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A Comparative Study on Biometrics For Building Similarity Based Multimodal Biometric System

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Abstract

Single biometric systems have a range of issues like noisy information, non-universality, spoof attacks and unacceptable error rate. In order to avoid these attacks Multimodal biometric template securing system can be developed by fusing multiple biometric of a human. This paper proposed a comparative study on two different biometric in term of their similarities. The chosen biometric are retina and hand vein patterns of a person. These two biometric had shown good number of similar measures which will be used to design a better multimodal system. The main merit of choosing similarity based biometrics will address new dimension of fusing procedure to build and achieve a better security system.

Keywords: Multimodal biometric, Fusion, Similarity, Retinal Template, Hand vein pattern

Introduction

Biometrics refers to automatic systems that use measurable, physiological characteristics or behavioural traits to recognize the identity, or verify/authenticate the claimed identity of an individual. The examples of biometric characteristics that have been used for automated recognition. These systems are based on a biometric sample taken from an individual. This physical characteristic may be presented by an image. Often features are extracted from that sample. These extracted data constitute a biometric template.

Extracted features are plays vital role to develop an enhanced biometric system. When developing uni-model biometric system individual parameter like bifurcation point, ridges will be taken for matching process.

Unimodal Biometric systems are vulnerable to many problems such as noisy data, non-universality and spoofing. This leads to a high false acceptance rate and false rejection rate, limited discrimination capability, and lack of performance. The limitations of unimodal biometric systems can be overcome by using multimodal biometrics where two or more sources have been used to validate identity. To develop a multimodel biometric system need to extract various parametric points from multiple biometric. Multimodal biometric systems improve the recognition accuracy more than unimodal methods. There is number of biometric models have been developed with arbitrarily selected biometric of a person. Instead of choosing haphazardly, similarity based biometrics may be chosen to increase the accuracy of identification system. This paper proposed a multimodal system with similarity based biometrics of human namely retina and hand vein pattern. Both the biometric have common similarities in terms of recognition, verification, identity features, uniqueness, measurable characteristics and behaviours compared with others. And this method asserts to develop a secure identification system[12].

Hand Vein and Retina Biometric Image Acquisition

Physiological biometrics is one class of biometrics that deals with physical characteristics and attributes that are unique to individuals. Vein recognition is a type of biometrics that can be used to identify individuals based on the vein patterns in the human hand.

Hand Vein recognition is a fairly recent technological advance in the field of biometrics. Vein recognition biometrics is a particularly impressive and promising technology because it requires only a single-chip design, meaning that the units are relatively small and cheap[10][14]. Using a light-transmission technique, the structure of the vein pattern can be detected, captured and subsequently verified. Hand vein authentication uses an infrared beam to penetrate the users hand as it is held over the sensor; the veins within the hand of the user are returned as black lines. Hand vein authentication has a high level of authentication accuracy due to the uniqueness and complexity of vein pattern of the palm backside. Because the hand vein patterns are internal to the body, this is a difficult method to forge. Also, the system is contactless and hygienic for use in public areas[2]. The structure of the vein pattern can be obtained through thermal imaging, also called Far Infra-Red.

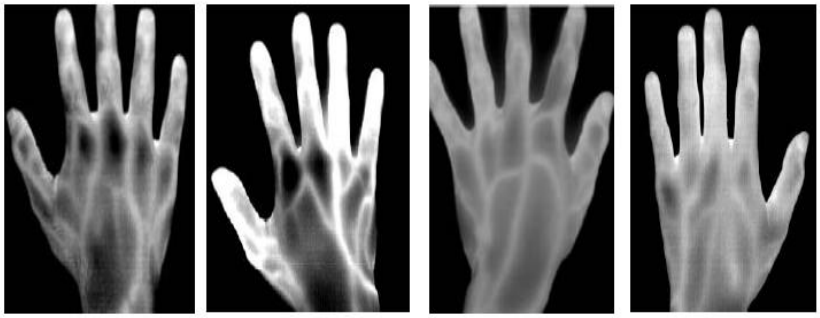

Figure 1: Thermal images of the back of the hands[16].

The second biometric is retina. As a person looks into the eyepiece, an invisible beam of low-energy infrared light traces a circular path on the retina at the back of the eye. Retinal scanning involves reading of vascular patterns found in the back of the eye where the retina is located[8]. This method requires light to pass through each physiological layer of the eye. The light most commonly used by retinal scanning is infrared light which is preferred to other types of light for easier illumination of the distinct blood vessel patterns.

Figure 2: Retinal image at back side of the eye[9]

Both the biometrics has the features to capture their patterns through infrared light source.

