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A study of dorsal vein pattern for biometric security

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Abstract

There are many biometrics and vein pattern is one of them. Palm vein pattern has attracted many researchers as a biometric. However, dorsal vein pattern has not received enough attention. In this study dorsal vein pattern is being investigated with a view to use it as a biometric.

There is a distinctive pattern of veins at the back of the hand. When a fist shape is made by the hand, a unique pattern of blood vessel is formed. This pattern can be used as a biometric in security systems. However, there are a number of challenges in this approach. The position of the hand while capturing the pattern and the effect of mental, physical and biological changes, like aging, in the human being concerned are major problems to be addressed. In this paper, we study one of the main challenges, viz., the position of the hand while capturing the main pattern and discuss a suitable method of implementing the same. The paper also outlines a discussion on the other challenges.

Keywords: Biometric, hand vein pattern, challenges, ROI, Feature point extractions

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1.0 INTRODUCTION

Personal verification is an important aspect of security access systems. Traditional personal verification methods, such as passwords, personal identification numbers (PINS), magnetic swipe cards, keys and smart cards offer only limited security and are unreliable [1]. To ensure more reliable security, many biometric verification techniques have been developed and implemented. Compared to traditional methods, biometric features are much harder for intruders to copy and forge. Hence, for identification systems making use of biometric features, they offer a much more secure and reliable performance [2].

Biometric involves the analysis of human biological, physical or behavioral characteristics. Human physiological features possess the properties such as universality, uniqueness, permanence, collectability and circumvention [1]. The most popular biometric features that are used are fingerprints, iris scans, faces as well as signatures. Recently hand vein pattern biometric has attracted increasing interest from both research communities and industries [2].

The physical shape of the subcutaneous vascular tree of the back of the hand is a potential pattern for authenticating the identity of an individual [3]. Anatomically, aside from surgical intervention, the shape of vascular patterns in the back of the hand is distinct from each other [4], and it remains stable over a period of time [2]. Furthermore, veins are found below the skin and cannot be seen with naked eyes. It is difficult for someone to tamper with the vein pattern. This feature makes it a more reliable biometric for personal verification.

2.0 REVIEW OF LITERATURE

Humans have used body characteristics such as face, voice and gait for thousands of years to recognize each other. Many applications are now opting to use biometric since traditional methods are becoming very unreliable. Any human physiological and / or behavioral characteristics can be used as long as it satisfies the following: universality, distinctiveness, permanence and collectability. However, for any biometric system, issues like performance, acceptability and circumvention have to be taken into consideration [5].

All biometric system is essentially a pattern recognition system that operates by acquiring biometric data from an individual, extracting a feature set from the acquired data, and comparing this feature set against the template set in the database [5]. In fact, all biometric systems require each authorized user to be enrolled. This involves the user presenting the characterizing trait to the system one or more times. A library template or signature is then formed from this sample [6].

A biometric system can function in any of these two modes; verification mode or identification mode. When using the verification mode, the captured biometric data is compared to the person's own template stored in the database. When using the identification mode, the system has to search through all the templates stored in the database upon receiving a biometric data.

A practical biometric security system should meet the specified recognition accuracy, speed and resource requirement, be harmless to users, be accepted by intended population and be sufficiently robust to various fraudulent methods and attacks to the system [5]. Factors that may influence the popularity, applicability and performance of biometric verification techniques are uniqueness, repeatability, maximum throughput, whether operable under controlled light or not, invasiveness or noninvasiveness, immunity from forgery, successful identification of dark-skinned subjects, false rejection rate and false acceptance rate, ease of use, user cooperation, cleanliness and so on. Up to now, it is not surprising that there has been no biometric verification technique that can satisfy all these requirements [1].

Among all biometric techniques, fingerprint- based identification is the oldest method which has been successfully used in numerous applications. Everyone is known to have unique, immutable fingerprint. A fingerprint is made up of ridges and furrows on the surface of the finger. The uniqueness of a fingerprint can be determined by the pattern of ridges and furrows as well as minutiae point [7]. There are many problems associated with this biometric. Fingerprint readers can be fooled more easily than one might imagine. Japanese cryptographer Tsutomu Matsumoto at Yokohama National University found that by making moulds out of gelatine, he could produce a fingerprint that would fool 80 percent of commercial readers. Worse, fingerprints on surfaces could be photographed, enhanced and etched onto circuit board material from which a gelatine mould could then be made [7].

