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Vein Pattern Database and Benchmark Results

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Abstract

In this paper a vein pattern database collected by the authors and freely available for research purposes only is described. The results obtained after segmentation with a local thresholding method and classification by using 2D correlation of images gathered in this database are presented. Complete results are attached to the database as a reference for other researchers using it.

1 Introduction:

Biometrics is a rapidly growing branch of access control technology. Biometric systems are easy to use and more resistant to the possibility of unauthorized access as they are based on people's individual features or behaviours. They eliminate the need to use additional devices (like access cards or tokens) or remember passwords. Among other human features used in biometrics, vein pattern has many advantages. It is stable over time, different even for twins [2], can be acquired without contact, and requires the presence of blood in the veins to be registered, which solves the liveness problem. An image of a vein pattern can be taken in the near infra-red (NIR) band by a standard camera with a CCD or CMOS sensor, which makes the costs of the acquisition system low. Due to the fact that vein pattern based recognition is still a rather young field of research, no public database for benchmarking is available [3]. The database made by the authors and described in this article is available for research purposes only at biometrics.cie.put.poznan.pl. Benchmark results obtained by the authors with popularly used methods are also presented.

2 State of the Art:

In previous studies, vein pattern authentication (VPA) researchers used to build their own acquisition devices to acquire vein pattern images. This resulted in many different proposals for the choice of region of interest (ROI), different positioning equipment, various image parameters (for example resolution), and different image collection processes. The results of classification in such different conditions are thus difficult to compare. In VPA the back of the hand or the finger is usually used as the ROI, but the wrist and palm seem to be gaining popularity. Additional positioning equipment design depends on the chosen ROI. Some researchers constrain movement of a hand or a finger; others only require a hand to be placed on a flat surface beneath a camera, leaving the problem of locating the ROI to additional algorithms. The resolution of images is usually rather low in comparison to today's standards. The number of images per single person and the time intervals between acquisitions are also very different in each database. That last parameter is often ignored by researchers presenting their results in papers. Examples of such databases can be found in [6, 7, 5]. The most complete research in vein pattern recognition was conducted by Fujitsu in Japan and is described in [1]. Its database contained images of 150 000 palms acquired from 75 000 people of different ages, but little is known about intervals between acquisitions or the number of images for the same hand. Therefore the authors decided to make their systematic database available to allow the creation of a benchmark platform for VPA methods.

3 Database Collection and Organization:

The dataset introduced in this paper consists of 2400 images showing human vein patterns. Half of the images contain a palmar vein pattern (1200 images) and the other half contain a wrist vein pattern (another 1200 images). Exemplary images from the dataset are presented in Fig. 1. Images were acquired by the acquisition system designed by the authors [4]. The system consisted of a low cost USB camera able to register images in the near infrared band and IR emitting diodes enclosed in housing with an acquisition window. The registration process assumed that the subject covers the acquisition window with his or her palm or wrist, cutting off external light sources. Therefore objects were illuminated in controlled stable lightning conditions with near infrared uniform light of wavelength 880ñm. Uniformity was assured by a diffusion-like light reflection system inside the housing. This method of hand positioning seems to be natural. For hand image acquisition, no additional positioning set-up was used. Volunteers were only asked to place a hand on the box so that the line below their fingers was coincident with the upper edge of the acquisition window. The positioning of the hand on the device can be seen in Fig. 2a. In the case of the wrist acquisition, an additional set-up was used to help place the hand on the device. This construction not only helped make users more comfortable but was also used as a reference for wrist positioning. The device with additional set-up and placed wrist is shown in Fig. 2b. Images were acquired from 50 volunteers for both left and right hands. For each subject, images were obtained in three series of four pictures each. Series were separated by intervals of at least one week. Images of the left and the right hand of the same person in series were taken alternately one by one with an interval of no longer than a few seconds. Images were acquired from the same person on the same day of the week at the same time of day. Before each acquisition in different series people were instructed precisely what to do. Each obtained image is a $1280x960$ bitmap saved in bmp format. The database is divided into two sections: "Hand" and "Wrist". Every section contains folders for every person. Person folders are divided into "Left Hand" and "Right Hand" folders, which contain a series of folders. Series folders contain four images each. Image names specify all those items of information exactly. For example the image named: "`P_o034_R_S2_Nr3.bmp`" is the third image in the second series of the right palm of the 34th person and has the path: "`...\Database\Palm\o_034\Right\Series_2\`".

