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A Multimodal Biometric Identification System Using Finger Knuckle Print and Iris

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Abstract: Multimodal biometric system becomes an emerging trend in biometric world due to its optimal False Acceptance Rate (FAR) and False Rejection Rate (FRR) Its aim is to fuse two or more biometric traits i.e. face, palm print, finger print, ear, Iris, retina, voice etc. to provide higher security level. This paper describes a new multimodal biometric system by combining Finger Knuckle Print and Iris traits. The identification of proposed system is considerable reliable as compared with unimodal biometric systems. The performance has been tested using PolyU Finger Knuckle Print and CASIA Iris database. The effectiveness of proposed system regarding False Accept Rate (FAR), False Rejection Rate (FRR) and Genuine Accept Rate (GAR) is demonstrated with the help of Multimodal Biometrics Integration (MUBI) software.

Keywords: Biometric Fusion, Finger Knuckle Print, Iris, Matching Score, Multimodal biometrics.

1. INTRODUCTION

Biometrics authentication is an effective method for automatically recognizing a person's identity. Unimodal biometric systems perform person identification based on a single source of biometric information. Such systems are often affected by some problems such as noisy sensor data, non-universality and spoof attacks. Multimodal biometrics overcomes these problems. Multimodal biometric systems accumulate evidence from more than one biometric trait (e.g. face, Iris, Finger Knuckle Print and hand geometry etc.) in order to identify a person [1]. Finger Knuckle Print, Iris, hand geometry, face and palm print are some good examples of physiological biometric traits. While signature, gait, keystroke and voice are behavioral biometric traits. Multimodal biometric system can provide higher identification accuracy and larger population coverage as compared to unibiometric system. Such as multibiometric systems are being widely adopted in many large-scale identification systems, including UIDIA system in India, US-Visit, FBI-IAFIS Banking ATM, Credit Card, Airport and physically access control of sensitive building and places [2]. In high security applications, extremely low false accept rate (FAR) and false reject rate (FRR) are desired at the same time, which is also known as double-low problem [3]. However, it is difficult to solve this problem only by improving the performance of a unibiometric system. Therefore, the fusion of different biometric traits becomes a promising way to solve the problems in unibiometric system [4, 5]. In a multimodal biometric system, fusion can be accomplished by utilizing available information in any of the four biometric modules i.e. sensor, feature extraction, matching score, and decision modules [6].

a. Sensor level Fusion: We combine the biometric traits taken from different sensors to form a composite biometric trait and process.

b. Feature level Fusion: Signal coming from different biometric channels is first pre-processed, and Feature vectors are extracted separately, using specific algorithm and we combine these vectors to form a composite feature vector. This is useful in classification.

c. Matching score level fusion: Rather than combining the feature vector, we process them separately and individual matching score is found, then depending on the accuracy of each biometric matching score which will be used for classification.

d. Decision level fusion: Each modality is first pre-classified independently.

Multimodal biometric system can implement any of these fusion strategies or combination of them to improve the performance of the system; different levels of fusion are shown in below Fig. 1.

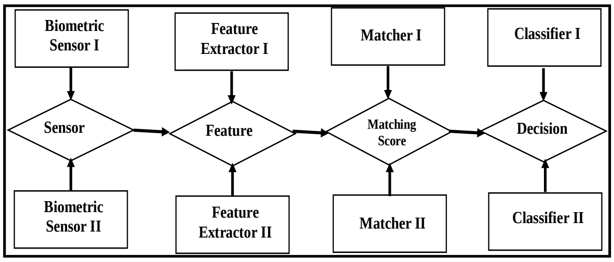

Fig. 1 Fusion levels in multimodal biometric system

There are many advantages and disadvantages in each level of fusion for example in feature level fusion the main problem is to choose the best classifier for high dimensional joint feature vectors. In Match score level fusion, each biometric trait act as unimodal biometric system and normalization is used at score level to make two biometric scores into similar unit [8]. As matching score contains sufficient discriminative information, the score-level fusion is fairly popular in the field of biometrics [7].