Image Enhancement

The quality of these images needs to be enhanced before further processing. A Median Filter could be used to remove the speckling noise in vein and retinal pattern images. Then, a 2-D Gaussian low pass filter

$H(u, v) = e^{-D2(u,v)/2\sigma 2}$

with standard deviation σ = 0.8 could be applied to the vein and retinal pattern images to suppress the effect of high frequency noise.

After removing the speckling and other high frequency noise, the both the biometric pattern images are normalized to have pre-specified mean and variance values. The normalization process is to reduce the possible imperfections in the image due to the sensor noise and other effects. After doing normalization it is often necessary to further improve the contrast before extracting features from the image.

A simple but very effective method to do this is histogram stretching. This method exploits the fact that most images pixel values don't span the entire range of possible values from 0 to 255. In the simplest form, a histogram stretching algorithm uses the lower limit and the upper limit to transform the colors in the image. All color values in between lower and higher will be transformed so they span the entire range from 0 to 255. The colors below lower and above higher will be set to 0 and 255 respectively. Using this method, the color space is stretched equally around the mean of the two limits[8].

Feature Extraction

This is the process obtaining the unique blood vessels from the vein and retina image using image processing techniques. This is a post processing procedure carried out on the image. It involves the following processes

- Morphological structuring.
- Thinning.
- Feature Detection.

Morphological Structuring

Morphological methods include a lot of different image processing operations that base their processing on shapes. Morphological structuring applies mathematical morphology operators by applying structuring elements to binary images. The operators include Dilation and erosion[8]. Dilation expands objects by structuring elements, filling holes and connecting disjointed regions while erosion shrinks objects by structuring element, therefore small object are eliminated.

Thinning

The global shape of the vein pattern needs to be extracted in order to perform an accurate recognition. The term skeleton describes the representation of a pattern by a collection of thin arcs and curves. The thinning algorithm extract only the global shape of the pattern whereas the skeletonisation also extract the size the pattern had on the input binary image. Indeed by using the thinning, the skeleton is successfully extracted, whereas by using skeletonisation it is not perfect[8].

The method used to implement thinning is to obtain the skeleton of a pattern by iteratively remove layers of pixels on the boundary, without shortening it or breaking it apart. Depending on the way the algorithm examines pixels, the thinning algorithm is called either parallel or sequential. In parallel thinning, only the result of the previous iteration is used to examine the deletion, whereas in sequential thinning, contour points are examined for deletion in a predetermined order. Parallel algorithm

can be applied on vein and retinal pattern images to extract better accurate skeletal form.

Feature Detection

In for the detection of these blood vessels, the corners of the lines that form the blood vessel were used to identify the blood vessels. Since the blood vessels lines are inconsistent and have numerous sharp bend, the FAST feature detection tool could be used to detect them and return corner points[10].

After applying pre-processing methodologies on both the pattern templates, the resultant images will be like the following templates which are having similar structural patterns for enhanced fusion process.

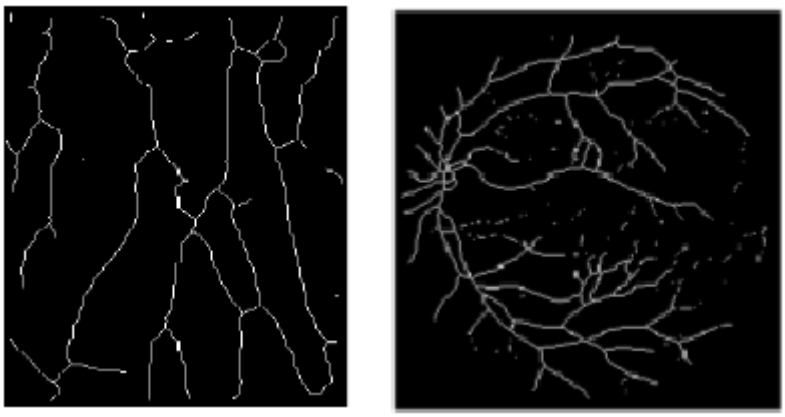

Figure 3: Feature extracted image of hand vein (left side)[4] and retina (right side)[9].

The pruning algorithm would be used to improve the result of the thinning, reduces the number of small branches. The branches to remove are found by measuring the distance along the vein from its end points to the nearest crossing points. If the distance is less than a specified threshold, then the branch is removed. These two biometric templates are having measurements like bifurcation points, minutiae, ridges cross lines and end points which are used to ensure the better fusion system.

Multimodal Biometric System Design

Image fusion techniques will be applied on those biometrics which can enhance a digital image without indulge the original image pattern. There are two distinct enhancement methodologies widely used to fuse two different biometric templates namely Spatial domain methods and frequency domain methods.

Spatial domain techniques are directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. The fusion methods, such as averaging, the Brovey method, principle component analysis (PCA), and IHS based methods fall under the spatial domain approaches[15].

