Processing of Features in Vein Images

Ivo Draganov[1], Darko Brodic[2]
[1]Technical University of Sofia
8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria
idraganov@tu-sofia.bg

[2]University of Belgrade, Technical Faculty
in Bor, V.J. 12, 19210 Bor, Serbia
dbrodic@tf.bor.ac.rs

ABSTRACT: *We have assessed the features of some finger vein databases available in this work. The intention is to find the quality of images and other features such as contrast, sharpness and possible noise. We report these assessment work in terms of quantity data. The results help to find the distribution of visual images of the veins that can do recognition. We have given outline about the impact of the research on the processes such as image segmentation.*

Keywords: Finger Vein Recognition, Database, Contrast, Sharpness, Noise

Received: 17 October 2021, Revised 2 December 2021, Accepted 13 December 2021

DOI: 10.6025/jmpt/2022/13/1/1-6

1. Introduction

Finger vein recognition becomes more popular in the recent years as additional modality available in biometric systems [1- 7] that could be used separately or in combination with other modalities. Vein patterns captured in two-dimensional image representation by illuminating human finger either from above relying on transmissive principle or from below based on diffusive scattering and reflectance with near infrared light provide a number of advantages compared to other biometric features [2]. First of all they are considered unique for every human even between twins [3]. Since finger veins are located under the skin there is less probability for visual change over long period of time and in parallel to that the current outer condition of the finger is of no importance to the capturing process, e.g. whether it's dry, wet or contaminated [4]. The vein patterns are permanent with aging. Like other features they allow to check the liveness of the sample, i.e. it's an effective measure against forgery [6]. The authentication is eased by the contactless way of acquisition. It is also thought to be zero-valued as for the Failure to enrolled rate (FER) and along with its other benefits qualified as highly secure and reliable.

Since a set of promising algorithms for finger vein recognition were proposed in the last decade [1-4] and still there are currently introduced enhancements to them a unified approach is needed for estimation of their overall performance and applicability to the practice. Considered as appropriate for incorporating in electronic passports and additionally assuring robust personal identification together with facial and fingerprint recognition [7] especially in the variable conditions in developing countries [5] a suitable database of finger veins needs to be selected as a starting point for the foundation of such unified testing framework. It should have a variety of abundant properties such as wide range of covered ages for the volunteers, equally spread from youngsters to elderlies with equal presence between men and women. Different nationalities preferably from all continents are desirable to participate. Also, more captured fingers from both hands would assure better selection of the proper ones for application and better evaluation of the tested algorithms will be made although the index and middle fingers are thought to be the most promising followed by the ring finger and much less attention is directed to the thumb and little finger. A few captures should be made of all selected fingers for testing with positional variations and partly such for the illumination conditions aiming to resemble real-case scenarios. Proper indexing preferably in the form of a related database and/or following specific xml schema is another requirement for efficient access while testing. All these features along with the objective measures for image quality are going to be evaluated below in this paper.

In Section 2 description is given for each of 5 evaluated databases, in Section 3 - quantitative analysis of the quality of the images from them and some considerations based on subjective inspection, and then in Section 4 a conclusion is made.

2. Evaluated Databases

SDUMLA-HMT database [8] is presented in 2010 by the Group of Machine Learning and Applications from Shandong University (SDUMLA) as a Homologous Multi-modal Traits (HMT) set. It consists of face images incorporating 7 view angles, finger vein images including 6 fingers per individual, iris images from a single sensor and fingerprint images obtained with the use of 5 different sensors. All this multimodal data is collected from 106 individuals. It is considered by its collectors as the first open database of this kind. The capturing device used for the finger vein images was developed by the Joint Lab for Intelligent Computing and Intelligent Systems of Wuhan University. Each participating individual in the collection process provided an image of his/her index, middle and ring fingers from both hands for totally 6 times. Thus 3816 images were gathered in bmp format with resolution of 320x240 pixels resulting in 0.85 GB database size.

The Hong Kong Polytechnic University Finger Image Database [9] has been gathered since April 2009 aiming large scale bundling of finger vein images publicly available for research. Along with the finger vein images finger surface texture images were also acquired from both male and female volunteers - a process which ended in March 2010 followed by database release in September 2010. A contactless capturing device was used producing 6264 images from 156 individuals in bmp format. Around 93 % of the subjects were below 30 years of age at the time of the collection. It was done in 2 sessions separated from 2 to 6 months apart in each of which 6 images of the finger vein patterns of the index and middle fingers of the left hand and 6 finger texture images or 24 images totally per subject.

