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Research paper

Multimodal Authentication of Ocular Biometric and Finger Vein Verification in Smartphones: A Review

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Abstract

Biometric authentication has demanded a lot of attention from the researchers in the current age, as the field aimsto identify human behavioral charcteristics based on fingerprint, finger vein, ocular, face, palm, etc. So, this field is useful in many applications for offering security and authentication of industry or business. Also, the multimodal biometric system is used to provide a greater security and higher reliability that combines two or more biometric identifiers. Finger vein and ocular-based multimodal biometric authentication system are one of the major techniques which have been considered for efficient identification and verification purpose. This system mainly works in some common stages which include, scanning of finger vein and ocular, pre-processing, feature extraction and matching of finger vein and ocular in a database as well. This paper attempts to review various recent and advanced multimodal finger vein and ocular biometric authentication systems. Finally, possible directions in the multimodal biometric authentication system for the future work are also discussed.

Keywords: *Multimodal Authentication, Ocular biometric system, finger vein verification, personal identification.*

1. Introduction

Currently, an accurate user authentication is more essential for information security due to increasing awareness in an electronically interconnected user community (Cheng et al., 2017). Hence, biometric authentication systems are becoming increasingly significant to advance security through a wide range of applications to provide primary functions such as enrolment, verification and identification purposes (Holland & Komogortsev, 2014). Biometric enrolment is used to accept valid/authentic users to the biometric database. Biometric verification is used to authenticate a user as a provided identity and biometric identification is used to decide the identity of a user (Holland & Komogortsev, 2014). Biometric authentication describes the retrieval of a person's identity or biometric features such as fingerprints, ocular, voice, palm, face, finger veins, etc. which are being used for authentication (Tagkalakis etal., 2017). The most commonly used biometric modalities are the fingerprints and the iris images.

The advances in iris recognition have majorily driven the growth of Ocular biometrics (Kumar et al., 2012; Rai & Yadav, 2014). Due to its stability and high unpredictability factors, it has become a credible biometric feature and considered to be one of the prime parts of human body (Kihal et al., 2017). Finger vein authentication is an emerging technique where the images are captured at the near-infrared (NIR) spectrum (Yang et al., 2012). This authentication technique has a lot of benefits that includes low forgery risk, non-invasive data acquisition, and detection of person's aliveness. Also, the haemoglobin of the blood absorbs the infrared light, creating the veins visible as darker areas inside the finger (Zharov et al., 2004).

The purposes of the finger vein authentication include the fields of the public sector, healthcare, logistics, education, welfare, and finance (Nakamaru et al., 2015).

Multimodal Biometrics scheme is the ability to use more than one behavioural characteristic for enrolment, verification, and identification (Raju & Udayashankara, 2014). Therefore, a multi-biometric system combines two or more biometric identifiers and proceeds benefit of the abilities of each biometric to offer greater performance and higher reliability (Sim et al., 2014 & Brindha et al., 2014). There are three types of fusion methods that are used in the multimodal biometric system, which include fusion at the feature extraction level, matcher score level and fusion at the decision level (Kalra & Lamba, 2014).

2. Literature Review

a) Ocular biometric-based authentication

Ahuja et al., (2016) proposed an ocular biometric authentication technique based on a supervised learning-based approach for a mobile device. In this, Speeded-Up Robust Features (SURF) based local feature descriptor was usedto detect local features in the eye region. In addition, a multiphase training model is developed using a Multinomial Naive Bayes learning, including a pyramid-up topology. Thus, the extracted features are fed to the dense Scale-Invariant Feature Transform (SIFT) to match their nearest neighbour. Ahuja et al., (2017) presented a hybrid convolution-based model for verifying a pair of periocular images

which was based on the combination of unsupervised and supervised convolution neural network with known geometry-based Root SIFT model.

Periocular characteristics are an additional feature for biometric authentication systems using iris characteristics to alleviate effects of noisy iris. Raja et al., (2016) proposed a new system of employing a bank of Binarized Statistical Image filters along with distance metric to handle the cross-spectrum data. The performance obtained indicates that the proposed technique reduces the complexity of the realistic cross-spectrum biometric ocular authentication system. However, the system improves the security, the equal error rate is more in the proposed approach. To overcome this issue, Raja et al., (2016) proposed a novel ocular biometric system for detecting the artifacts based on set of feature descriptors. The local micro-features and global spatial features are extracted from various ocular images by employing adaptive and quantized texture patterns. The extracted features used to learn a spectrally regressed discriminant classifier for identifying the normal ocular against the artefact ocular images. Raja et al., (2016) proposed a collaborative depiction of deep sparse filtered features for robust authentication of a smartphone. The simulation results demonstrate that the proposed ocular biometrics characteristic provided good verification performance.

Kihal et al., (2017) proposed to improve a biometric authentication based on a multimodal ocular biometric system using iris pattern and the three-dimensional (3D) shape of the cornea. In this, intra-ocular and cornea are integrated to improve the performance of the system. Feature extractions are obtained based on the shape of the cornea and Zernike polynomial expansion. These extracted features are fed to the Linear Discriminant Analysis (LDA) for identifying biometrics. Bakshi et al., (2017) presented a fast periocular authentication technique with reduced phase intensive local pattern, where the image is captured from handheld devices, such as mobile, etc. The features are extracted using Reduced Intensive Local Pattern (RPILP) approach to reduce feature dimension. In order to identify the ocular biometric nearest neighbour matching algorithm is used. Another method proposed by Stokkenes et al., (2017) was multimodal authentication which was based on the left-right periocular and face region. Further, the method is analyzed with and without bloom filter, and the features are combined using feature level fusion which includes two operations XOR and concatenation. The results show that the method provides a higher security and accuracy.