In this paper, we have proposed multimodal biometric identification system using Finger Knuckle Print

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(developed by Woodard and Flynn) and Iris; as matching score level have been tested and it's possible at match score level to achieve the desired performance and minimum total error. The organization of paper is as follows, section 2 describes related work. Section 3 describes the proposed multimodal biometric approach. Section 4 describes the result and discussion. Finally the conclusions and future work are given in last section.

2. RELATED WORK

The usage of Finger Knuckle Print and Iris images for personal identification has shown promising results and generated a lot of interest in biometrics for researchers [16]. Score level fusion refers to the combination of matching scores provided by the unimodal classifiers in the system. This is the most widely used fusion approach, as evidenced by the experts in the field.

In 1998, the first multimodal biometric identification system has been proposed by Fierrez-aguilar and Ortega-garaa [9], fusing face, minutiae-based finger and online signature at matching score level. This fusion approach obtained Equal Error Rate (EER) of 0.5.Viriri and Tapamo [10] introduced a multimodal approach including Iris and signature biometrics at score level fusion. This system achieves false reject rate (FRR) 0.008% on a false accept rate (FAR) of 0.01%. Ramachandra and Abilash [11], proposed multimodal biometric system using face and finger print with fusion at feature level. The best recognition rate was 90% at EER 0.13%. Karbhari V. Kale et.al [12] proposed multimodal biometric system using finger knuckle and nail using a neural network approach. Kazi an Rody [13] presented a multimodal biometric using face and signature with score level fusion. The results showed that face and signature based bimodal system can improve the accuracy rate about 10%, higher than a single face/signature based biometric system. Kisku et al. [14] proposed a multibiometric system including face and Palmprint biometrics at feature level fusion. This system attained 98.75% recognition rate with 0% FAR. Meraoumia et al. [15] presented a multimodal biometric system using hand images and by integrating two different traits palm print and Finger Knuckle Print (FKP) at EER=0.003%. Esther Perumal and Shanmugalakshmi Ramachandran [16] presented a multimodal biometric system based on palmprint and Finger Knuckle Print recognition methods. The results showed that palmprint and Finger Knuckle Print (FKP) based bimodal system can improve the accuracy rate about 10%, higher than a single palmprint/FKP biometric system.

3. PROPOSED MULTIMODAL BIOMETRIC APPROACH

As discussed in previous Sec. 1 unimodal biometric has a number of flaws. The primary aim of proposed system is to improve the performance of existing biometric system by eliminating its problems with unimodal biometric system. We have studied the different fusing techniques of proposed multimodal of FKP and Iris trait, here we are using fusion at its match score level due to its reliable nature as discussed in Sec. 1. Both these biometric traits are unique and believed to be stable over the years.

3.1 Image Acquisition and Feature Extraction

The images of two traits (FKP and Iris) are acquired using appropriate sensors and their feature set extraction mechanism discussed below:

3.1.1 Finger Knuckle Print Feature Extraction

There are three bones in our each finger, called (i) proximal phalanx, (ii) middle and (iii) distal phalanx. The first joint is where the finger joins the hand called the proximal phalanx. The second joint is the proximal interphalangeal joint and third joint is called distal phalanx. Finger knuckles of the human hand are characterized by the creases on back of finger as shown in Fig. 2.

Fig. 2 Finger joint

These creases are unique for every person. After collecting the FKP images, we apply preprocessing techniques on FKP images and then extract the feature set of the input finger images as shown in Fig. 3. Knuckle crease patterns and stray marks as a means of photographic identification [17]. Such features are unique and can be used for further identification. The FKP feature extraction has following phases [18]:

a. Capture the FKP images through data acquisition device.
b. Localization of Region of Interest for the feature extraction.
c. Extracting segmented finger knuckle image: ROI is to be automatically extracted using edge detection approach. This gives the segmented finger knuckle image.
d. Knuckle image enhancement using image enhancement techniques.
e. Knuckle feature extraction, which uses 2D Gabor filters to extract the image local orientation information, is employed to extract and represent the FKP features.
e. The matching score is generated by Euclidean distance between Gabor feature vectors of query and enrolled images of FKP.