Idiap Research Institute in Martigny with the assistance of Haute Ecole Specialisee de Suisse Occidentale in Sion, Switzerland, developed the VERA finger vein database [10]. It consists of 440 images from 110 subjects. An open finger vein sensor [11] was used for the purpose. Both index fingers were scanned of each subject in two sessions following in 5 minutes one after the other. Forty women and seventy men between 18 and 60 years old volunteered in the process. Images are in png format with resolution 665 x 250 pixels with an average size of 80 kB per file.

Another effort for free finger vein database for academic use was made by the Tsinghua University by putting together Finger Vein and Finger Dorsal Texture images (THU-FVFDT) [12]. All images were taken from 610 subjects in two sessions separated by a period from a few dozens of seconds up to a week where four finger vein and four finger dorsal texture images were captured. In the publicly available version of the database only one of these four images of each type is offered since the difference with the rest three is considered negligible. The resolution is 720 x 576 pixels and consequently a Region of Interest (ROI) was introduced with a size of 200 x 100 pixels covering the veins' area for each picture.

Incorporating information for the finger veins along with finger geometry it becomes possible to verify unimodal or bimodal (fusion of vein data with outer shape of the fingers) biometrics systems as it is done in the Finger Vein UniversitiSains Malaysia (FV-USM) database [131.A ROI was also introduced in it for the veins to be used in algorithms' testing and comparing. Totally of 123 volunteers participated in the data collection of whom 83 were males and 40 females, mainly staff and students from the

UniversitiSains Malaysia Their age ranges from 20 to 52 years. Four fingers were captured - left index, left middle, right index and right middle which led to obtaining of 492 classes. Six snapshots were made for each finger in one session and after more than two weeks period the capturing was repeated and thus 5904 images were gathered as a result, with 2952 images from each session Resolution is 640 x 480 pixels with 256 shades of gray per pixel.

3. Database Image Properties

In order to evaluate quantitatively the images from the databases described in Section 2 here the approach described in [14] is employed where the following parameters are found on average for each one:

$$\bar{I} = \frac{1}{P.M.N} \sum_{p=0}^{P-1} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} I(i, j) , \qquad (1)$$

where $\bar{I}$ is the average intensity of the images; P - their number in the current database; M and N - the dimensions of the images from it in number of pixels.

The intensity $I(i, j)$ for the current spatial position (i, j) where $i = \overline{0, M-1}$ and $j = \overline{0, N-1}$ is changing between 0 and 255, i.e. in 8 bpp scale representing single tone variability.

Secondly, the average Root-Mean-Square (RMS) contrast $\bar{C}$ for a whole database is found based on the definition

$$\bar{C} = \frac{1}{P} \sum_{p=0}^{P-1} \sqrt{\frac{1}{M.N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left[I(i, j) - \bar{I} \right]^2} . \qquad (2)$$

Lastly, the average image entropy $\bar{E}$, again for a whole database, is found using the following expression

$$\bar{E} = \frac{1}{P} \sum_{p=0}^{P-1} \left[- \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} h(I(i, j)) \log_2 (h(I(i, j))) \right], \qquad (3)$$

where h is the probability for particular intensity I to occur inside the image.

Sample images from the tested databases are given in Figure 1.

The results from calculating (1)-(3) for all 5 databases described above are given in Table 1. The average intensity for the SDUMLA-HMT and HKPUFID are the same as those estimated in [14] but the average contrast and entropy differ since the calculations are performed for the images as a whole here rather than using mosaicking windows.

First of all, an impression makes the significant difference for the mean intensity between FV-USM from below as minimum and HKPUFID as maximum more than 7 times. The other three databases are scattered in between at more than 2 and 4 times higher than the darkest set Obviously the intensity of the LEDs used and the sensitivity of the receiver influence considerably the quality of the images in general. Darker images not necessarily mean worse quality. As the average contrast shows no more than just 3 levels is the difference with the highest value for the SDUMLA-HMT in comparison to FV-USM and less with the others. From Figure 1.e it is visible that there are no surrounding flashes from diffuse scattered light around the finger contour for FV-USM and the contrast itself is decent as a subjective estimate. Not that is the case for the images from Figure 1.b, c, and d – considerable side illuminations are present which possibly could affect the recognition process further without additional pre-processing. Parts of the support equipment are also visible in the Figure 1.a, b and d which is desirable to be removed before further processing possibly at the stage of finger contour detection.