Frequency domain methods, transforms the image in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image.

These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values. Spatial domains techniques will be very opt for above discussed biometric templates in terms of their features.

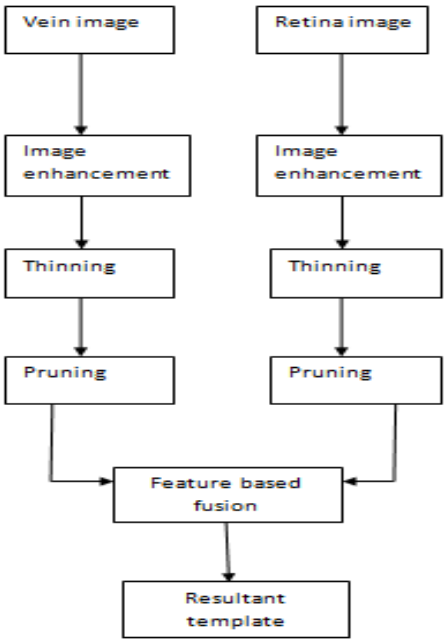

Figure 4: Basic diagram for biometric fusion.

Discussion About Selection of Biometrics

Biometric must satisfy the following requirements.

There are seven basic criteria for biometric security system: uniqueness, universality, permanence, collectability, performance, acceptability and circumvention. As mentioned above, uniqueness is considered as the priority one requirement for biometric data. It will indicate how differently and uniquely the biometric system will be able to recognize each user among groups of users. For instance, the DNA of each person is unique and it is impossible to replicate. Universality is the secondary criteria for the biometric security. This parameter indicates requirements for unique characteristics of each person in the world, which cannot be replicated[11].

For example, retinal and iris are characteristics will satisfy this requirement. Thirdly, a permanence parameter is required for every single characteristic or trait

which is recorded in the database of the system and needs to be constant for a certain period of time period. This parameter will mostly be affected by the age of the user. Following the permanence parameter is the collectability. The collectability parameter requires the collection of each characteristic and trait by the system in order to verify their identification[14]. Then, performance is the next parameter for the system which outlines how well the security system works.

The accuracy and robustness are main factors for the biometric security system. These factors will decide the performance of the biometric security system. The acceptability parameter will choose fields in which biometric technologies are acceptable. Finally, circumvention will decide how easily each characteristic and trait provided by the user can lead to failure during the verification process.

On the basis of the study only few comparisons between the different existing biometrics have been taken and are analyzed theoretically which are shown in Table 1 and Table 2 as below.

Table 1: Comparison of Various Biometric Technologies at Seven Factors[5]

Category	Traits	Universality	Uniqueness	Permanence	Measurability	Performance	Acceptability	Circumvention
Conventional	Face	H	L	M	H	L	H	H
	FP	M	H	H	M	H	M	M
	Vein	M	M	M	M	M	M	L
	Retina	H	H	H	M	H	L	H
	Voice	M	L	L	M	L	H	L

H: High M: Medium L:Low

Table 2: Comparison of Various Biometric Methods[5]

Category	Traits	Anti – Forgery	Accuracy	Speed	Enrolment rates	Resistance	Cost
Conventional	Face	M	L	M	M	H	L
	FP	L	M	M	L	L	M
	Vein	H	H	H	M	M	M
	Retina	H	H	H	M	H	H
	Voice	M	L	M	M	H	M

H: High M: Medium L: Low

From the above comparison retina and vein biometrics had reasonable similarities in term of their accuracy, speed and anti forgery categories which may used to build a better multi dimension biometric system compared with others.

The above comparison is also taken those requirements to select a better combinational biometrics for fusion.

Above mentioned biometrics had defined as the unique (personal) physical/logical characteristics or traits of human body.

Some of the common factors of retina and hand vein pattern.

- The hand vein pattern and retinal pattern in an individual's hand and eyes are unique from person to person and even between one's left and right hands and eyes.
- Both the biometrics resides inside the body. External facts do not affect the bio metric.
- Both the biometrics will not change from birth to death and cannot be transfer.
- Retina and hand vein pattern had False Acceptance Rate of 0.0001% and false Reject ion Rate of 0.1%.
- After death both of them became unused.

Conclusion

Biometrics systems are expected to add a new level of security and reliable user authentication to all sorts of applications. Compared with other biometrics hand vein and retinal biometric had maximum number of similarities which are very prominent. And the comparison had been analysed theoretically. These features are extracted as numerical values and could be stored as a matrix for further implementations. The selection of biometric has been proposed in this paper. Security issues of multimodal biometrics of existing system shall be overcome by selecting similarity based biometrics to build a more secure system in simpler way.

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