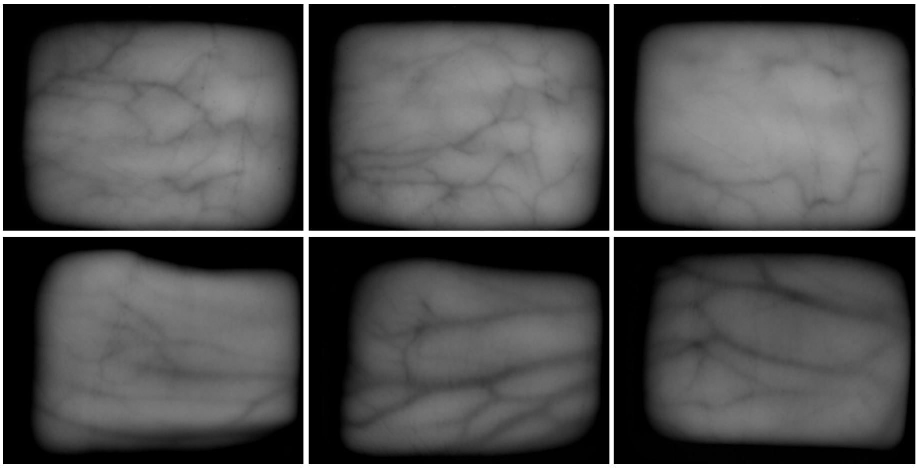

Figure 1: Exemplary images from the dataset. Top row: images of palmar vascular patterns; bottom row: wrist vascular patterns

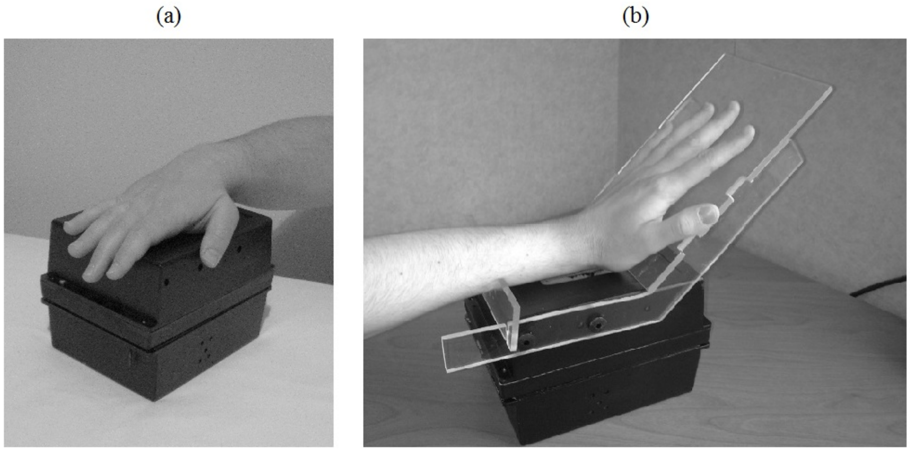

Figure 2: (a) Hand positioning on the device during palmar vascular pattern image acquisition; (b) additional set-up and hand positioning during wrist vascular pattern image acquisition