The iris pattern is a colored ring of textured tissue that surrounds the pupil of the eye. It is a unique structure which features a complex pattern. It is a reliable method of security. In fact, it is closely connected to the human brain and is said to be one of the first part to decay after death [8]. The visual texture of the iris stabilizes during the first two years of life and its complex structure carries very distinctive information useful for identification of individuals. Initial available results on accuracy and speed of iris based identification are promising and point to the feasibility of a large- scale recognition using iris information. Furthermore, the iris is more readily imagined than retina. It is extremely difficult to surgically tamper iris texture information and it is easy to detect artificial iris [9].However, different lighting conditions of the environment does affect the image during data capture. Image should be taken in a well-lit environment. Sunglasses and glasses should not be worn during data capture.

Face recognition is another biometric that is commonly used. Identification based on face is one of the most active areas of research, with applications ranging from the static, controlled mug-shot verification to a dynamic uncontrolled face identification in a cluttered background [9]. Facial recognition includes upper outlines of eye sockets, areas around cheekbones, the sides of the mouth and the location of the nose and eyes. Most technologies avoid areas of the face near the hairline so that hairstyle changes won't affect recognition [7]. While performance of the system commercially available is reasonable, it is questionable whether the face itself without any contextual information is a sufficient basis for recognizing a person from a large number of identities with an extremely high level of confidence. It is difficult to recognize a face from images captured from two drastically different views. Further, current face recognition systems impose a number of restrictions how the facial images are obtained, sometimes requiring a simple background or special illumination [9].

As discussed above there are many biometrics available like fingerprint, iris pattern and face recognition. Many researches are carried out worldwide to enhance the quality and performance of existing biometrics. However, there seems to be a lot of scope for further improvement of existing techniques in addition to finding more reliable biometric and technique for using them for security purposes. Vein pattern is one such biometric which is at the initial stage of investigation and research. The shape of the hand dorsal vein pattern is capable of authenticating a human being. The hand vein biometrics principle is a non-invasive, computerized comparison of subcutaneous blood vessel structures (veins) in the back of the hand to verify the identity of individuals for biometrics applications.

3.0 HAND DORSAL VEIN PATTERN AS A BIOMETRIC

Vein check measures are the shape and size of veins in the back of the hand. The vein pattern is best defined when the skin on the back of the hand is clenched. The skeleton of the hand then hold the vein tree rigid. Non harmful, near infrared lighting is employed. The vein "tree" pattern is picked up by CCD video camera with an infrared filter installed on its objective lens to prevent the visible light from reaching its sensor array to construct a pure infrared image for the back of the hand, and converted by a computer into a digital image that can be processed and stored. The infrared region is of special advantage. Since the skin tissue is relatively transparent and the blood absorbs infrared light well. Hence, the image contrast is higher than in the visible area [3].

It is quite difficult to obtain vein pattern for personal identification. There are many factors that contribute to obscure the palm dorsa vein pattern. In fact, it is not easy to obtain vein pattern in visible light. Skin surface features such as moles, warts, scars, pigmentation and hair cover the vein pattern. Subcutaneous fat and hand gesturing can obscure the visibility of the vein pattern. Fortunately the vein differs in temperature from the surrounding skin and the skin possesses a temperature gradient [1]. Based on this feature, techniques can be developed to extract vein patterns. Though thermal images of the vein pattern can be obtained there are still many factors that affect the distinctiveness of the vein pattern namely; the thickness of the skin, the degree of venous engorgement, the condition of the vein walls and the nearness of the vein to the surface [1]. Age, physical activity and hand position also affect the image capture of vein pattern [6].

The use of thermographic imaging in the near IR spectrum exhibit marked improvement with respect to the contrast between the subcutaneous blood vessels and surrounding skin and eliminates many of the unwanted surface features [6]. Since the arrival of fairly low cost CCD cameras and computer power, it seems straightforward to try to consider these technologies. Normally, black and white CCD cameras are also sensitive in the near infrared region, so a filter blocking the visible light is all that is needed on the camera. Proper lighting is of course essential to obtain an even illumination on the skin surface. The images are transferred to a PC, where some filtering is done. The results are obtained within seconds of examination. There are many research attempts for the extraction, segmentation and tracing of subcutaneous peripheral venous patterns, its main aim is to make data reduction and noise suppression for good diagnostic purposes and for making some quantitative measurements like lengths and diameters for the extracted vessel segments. These techniques are based on mathematical morphology and curvature evaluation for the detection of vessel patterns in a noisy environment [1].

Effects caused by ambient temperature, the thickness of the overlapping skin, the degree of venous engorgement, the condition of the veins wall, the nearness of the vein to the surface, etc need further investigation and possible elimination. Any variation on the surrounding temperature may lead to unstable distribution patterns of gray value in the thermal images. This problem is very difficult to resolve by relying only on vein pattern features in palm-dorsum thermal images. One possible solution would be to combine vein pattern with another biometric features for verification [1].