Similar is the case for the average image entropy (Table 1) – there is less than 2 levels deviation among evaluated databases – from 5.48 to 7.37. Nevertheless, of the presence of uneven background due to scattered light, sustaining elements or other

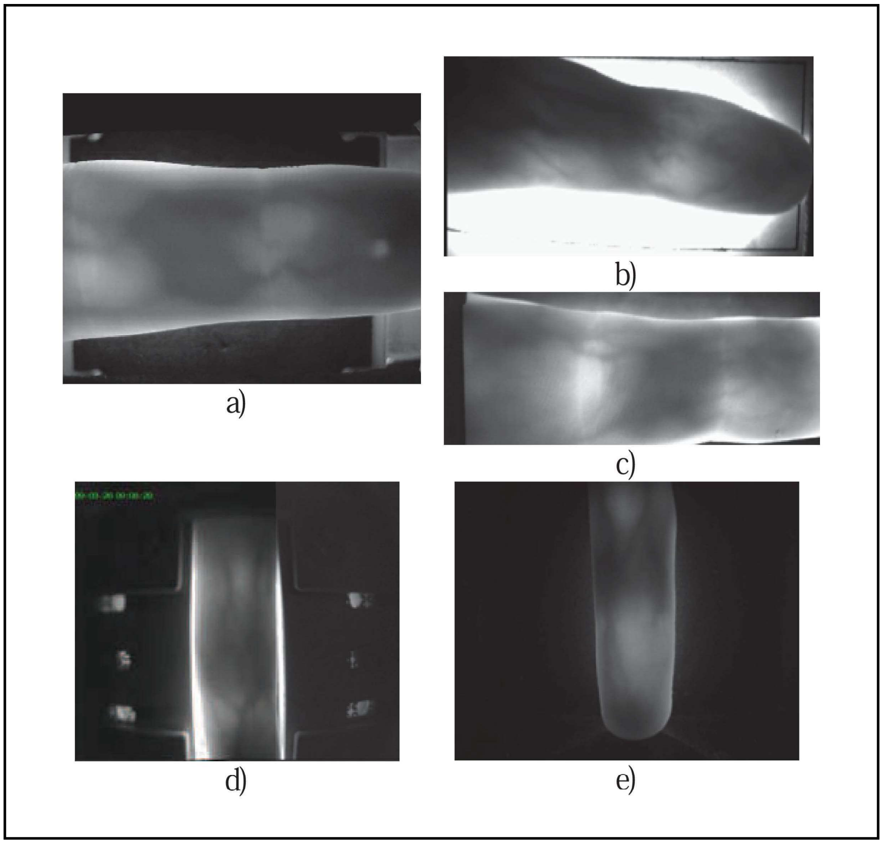

Figure 1. Sample finger vein images from: a) SDUMLA-HMT, b)

factors the homogeneity of the image structure is affected mostly by the blood vessels pattern and the smooth intensity change introduced by finger bones and tissue. It is a positive factor which indicates the possibility for higher recognition rates when combined with proper normalization procedures.

Parameter	**SDUMLAHMT**	**HKPUFID**	**VERA**	**THUFVFDT**	**FVUSM**
Average Intensity	55.51	191.33	119.51	53.49	26.78
Average Contrast	10.72	10.06	9.61	8.09	7.67
Average Entropy	6.85	6.22	7.37	5.66	5.48

Table 1. Evaluated finger vein databases parameters

Detailed examination of the structure of the finger region inside tested images and the surrounding area poses additional considerations about the quality of veins' structure (Figure 2). For the first two cases – excerpts from the SDUMLA-HMT (Figure 2.a) and HKPUFID (Fig. 2.b) there are significant portions of the finger area that possess almost even distribution of intensity for both darker and lighter areas. The presence of these isles as they could be called lead to smaller local contrast which in turn makes the veins' pattern less distinctive over the tissue surroundings. This effect is considerably suppressed if not absent at all for the VERA, THU-FVFDT and FV-USM databases (Figure 2.c, d and e). Although for the latter two the average entropy is smallest the intensity change around blood vessels has its repetitive nature underlying better their path. Various reasons may cause such differences among examined databases – from unsatisfactory set saturation levels (calibration) of sensitivity for the sensors accompanied by unwanted reflections from adjacent structures, through unsatisfactory initial image transformation, e.g. inappropriate intensity modification curve, or particular properties of the selected file format (mostly predetermined by the coder at use) for permanent storage as well as other factors. All of them should be carefully examined at the stage of design and implementation of the experimental setup for gathering the database and only as exception post-processing after the final files had been written would be recommended for further enhancement of image quality.

