A EAR AND TONGUE BASED MULTIMODAL ACCESS CONTROL SYSTEM

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ABSTRACT: Multimodal biometrics has attracted lot of attention in recent days as it provides more reliable scheme for person verification. Multimodal biometrics includes the fusion of information from different biometric modalities. This research work presents a novel method for access control system using ear and tongue images. PCA was employed for feature extraction of ear and tongue images and SOFM was used for training and testing of the system. The proposed method is evaluated using 5000 ear images and tongue images. The images were collected using a digital camera and were fused at the feature extraction level. The fusion results of ear and tongue images showed an improved performance and a huge step closer for user access control.

KEYWORDS: Multimodal, PCA, SOFM, Fusion, Digital Camera.

1. INTRODUCTION

Biometrics is the safest method to meet the digitization necessities of identity and virtualization in the field of information society. It refers to the automated authentication of a person through the use of physiological or behavioral traits [JBP01]. Practically, no modality is best as each modality has its own merits and demerits. Biometric systems are used in authentication to reduce financial fraud and increase security in various fields. In the field of biometrics recognition, ear recognition is drawing more and more consideration. Since, the ear of human beings ha special characteristics such as stability and uniqueness, several researches are implementing based on ear modality [YZ09]. The ear does not undergo from changes in facial expression and is rigidly set in the middle of the side of the head so that the immediate background is knowable [H+14]. As a result to non-contact biometric recognition, ear recognition has turn out to be an efficient and appealing strategy [DS04].

Also, tongue print is the information carried on the exposed portion of the tongue that is the shape and texture put together. The geometric shape of the tongue is usually constant, and the physiological surface texture does not vary a lot. Tongue is an organ that can be easily exposed for inspection but at the same time well protected from environmental influences and therefore very difficult to manipulate or forge unlike other identification systems. The uniqueness of the tongue print is that no two tongues are the same, and studies have found that the tongue of identical twins also does not resemble each other [MEH14]. The tongue provides both static and dynamic features for authentication. [S+11] Therefore, the use of tongue prints as a biometric authentication system is gaining a lot of momentum. In the past 10 years, research has been targeted towards developing a tongue print recognition system, and the first of its kind was proposed by [L+07]. Recently, tongue recognition systems based on 2D dual-tree complex wavelet transform have been proposed by [BAM99] Tongue scanners are under research and being tested.

Biometric systems based on single source of information are called unimodal systems. Multimodal biometric systems, combine information from multiple modalities (like face, fingerprint and iris). Multimodal biometric systems can achieve better performance compared with unimodal systems. The information from the multiple sources are integrated either in the earlier stage of the process or in the later stage of the process. This has achieved high performance and high security and is considered more reliable due to multiple biometric modalities [GD15].

[RRH09] fused face, speech and palm print modalities from three different databases; [DDR10] fused gait and fingerprint; [VY13] evaluated three normalization and four fusion techniques for multimodal biometric fusion using fingerprint and iris biometrics; [P+14] used triangular norm technique to fuse four biometric characteristics, such as finger vein, fingerprint, finger shape and finger knuckle print. However, based on the available literatures, tongue and ear multimodal based system is still an unexplored area, hence this study.

2. LITERATURE REVIEW

At the present time, hand gestures recognition system could be used as a more expected and useable approach for human computer interaction. Automatic hand gesture recognition system provides us a new tactic for interactive with the virtual environment. [A+14] Developed a face and hand gesture recognition system for controlling computer media player. Hand gesture and human face are the key element to interact with the smart system. Face recognition scheme was used for verification and the hand gesture recognition in mechanism like volume down/up, next music and etc. The hand gesture and face location was extracted from the captured image by combination of skin and cascade detector and then is sent to recognition stage. The developed technique was applied on video dataset and achieved proximally 99.20% accuracy rate. The algorithm was applied on static American Sign Language (ASL) database and 99.40% correctness ratio was obtained.