One of the main problems that affect image capture of vein pattern is the position of the hand while taking the image. It is very important to locate a fixed region to locate the vein pattern. Cross and Smith [6] has used a simple U-shaped docking frame to constrain the subject's hand. The hand is presented as a clenched fist with the thumb covered by a piece of black card. The docking frame and the base of the unit are painted with poster black, flat acrylic, scenic paint to minimize reflection of IR radiation from their surfaces. The sides and back of the imaging unit are completely closed [6]. In the original work of MacGregor and Welford, the vein structure information of the vein patterns were displayed on the VDU and plotted manually onto acetate. The image was traced to enable feature extraction and further analysis to take place away from the graphics display. Detection of vein structure was determined in the most part by viewing the IR images using the intensity and contrast control on the VDU to provide for optimal detection of structure. Each vein was presented as a vector which has position and angle and can be regarded as a length of vein centerline. The approach was to automatically segment the vein pattern from the digitized image of the back of the hand and then obtain a medial axis representation of the vein pattern [6].

To increase the verification, accuracy and reliability, the features of the vein extracted from the same region in different thermal images of the palm-dorsa are compared for verification. The region is known as the region of interest (ROI). For this reason it is important to fix ROI to be in the same position in different palm-dorsum images to ensure the stability of the principal extracted vein features. It also has significant influence on the accuracy of verification. However, it is difficult to fix the ROI at the same position in different palm-dorsum images without using a docking device to constrain the palm position [1]. Docking device used by Cross and Smith were impractical and people had to place their hands inside the docking device. Other techniques were thus developed to find the ROI. In fact, there should be a region which can be used to select the vein patterns. Lin and Fan [1] has selected the second and fourth fingers as datum points to define ROI. The two finger webs can substitute for docking devices and determine approximate immovable ROI, thus reducing the displacement of the ROI to an acceptable range in palm-dorsum thermal images. After that the feature point should be extracted from the vein pattern. It is very important to get the correct ROI to reduce error rate.

4.0 IMPLEMENTATION METHODS FOR VEIN PATTERN EXTRACTION

Any biometric system is designed using four main modules namely; sensor module, feature extraction module, matcher module and system database module [5].for vein pattern, the sensor module will capture the unique vein pattern of an individual. Then the discriminatory feature of the vein will be extracted by the feature extraction module. The position of the vein pattern is extracted as well. The matcher module, in turn, will compare the features extracted with one stored in the database. In fact, the matcher module encapsulates a decision making module [5]. This module will decide whether there is a match. System database module is another module used by biometric system to store templates of individuals.

First of all, in any biometrics, the image should be captured. Lin and Fan [1] has used thermal technology to capture the images of the palm-dorsa vein pattern. Since there is a difference in the temperature of the surrounding skin and that of the vein, it is easy to remove unwanted surface features of the skin, hairs and scars. Lin and Fan [1] has used a well-known heat radiation law, the Stefan-Boltzmann law. Then the ROI was extracted from the images obtained. Datum points were devised to get a fixed region. In fact, the second and the fourth finger webs were used. In that paper the mode method were used to automatically determine the threshold for the segmentation of the palm region .Then the inner tracing algorithm was used to find the palm border. The middle point of intersection line that is formed by the wrist and the bottom margin of the thermal image of the palm-dorsum was located. Then the Euclidean distance between each border pixel and the wrist middle point was computed. These distances are adopted to construct a distance distribution diagram whose shape is quite similar to the geometric shape of the palm. Then the wavelet transformation was applied to determine the local minimums of the distance distribution diagram. They are the locations of the four finger webs. The second and fourth finger webs are selected as datum points to define a square ROI. After that the feature point of vein pattern (FPVP) are extracted and the multiple vein pattern are extracted from this feature point vein pattern. Based on Fourier law, the FPVP locations, gray values of the FPVPs, and the distance between the FPVPs determine the temperature gradient and the gradient direction. Although the ROI has been carefully located according to the finger webs, it still cannot ensured that the ROI will always be located in the same position in different palm-dorsum thermal images. To resolve this problem, multiresolution analysis is applied to decompose the feature point images (FPI) into multiscale FPIs [1].