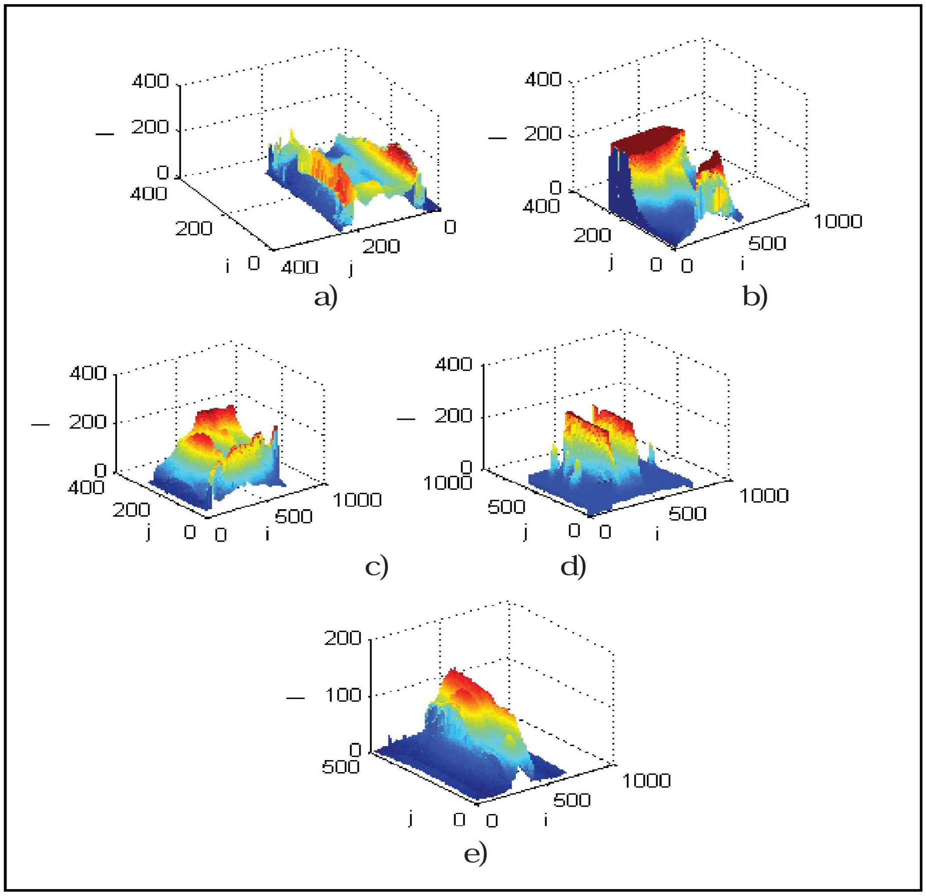

Figure 2. Intensity distributions of sample finger vein images from: a) SDUMLA-HMT, b) HKPUFID, c) VERA, d) THU-FVFDT, e) FVUSM databases

Image compression especially block-based owned such as the JPEG algorithm may additionally, increase the effect of lowering the local contrast around veins. Since image dimensions are relatively small – of about 100x200 pixels or so for the Region of Interest (RoI) where the vessels are located and because of their repetitive structure with smaller number of intersections and small overall contrast it would be recommended to use some other compressor preserving more naturally continous tones along separate directions such as the JPEG-2000 for example. Indexed-based formats, e.g. GIF, are also less perspective for such application. Ofcourse, the optimal solution disregarding content size is to store data in a raw stream or in a popular uncompressed format such as the BMP as in some of the databases described here.

Noises are other aspect of the quality assessment of the finger vein database images. They are related with the magnitude fluctuation of the near-infrared light flow used for capturing the image and the level of thermo generated currents inside the sensor. Due to the absence of raw data obtained with another type of illuminator and detector it is impossible to have quantitative estimation for their level and change over time with modifications of the experimental setup. Visually a partial evaluation could be done, e.g. from Figure 1 it is observed that with the lowering of the contrast (case d) and e)) the noise level is perceptibly higher (than that of the case for a) – c)). The selection of optical gathering system with appropriate filtering properties is another aspect to be considered when designing the complete finger vein sensor.