Today an extensive range of systems requires sophisticated identification to verify or determine the identity of a person. The principle of these systems is to make sure that the services provided are accessible by a genuine user only. In this research work, an efficient and robust multi-modal biometric system was proposed that used Finger Knuckle Print (FKP) and iris as input biometric modalities for verification. Features were extracted from FKP using scale invariant feature transform (SIFT) and speeded up robust features (SURF) methods respectively. Log-Gabor Wavelet was used to extract iris feature set. The proposed method was implemented using MATLAB R2009a software and tested with PolyU FKP database and CASIA iris database is used in recognition method.

The user confirmation systems witch using a biometric method are mostly encounter noisy data and infinite orders of error. To improve special matching in such situations, hybrid biometric systems are utilized. In this research work, a multimodal biometric authentication system is proposed which use ear and face features to recognize people. The features of ear and face were extracted separately and wavelet probability neural network is exploited for multi factor decision making. Three face databases Cohen-Canada, Indian Institute of Technology and FEI with PNU ear database to generate an experimental biometric database. These databases were used to investigate reliability of proposed method and performance of multimodal biometric systems. For each person 6 photos are randomly selected as training samples and 8 remained photos are considered as test sample and 100 ear of subject were chosen. Four images are selected as training samples and four remained ones are considered as test samples. Each person in ear database was randomly paired with one person in face database. This procedure was repeated 100 times and the experiment results showed 0.01% EER which revealed that multimodal biometric authentication system is much more reliable and precise than single mode biometric systems [MAM18].

Human Recognition is one of the admired tasks over the world for recognizing a person using biometrics. In this work, ear and fingerprint modalities were used for personal authentication. The stages in proposed recognition system were; Pre-processing; Feature Extraction; Grouped feature vector creation and Fusion and Recognition. The proposed multimodal biometric recognition system with fingerprint and ear modalities was effectively implemented in Matlab. Evaluation metrics employed were false acceptance rate, false rejection rate; GAR and Accuracy were measured by changing the secret key size at each time. The results of our proposed work facilitated better accuracy value of 98.8166% on average, for the recognition of persons with the fingerprint and ear modalities [VA14].

Biometrics identification using multiple modalities has attracted the attention of many researchers as it produces more robust and trustworthy results than single modality biometrics. A novel multimodal recognition system that trains a Deep Learning Network to automatically learn features after extracting multiple biometric modalities from a single data source, i.e., facial video clips was presented. Utilizing different modalities such left ear, left profile face, frontal face, right profile face, and right ear, present in the facial video clips, and train supervised denosing auto encoders to automatically extract robust and non-redundant features. The automatically learned features are then used to train modality specific sparse classifiers to perform the multimodal recognition. Experiments conducted on the constrained facial video dataset (WVU) and the unconstrained facial video dataset (HONDA/UCSD), resulted in 99.17% and 97.14% rank-1 recognition rates, respectively. The multimodal recognition accuracy demonstrated the superiority and robustness of the proposed approach irrespective of the illumination, non-planar movement, and pose variations present in the video clips [SMS17].

In this work, a new biometric fusion framework based on Subjective Logic (SL); a type of probabilistic logic that explicitly takes uncertainty and trust into consideration was presented. The proposed fusion framework uses two modalities; iris and fingerprint. Furthermore, the individual scores obtained from various comparators are combined at score level by applying four score fusion approaches (minimum score, maximum score, simple sum, and subjective logic) and three score normalization techniques (min-max, z-score, hyperbolic tangent). Fusion results showed that the combination of fingerprint and iris biometrics using hyperbolic tangent score normalization technique and subjective logic fusion approach gives an EER of 0.00011%. Specifically, the work achieved an improvement of 99.98% recognition accuracy compared to other classical fusion methods. The experimental results showed that the proposed score level fusion approach (subjective logic) give the best authentication accuracy even when particular biometric classifiers give distinct comparison scores. Furthermore, it demonstrated quality of images (acquisition unit) has an important role in biometric systems; and recognition performance of the multimodal biometric system is better than unimodal biometrics [KA17].

3. MULTIMODAL BIOMETRICS

Since most of biometric systems utilized in real life are single mode ones, they rely on information achieved from one source to authenticate people. Consequently, they might encounter several problems including noise in received data, variation of data classes, similarity between classes, and lack of comprehensiveness and manipulation attacks. One of the solutions to address these problems is using more than one source to perform authentication. In such systems two or more biometric systems are employed. Using multiple biometric systems considerably increase performance of authentication system [KA17].