b) Finger vein based authentication

Wang et al., (2010) came up with a user identification scheme where finger-vein was used for personal consumer electronic appliances. The scheme offers efficient features extraction based on Radon transform and Singular Value Decomposition (SVD). Later, the classification is achieved based on the measurement of normalized distance. To achieve efficient identification, Huang et al., (2010) presented a wide line detector for feature extraction, which provides accurate width information of the vein and improves information of extracted features. Moreover, they also proposed a pattern normalization approach for reducing irregular distortions affected by difference in pose of the finger. Kim et al., (2012) developed an illumination normalization method to overcome the brightness imbalance in the images of the finger vein. Initially, the illumination components are computed by image convolution and moving average filter and then balancing the image by subtracting the computed illumination components. Following, histogram equalization is employed to free the image of illumination in order to enhancing the quality of image. Finally, feature extraction and matching process are obtained using Scale-Invariant Feature Transform (SIFT).

Gupta & Gupta, (2014) proposed a highly secure personal authentication technique using palm-dorsal vein patterns. The pre-processing is performed to extract vein pattern using multi-scale matched filtering. Then, the verification of user identity is obtained based on image registration based matching. In this, the pattern extraction process attained a low accuracy of identification.

To assuage drawback, an accurate finger vein based personal authentication scheme is presented (Gupta & Gupta, 2015). Initially, a matched filtering process is applied to the vein image at different scales to reduce noise effects. Further, local and global characteristics of improved vein images are joined to attain precise vein pattern. The simulation results obtained shows better performance than other traditional techniques. It is noticed that the geometric deformation issue reduced the performance of finger vein. Gupta et al., (2016) proposed a precise personal authentication using finger and hand dorsal images, where features are extracted using the variational method from enhanced vein images. Matching scores are achieved by matching veins and infrared hand geometry features. Results demonstrate the superiority of the new identification system.

Parthiban et al., (2014) presented a technique, personal identification using finger-vein patterns. In pre-processing, the noise and irregular shading areas are removed by using median filtering. The finger vein features are extracted by using gradient feature extraction approach. The identification is achieved by Euclidean distance algorithm which in turn is attained by the minimal error rate. Li et al., (2014) proposed a hybrid biometric system, which is obtained by the integration of finger vein and face identification schemes, where the user wants to touch the device screen for their finger vein and face images are attained and registered in the face-identification unit simulaneously. Results show that the method achieved a higher security and reliability. Yang et al., (2014) proposed a multimodal identification system which integrates finger vein and fingers dorsal images based on feature level fusion approach. The identification is achieved through the extracted features, which are fed to the Nearest Neighbour (NN) classifier.

Matsuda et al., (2016) proposed a unique finger-vein authentication technique, using feature-point matching approach, in which the curvature of image-intensity profiles is used for feature point extraction due to the robust feature against irregular shading. Further, finger-shape and non-rigid registration models are proposed. The results show that the method attained more robust as well higher accuracy than existing methods. Banerjee et al., (2017) proposed another special system called ARTeM for finger vein authentication. This process is developed based on following: 1) a fuzzy contrast enhancement with 2) registration using a mutual information and affine transformation and 3) matching algorithm based on a correlation coefficient to identify the identity of a person. Cheng et al., (2017) presented an efficient matching technique for finger-vein recognition system to condense memory requirement and narrow down complexity of the system. Liu et al., (2017) introduced a finger vein-based secure biometric system using deep learning and random projections named FVR-DLRP, which protects and safeguardsbiometric information even if the user's password is.

c) Multimodal authentication using ocular and finger vein verification

Brindha et al., (2014) proposed a secured multimodal biometric authentication system through combining eye vein and finger vein images. In this, the intersection of minutiae points of eye vein and finger vein are highly considered for verification. There are several types of features that are considered in the multimodal biometric system. Finally, a multimodal fusion of this new approach will confirm high level of security. The proposed model has highly assured security of the system adduced by FAR and FRR curves. The automatic biometric authentication system is possible with sclera recognition on the move and finger vein scanner.

Galbally et al., (2014) invented a new software-based fake detection approach, which used multimodal biometric systems to detect different types of fraudulent activities. The prime focus of the multimodal system is to improve the security of biometric recognition schemes by including live evaluation in a fast, user-friendly and non-intrusive manner.

The proposed method is less complex, which makes it appropriate for real-time applications using universal image features extracted from one image to judge between legitimate and impostor models. Bharadi et al., (2014) proposed a multimodal biometric authentication system based on iris and fingerprint images, from which the texture feature extraction using hybrid wavelets approach is done. These extracted feature vectors of iris and fingerprint are fused using decision fusion technique. Then, the fused feature vector is fed to the KNN classifier used for multimodal fingerprint recognition and iris recognition. The simulation results provide a greater security and accuracy than the unimodal biometric system.

3. Conclusion

Unimodal biometric systems fail due to lack of biometric information for a particular feature. Thus, it is robust to use multimodal biometrics for providing greater authentication. This review observed that multimodal biometrics authentication solve the issues in unimodal biometrics system such as interclass similarities, noisy data, and non-universality. In multimodal biometric, the biometric identifiers are fused based on feature extraction level, matcher score level and decision level. In this paper, the various existing techniques used for the finger vein and ocular multimodal biometric system have been reviewed. In the future work, the finger vein and ocular multimodal biometric system with a novel feature extraction and matching techniques can be used to offer better accuracy and security.

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