4. Conclusion

In this paper evaluation is presented for 5 popular finger vein databases. It is based on objective comparison considering the average brightness, contrast and entropy of the images from each database as well as on visual inspection of the vein patterns captured, present noise, distortions and other factors concerning the overall perception of the content closely related to the recognition accuracy when identification stage takes place later. There is no particular parameter on which one can rely for simple selection of one database over the other for higher degree of confidence at testing newly developed recognition techniques. Moreover, it is desirable to have images with implied imperfections such as higher noise level, distortions, diffused light, etc. in order to try unrepresentative capturing conditions which may be valid for some type of sensors from the practice. Useful directions for improving the capturing process are given in addition to the analysis of the factors leading to poor quality finger vein images which may be particularly effective for sensors design and their continuous exploitation.

Acknowledgement

This work was supported by the National Scientific Fund at the Ministry of Education and Science, Republic of Bulgaria, within the project DFNI I02/1 “Intelligent man-machine interface for assistive medical systems in improving the independent living of motor disabled users”.

References

[1] Yang, L., Yang, G., Yin, Y., Zhou, L. (2014). A survey of finger vein recognition, Chapter from Biometric Recognition, Z. Sun et al. (Eds.), *Lecture Notes in Computer Science Series*, Vol. 8833, Springer, Proceedings of the 9th Chinese Conference, CCBR 2014, Shenyang, China, 234-243, November 7-9.

[2] Gowsica1, G., Latha, L. (2014). A survey on biometric authentication techniques using finger vein, *International Journal of Science and Research (IJSR)*, 3 (11) 1227-1231, November.

[3] Jadhav, M., Ravale Nerkar, P. (2015). Survey on finger vein biometric authentication system, *International Journal of Computer Applications*, 3, 14-17.

[4] Vinothkumar, S., Sanmugasundaram, R., Divya, D., Padma Sarath, S. (2014). A survey of finger vein extraction techniques and its applications, *International Journal of Engineering Research & Technology (IJERT)*, 3 (2) 2160-2165, February.

[5] Use of finger vein authentication for population-based surveys in developing countries, Report, *Hitachi Review*, 62 (8) 456-462, 2013.

[6] Raghavendra, R., Avinash, M., Marcel, S., Busch, C. (2015). Finger vein liveness detection using motion magnification, *In*: Proceedings of the IEEE 7th International Conference on Biometrics Theory, *Applications and Systems (BTAS)*, 1-7.

[7] Sree, S., Radha, N. (2014). A survey on fusion techniques for multimodal biometric identification, *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)*, 2 (12) 7493-7497, December.

[8] Yin, Y., Liu, L., Sun, X. (2011). SDUMLA-HMT: A multimodal biometric database . The 6th Chinese Conference on Biometric Recognition (CCBR 2011), LNCS 7098, 260-268, Beijing, China.

[9] Kumar, A., Zhou, Y. (2012). Human identification using finger images, *IEEE Trans*. *Image Processing*, 21, 2228-2244, April.

[10] Tome, P., Vanoni, M., Marcel, S. (2014). On the vulnerability of finger vein recognition to spoofing, IEEE International Conference of the Biometrics Special Interest Group (BIOSIG), Darmstadt, Germany, September, 10-12, 1-10.

[11] Ton, B. Vascular pattern of the finger: biometric of the future? Sensor design, data collection and performance verification, Master’s thesis, University of Twente, July 2012.

[12] Yang, W., Yu, X., Liao, Q. (2009). Personal authentication using finger vein pattern and finger-dorsa texture fusion, *In*: Proceedings of the 17th ACM international conference on Multimedia, ACM, 905-908.

[13] Asaari, M., Suandi, S., Rosdi, B. (2014). Fusion of band limited phase only correlation and width centroid contour distance for finger based biometrics, Expert Systems with Applications, 41 (7) 3367-3382, ISSN 0957-4174. http://dx.doi.org/10.1016/ .eswa.2013.11.033, June 1st, 2014.

[14] Lu, Y., Xie, S. J., Yoon, S., Wang, Zh., Park, D. S. (2013). An available database for the research of finger vein recognition, In: Proceedings of the 6th International Congress on Image and Signal Processing (CISP 2013), Hangzhou, China,pp. 410-415, December 16-18.