Table 1: Multimodal Based Systems

S. No	Year	Author	Traits
1	2014	Hiew [H+14]	Face and Iris
2	2016	Ahmed [AWS16]	Face and Palmprint
3	2017	Sayan [SMS17]	Iris and Fingerprint
4	2017	Mansouri [MMY17]	Gait Fusion
5	2017	Kamer and Audun [KA17]	Iris and Fingerprint
6	2018	Mostafa [MAM18]	Ear and Face
7	2018	Sukhdev and Chander [SC18]	Finger Knuckle Print and Iris

4. METHODOLOGY

4.1. Data Acquisition

Data acquisition is the first stage of any pattern recognition process as shown in Figure 1. It is the process that involves the sampling of biometric feature and the conversion of these features into the form that can be manipulated by the computer. The data that were used in this research work was acquired using a digital camera. A programming interface will be developed to acquire 3,000 ear and 2,000 tongue images of 500 subjects or volunteers (i.e. 500 * 6 for Ear and 500* 4 Tongue = 5,000). All these images will be stored and were used as training and testing datasets.

4.2. Data Preprocessing

The tongue and ear images acquired were fed as input to the preprocessing stage. The raw data collected were subjected to a number of preliminary steps to make it usable in the identification and verification stages. Feature extraction stage relied on the output of this preprocessing. The following preprocessing steps will be carried out in this research work:

Step 1: Resizing of Tongue and Ear Images
The acquired ear and tongue images were resized from the original dimension of 480×640 to 200×200 pixels.

Step 2: Extraction of Region of Interest (ROI)
A tongue and ear ROI extracting scheme must be extremely effective and efficient. As depicted in Figure 1, five stages will be followed in the extraction of ROI of resized ear and tongue images adopted from the work of [AA16]. The stages are as follows:

i. Median filter will be used to denoise the ear and tongue images.
ii. Binarizing the ear and tongue images by using Ostu thresholding algorithm.
iii. Apply edge detection algorithm to detect the boundary.
iv. Determine two important reference points and rotate image
v. Draw rectangle or square around the ROI

Step 3: Histogram Equalization (HE)
Histogram Equalization (HE) is a technique used to enhance quality of images for achieving more image information. This is a process of adjusting intensity values and transforming intensity value so that HE of the output image approximately matches a specified histogram. HE will be used in this research work to adjust the intensity of the binarized palm vein images. Also, it will improve the visual quality of the palm vein image and it will normalize it.

4.3. Feature Extraction

In principal component analysis, every eigenvalue and eigenvector are computed and arranged. Then, eigenvectors occurring at the topmost are selected to project the input data. Projecting the input into the selected eigenvectors, the size of the input data significantly decreased.

$$A^{II} = \frac{1}{A^{II}} \sum_{i=1}^{A^{II}} x_i \quad (1)$$

Where:
x_i = dimensional vector
m_j = mean centered image
C = Covariance

$$m_j = x_i - A^{II} \quad (2)$$
$$C = A^{II} A^{IIT} \quad (3)$$

assuming λ is eigenvector and n_i is the eigenvalue:

$$A^{II} A^{IIT} = \lambda (A^{II} n) \quad (4)$$

Projecting $L \lambda A^{II}$

$$\Omega^{II} = \{n_1, n_2 \ldots\ldots\ldots n_i\}^T \quad (5)$$
$$E_k^{II} = ||\Omega^{II} - \Omega_k^{II}|| \quad (6)$$

Final step minimum assigns the unidentified data into K.