4 Vein Pattern Segmentation and Matching:

Images gathered in the dataset were compared and classified to provide benchmark results. Methods used in this process are described in this section. It is assumed that comparing vein patterns on two images consists of two stages: the first stage is segmentation of the vein patterns from both images and the second is matching those patterns. In the segmentation process a binary image is obtained and therefore hereafter this process is referred to as "binarization". The image function of an obtained binary image is equal to "1" for pixels representing vessels and equal to "0" for pixels representing background. In this paper segmentation of the vein pattern is performed with the Local Thresholding (LT) method as it seems this method is the most popular among vein pattern researchers due to its simplicity [6, 7]. The method consists in analysing the image function in the nxn neighbourhood of a chosen pixel. A pixel is said to represent a vessel on the image if the value of its image function is lower than a threshold value. The threshold is calculated as a mean or median value of the image function of all pixels in this neighbourhood. In this method the threshold is calculated as the mean value of pixels lying in the $9x9$ neighbourhood of a pixel being analysed. The LT method requires an appropriate preliminary filtration to be applied to the image in the preprocessing stage. In this case the image was filtered with median and Gauss filters. After binarization, morphological closing was performed to improve the continuity of the obtained vein pattern. After segmentation, the binarization was reversed ("1" for vessels, "0" for the background). The maximum value of the 2D correlation function was taken as a measure of similarity of two patterns. Differences between two images of the same pattern result mainly from object translation and rotation, which are a consequence of the free hand positioning. Although we reduced the influence of translation by using correlation, to reduce the influence of rotation another method had to be applied. Correlation was calculated for two pictures while the second picture was rotated around the centre of mass of the vein pattern within the range -15^o, 15^o with a step of 1^o. Degrees of similarity were calculated for each pair of images in the dataset and gathered in the correlation matrix.

5 Benchmarking results:

Based on the data collected the following indicators were calculated in order to judge the results of comparison: FAR (False Acceptance Rate), GAR (Genuine Acceptance Rate), FRR (False Rejection Rate), and ROC (Receiver Operating Characteristic), as functions of the similarity threshold [7]. The similarity threshold (ST) determines the minimum value of degree of similarity for which two pictures are said to belong to the same class. Diagrams of these values are presented in Fig. 3. As can be seen on the GAR and FRR diagrams, the Equal Error Rate (EER) point differs between the within-series and between-series comparisons. For the results of the within-series hand comparison it equals 1.1%, and for the between-series comparison it equals 3.8%. Also, comparison of ROC diagrams confirms that within-series results are better than between-series results.

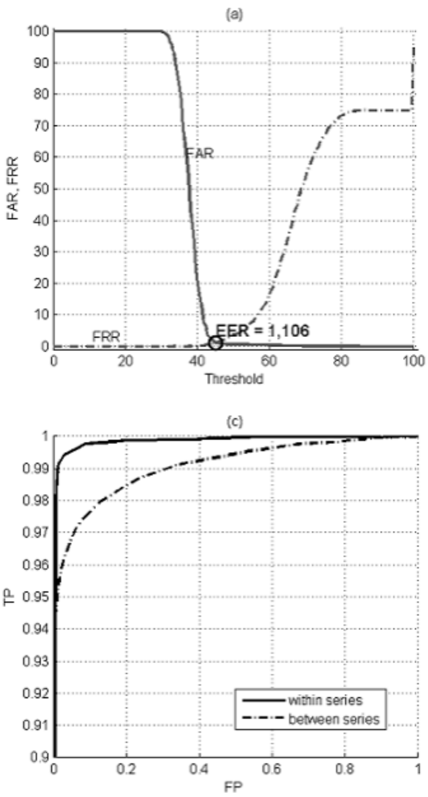

Figure 3: (a) FAR (continuous line) and FRR (dotted-dashed line) diagrams for images collected within-series; (b) FAR (continuous line) and FRR (dotted-dashed line) diagrams for images collected in different series; (b) ROC diagram comparing classification results for pictures collected within-series (continuous line) and between-series (dotted-dashed line)

6 Conclusion:

Sharing results of classification obtained on a reference database with different methods by different researchers is the simplest solution for the advancement of vein pattern recognition techniques. Therefore the authors decided to create an images database and make it available to other researchers. The results obtained so far demonstrate that the acquired images allow people to be properly identified even with simple and popular methods of segmentation and classification. Therefore the collected database fulfils the conditions for being a benchmark database. However, although the same conditions of acquisition were strictly preserved while images acquired in a single series are more similar than images of the same subject acquired in two different series. Results of classification of palms are better than those of wrists, which is a consequence of the more complex vein pattern in a palm.

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