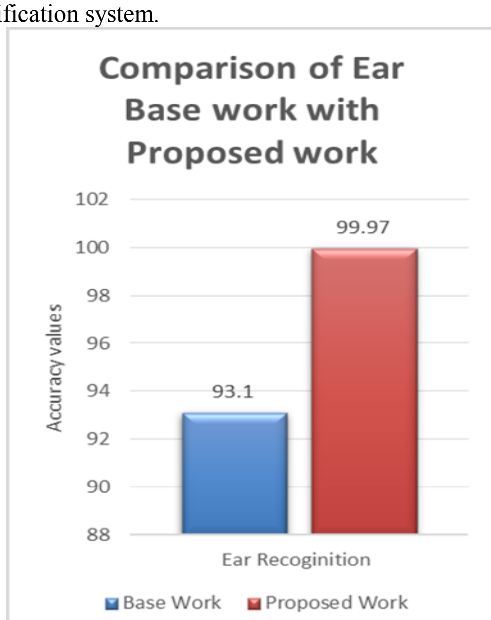

Figure 23 Comparison table of Ear recognition Base work with proposed work

In above graph we have compared proposed work results using accuracy parameter with base work done byFajriKurniawan [16]. This comparison shows that our proposed multi-modal biometric system is much better than base work which uses unimodal system.

CONCLUSION

In this paper, proposed work has concluded that a novel method for fusion of ear and thumbprint has been implemented using ICA and minutia extraction methods. Thumbprint features are extracted using Minutia extraction and Ear features are extracted using ICA technique. Fusion at score level has been done by storing score values after feature extraction process. Then afterwards neural network based network is used for testing. As a first level of fusion firstly individual recognition has been done for each ear and thumbprint template then afterwards fusion has been done in second level using neural network and performance values for obtained algorithm has been found out to be good.

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