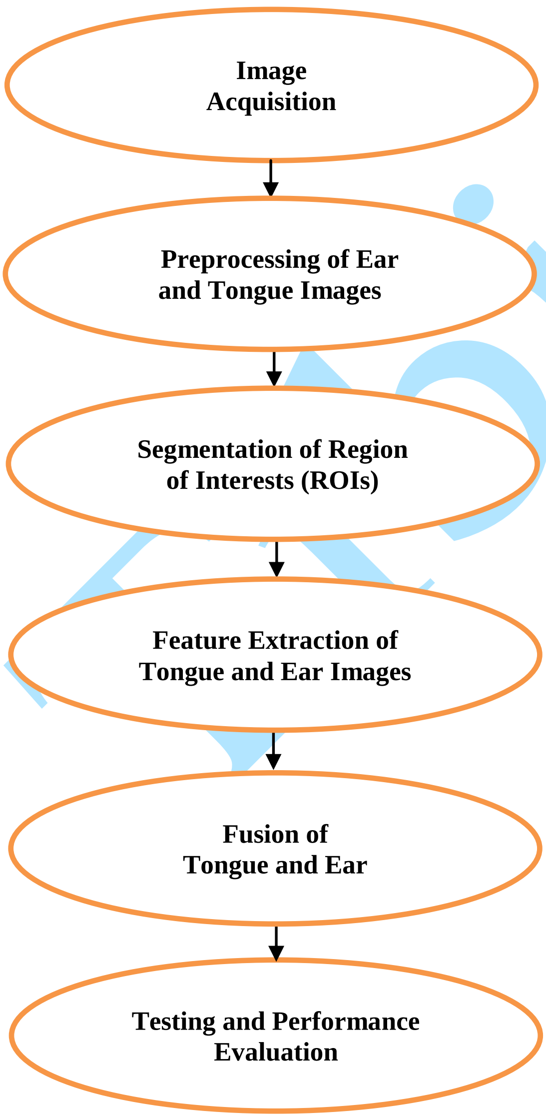


Figure 1: Block Diagram of the Tongue and Ear Multimodal System

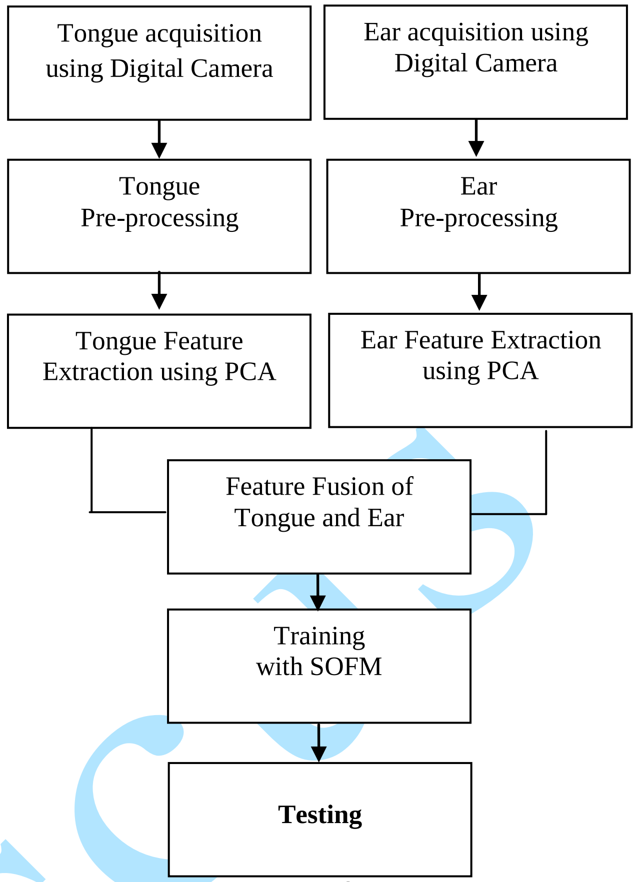


Figure 2: Block Diagram of the Tongue and Ear Multimodal System

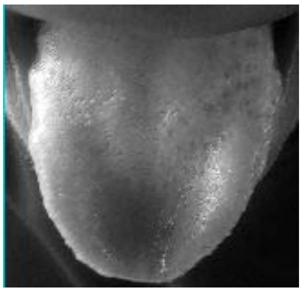
5. FUSION

The two feature vectors, a feature vector extracted from the tongue and ear second represents the feature vector extracted from the ear. These two feature vectors are combined and fused to present a novel user authentication system. The combination of feature vector of tongue and ear is performed by as given below:
X_i= Tongue feature vector
Y_i = Ear feature vector
M = Fusion value
$M = X_i + Y_i$ [SA16]