3.1.2 Iris Feature Extraction

Iris identification is considered to be one of the most accurate and strong biometric trait when compared to other trait, because of having less false match and false non-match. The structure of human eye is unique for every individual; even this pattern is different for both the Irises of the same person. Iris texture has a complex pattern and

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remains stable over time. There are approximately 266 distinct spots in Iris such as: furrows, ridges, freckles, corona, dark spots or rings etc. The presence of so many distinct points and their uniqueness makes Iris scan the most reliable technique [19]. It is very difficult to fool an Iris biometric system. The feature extraction of Iris trait is shown below in Fig.3:

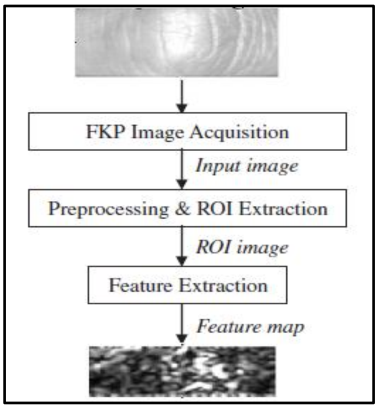

Fig. 3 Finger Knuckle Print feature extraction

a. A sensor captures an Iris image with sufficient resolution and sharpness, good contrast in the interior patterns and well framed Iris texture.
b. Sensor will capture the image of the Iris as a part of a larger image containing data from the surrounding areas as well. Before performing Iris matching, it is necessary to localization the area corresponding to Iris, only.
c. After localization, the useful patterns are filtered for analysis and corresponding to these useful patterns a vector set is generated.
d. An algorithm (wavelet transform) converts this vector set into an IrisCode of 256 bytes.
e. Distance between the IrisCodes (Hamming Distance) corresponding to the captured image and stored template is used for deciding whether both the Iris patterns were derived from same Iris source or not. Iris feature set extraction steps has shown in Fig. 4.

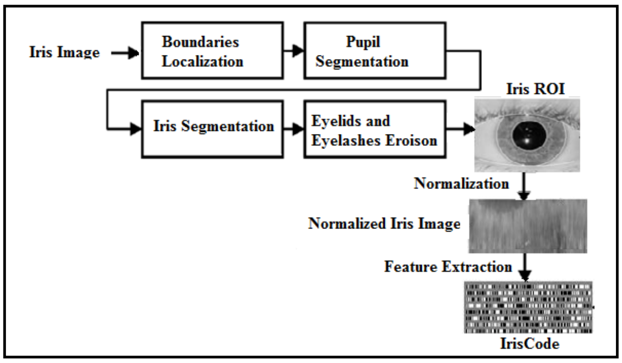

Fig. 4 Iris feature set extraction

3.2 Architecture of Proposed Approach

The architecture of the proposed approach multimodal biometric identification system is shown in Fig. 5. In the operational phase, the two biometric sensors capture the images individually from the person to be identified and convert them to a digital format. After capturing the image e feature extraction modules (m,m) of both traits, individually produce a compact representation according to the input image. The output of feature extraction is then fed to corresponding matcher to match with stored templates in the corresponding databases. The match scores are generated from the individual biometrics and finally, two different matching scores are fuesed into a normalized matching score using simple sum rule. Based on this unique matching score, a final decision is made (the user is genuine or imposter).