Wang and Leedham [2] proposed a new personal verification system which consists of five individual processing stages namely; hand image acquisition, image enhancement, vein pattern segmentation, skeletonization and matching. The system captures the vein pattern using a thermal camera. Unlike other vein pattern verification systems that compare the vein pattern based on a predefined set of features extracted using techniques like multiresolution analysis, the proposed system recognizes the shape of preprocessed vein pattern by calculating their line segment Hausdorff distances. In fact, Wang and Leedham [2] have used the same technique as Lin and Fan [1] for finding the ROI. In their work they have captured the images in a normal office environment since ambient temperature and humidity have a negative impact on the image quality, and the vein patterns in these images are not easily distinguishable [2].

The clearness of the vein pattern in the extracted ROI varies from image to image, therefore the quality of these images need to be enhanced before further processing. In fact a 5x5 Median filter was used to remove thee speckling noise in images. Then, a 2-D Gaussian low pass filter was applied to the vein pattern images to suppress the effect of high frequency noise. After removing the speckling and other high frequency noise, the vein 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.

The quality of the image improves after noise reduction and normalization. However, the vein pattern is still surrounded by many faint white regions. To obtain a better representation of the shape of the vein pattern, it is necessary to separate the vein pattern from the image background. Due to the fact that the gray-level intensity values of the vein vary at different locations in the image, global threshold techniques do not provide satisfactory results. Hence a locally adaptive thresholding algorithm was utilized to segment the vein patterns from the background. The algorithm chooses different threshold values for every pixel in the image based on the analysis of its surrounding neighbors [2].

The veins grow as human beings grow, only the shape of the vein pattern is used as sole feature to recognize each individual. A good representation of the pattern's shape is via extracting its skeleton. The skeleton is obtained after applying the thinning algorithm. It can be seen that after the pruning process, the skeletons of the vein pattern are successfully extracted and the shape of the vein pattern is well preserved. After acquiring the thermal image of the hand vein pattern, the second stage is the Hand Vein Verification System (HVVS) [3]. This covers the detection of vein structures from the acquired infrared image for the back of the hand. The vein tree detection stage includes four steps, which are hand region segmentation (i.e. region of interest localization and background elimination), smoothing and noise reduction, local thresholding for separating veins and finally the postprocessing.

Image segmentation is one of the most important steps leading to the analysis of processed image data. Its main goal is to divide an image into parts that have a strong correlation with objects or areas of the real world contained in the image. Binarization is the case if segmenting the image into two levels; object and background [3]. Therefore a white part is obtained which is the ROI and the black part that is obtained is the background.

Then the Gaussian blur filter is applied to filter noise. The disadvantage of this filter is that it is not an edge preserving technique. Then a median filter of 5x5 mask was applied to remove hand traces from the acquired image. Followed by this a nonlinear diffusion filter based on edge weighted diffusion was applied to smoothen the image while preserving the vein edges [3].

Specifically, hand vein segmentation is to divide a hand vein image into foreground and a background. Segmentation methods can be divided into four groups, which are threshold-based segmentation, edge-based segmentation, region-based segmentation and segmentation by matching. A local threshold process was applied to separate the vein pattern fon the background. Hence, the vein pattern was extracted. Experimentally, a 31x31 mask size for computing the threshold for binarizing the central pixel was chosen. Since the resultant binary hand vein contains some noise and un-sharp edges, a 5x5 median filter was applied for improving and validating the output binary hand vein pattern and for reducing the effect of these unwanted defects.

5.0 VEIN PATTERN MATCHING

After acquiring the thermal image of the vein pattern, matching should be done with the one stored in the database. Wang and Leedham [2] have done this by measuring the line segment Hausdorff distance between a pair of vein patterns. Hausdorff distance is a natural measure for comparing similarity of shapes. It is a distance between two point sets. Hausdorff distance uses the special information of an image, but lacks local structure representation such as orientation when it comes to comparing the shapes of curves. In fact, Wang and Leedham [2] has used line segment Hausdorff distance to match the shapes of vein patterns [2]. In fact, vein patterns are divided into a number of curve segments. Using these sample points as the end points, a set of line segments representing the shape of the vein pattern are obtained. By this means, the undirected line segment Hausdorff distance can be calculated to measure the similarity of two vein patterns.

To match hand vein pattern, A.M.Badawi [3], has used rigid registration technique since they have already constraint their data acquisition system with the attachment in order to prevent any large translation or rotation. One of the two images remains stationary while they apply 2D transformation on the other image in order to align it with the first pattern to find the maximum correlation percentage between two hand vein images [2]. They have used the contactless palm vein authentication which Fujitsu researchers have presented. They have developed a prototype but they suggested that in real systems, there is a need to capture the hand vein pattern at equal monthly intervals after correct authentication. This is suggested in order to track the changes in the hand with age. The matching percentage is calculated as the ratio of the count of the overlapped white pixels between input images to the number of white pixels in one of the two input images.

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