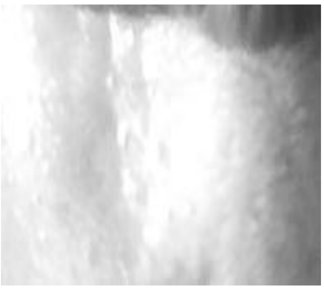
6. SIMULATION AND EXPERIMENTAL RESULTS

The simulation tools that was used for this research work is C# programming language, 64 bits operating system, 8.00GB RAM and run under Windows 8 Operating system on Pavillion i5-3230M CPU**.** The proposed multimodal based method for access control was evaluated on a data set of 5000 pairs of tongue and ear images from 500 subjects. The training database contains 3000 ear and tongue images and 2000 ear and tongue images for testing. The performance of the proposed system was evaluated based on recognition accuracy and Equal Error Rate (EER).

a - Acquired Tongue Image



b - Cropped Tongue Image

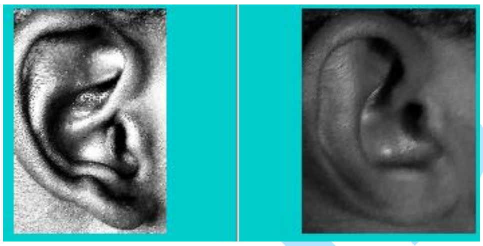


c - Preprocessed Ear Image

d - Extracted Ear Feature

Figure 3: Tongue Processing

a - Acquired Ear Image



b - Cropped Ear Image

c - Preprocessed Ear Image

d - Extracted Ear Feature

Figure 4: Ear Processing

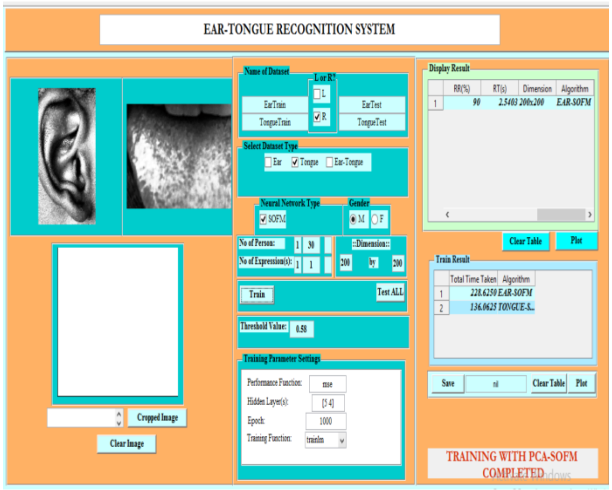


Figure 5: Fused Ear and Tongue Features

Table 2: Comparison of Results with Different Multimodal biometric Systems

Author	Traits	Eer %	Accuracy %
Mansouri [MMY17]	Gait Fusion		77.47
Kamer and Audun [KA17]	Iris and Fingerprint	0.00011	99.98
Mostafa [MAM18]	Ear and Face	0.5900	
Sukhdev and Chander [SC18]	Finger Knuckle Print and Iris		99.58
Proposed Method	Ear and Tongue	0.003	99.73

The accuracy and performance of proposed method is measured by plotting False Acceptance Rate (FAR) and False Rejection Rate (FRR). It is impeccable that the performance of proposed multimodal method (Ear and Tongue) is better than individual biometric i.e. Ear and Tongue. As denoted in the Table 2 overhead, the projected method has 99.78% performance recognition and 0.003% error rate than appraised multimodal methods.

7. CONCLUSION

In this work, a multimodal biometric authentication system is proposed which uses ear and tongue features for access control. In this work, ear and tongue images were acquired by a digital camera and these images were stored in the database which form the data set used for both training and testing of the proposed system. The features of ear and face are extracted separately using PCA and Self Organizing Feature Map Neural Network (SOFM) is exploited for training and tasting of the proposed system. Using the databases, the research investigated reliability of proposed method and performance of multimodal biometric systems. The experimental results have revealed that multimodal biometric authentication system is much more reliable and it might be used in real-time authentication systems. The projected method has higher performance and low error rates other than appraised multimodal methods. Future work will take account of learning the effect on some optimization algorithms on the performance of the projected multimodal method and the taking on of more biometric traits.

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