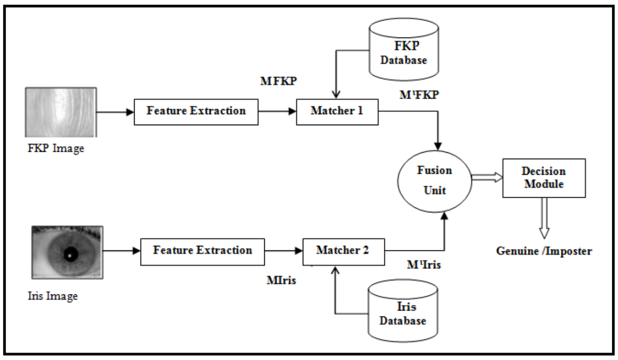

Fig. 5 Architecture of proposed multimodal biometric Identification system

3.2.1 Fusion at Match Score Level

It seems that merging of information from the different traits at some previous stage of the system (sensor level, feature level) will provide more effectiveness. There are several reasons that support match score as an effective fusion are conceptual simplicity, ease implementation, practical aspects. But before fusion at match scores, we have to normalize the match score. Since the match scores output by two biometrics traits are diverse because they are not on the same numerical range, therefore score normalization is performed to transform these scores into a common domain by using normalization techniques i.e. min-max, median-MAD and z-score [20]. In our proposed approach the min-max technique is used to transforms scores into a common platform. Finally the resulting match score is fed to the decision module, and based on the outcome of decision module a person is declared as genuine or an imposter.
The normalized scores are obtained by following normalization type [21]:

$$S_i' = \frac{Si - S_{\min}}{S_{\max} - S_{\min}} \qquad (1)$$

Where

S_i' : the normalized matching scores
S_i : the matching scores, $i=1,2,\ldots$
S_{min} & S_{max}: the min and max match scores.
After the normalization process, we have to combine the scores reported by the two matchers (FKP and Iris) using simple sum rule, as discussed below [21]:
Simple Sum Rule$=\sum_{i=1}^{n}(s_i)$ (2)
Where n= number of match score needed to be fused,
S= matching score,

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4. RESULT AND DISCUSSION

This paper presents a multimodal biometric identification system using Finger Knuckle Print and Iris. Two different databases (FKP and Iris) are used in the proposed approach. For Finger Knuckle Print, we have used FKP images of PolyU database [22].

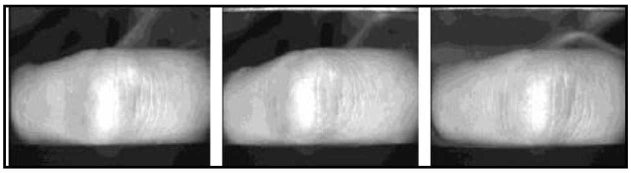

Fig. 6 Sample images of Finger Knuckle Print

For Iris we have used CASIA Iris Image Database [23]. All databases images of Iris 8 bit gray scale levels in the format of JPEG. Sample Iris image of CASIA Iris Database are shown in Fig. 7.

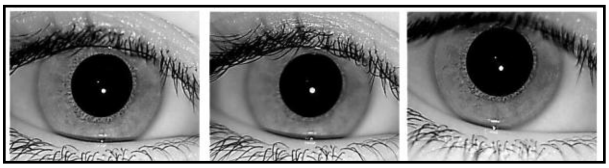

Fig. 7 Sample images from CASIA Iris database

The performance measurement of the proposed multimodal biometric identification system is presented by ROC (Receiver Operating Characteristic) curve as shown in Fig. 8-9. The ROC curve plots the probability of FRR versus probability of FAR for different decision threshold (t) values. The false reject rate (FRR), measures the probability of an enrolled individual and percentage of genuine pairs whose matching score is less than t. The false acceptance rate (FAR), measures the probability of an individual being wrongly identified as another individual and the percentage of imposter pairs whose matching score is greater than or equal to t [29]. In order to show the effectiveness of the proposed method, we compare the proposed system with individual biometric traits by plotting Receiver Operating Characteristic curve for Genuine Acceptance Rate (GAR) against False Acceptance Rate (FAR).

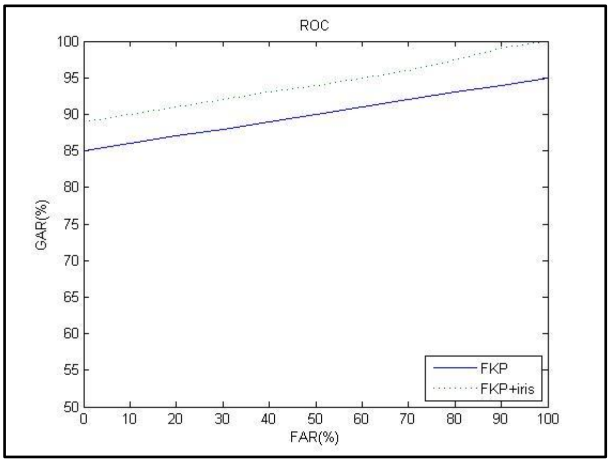

Fig. 8 ROC curve for proposed system and FKP

GAR (1–FRR) is the fraction of genuine scores exceeding the threshold [30]. Fig. 8-9 shows the comparison of proposed system with individual systems on the basis of genuine acceptance rate and false acceptance rate. It can be easily estimated from the ROC curves in Fig.8-9 that the performance gain is very high as compared to the two individual traits.

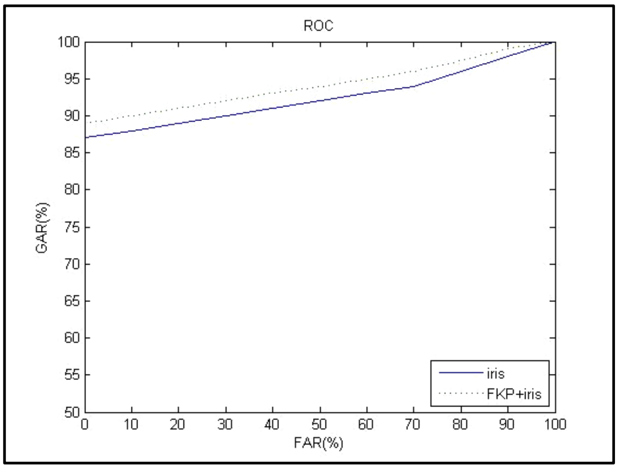

Fig.9 ROC curve for proposed system and Iris

It can also be concluded from Table 1 that the proposed system has improved false acceptance rate as compared to the other individual biometrics. This performance is a significant improvement, even over the best unimodal system (Iris) and it underscores the benefit of deploying multimodal systems.

Table I: Comparison between GAR of Proposed Approach and Existing System

S. No.	FAR (%)	Existing FKP System	Existing Iris System	Proposed (FKP+Iris) Approach
1.	0	85	87	89
2.	30	88	90	92
3.	60	89	93	95
4.	80	90	96	97.5
5.	90	92	98	99

6. CONCLUSION AND FUTURE WORK

Biometric systems are widely used for authentication, but the unimodal biometric system has some problem like noisy sensor data, non-universality, lack of individuality, lack of invariant representation and susceptibility to circumvention. So for overcoming these disadvantages, multimodal biometric system are used. In this paper, a multimodal biometric system (FKP and Iris) is used after fusing results of two different traits. Using Finger Knuckle Print and Iris as multimodal gives better result than other trait. The performance of proposed system is compared with each of the two individual biometric by plotting ROC curves. These curves show that fusion of multiple biometrics improves the recognition performance as compared to the single biometrics. It also prevents spoofing since it would be difficult for an impostor to spoof multiple biometric traits of a genuine user simultaneously. Future work will be focused on optimized algorithms for feature extraction to increase the security in multimodal biometric system.

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