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# Finger vein pattern extraction methods

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**Abstract**

In this paper the author presents techniques used for finger vein pattern extraction from raw biometric images. The proposition of a new image acquisition system is given. The main conclusion is the usability of image enhancement during acquisition process before taking the snapshot of a biometric probe. The proposed solution, compared to other techniques, improves the image quality and the overall effectiveness of the biometric system in the context of proper identification or verification.

**Keywords**: finger vein, pattern extraction, biometrics.

## Metody ekstrakcji układu naczyniowego

**Streszczenie**

W pracy przedstawiono metody wyodrębnienia wzorca układu naczyniowego palców dłoni z obrazów biometrycznych. Oprócz prezentacji najczęściej stosowanych metod przedstawiono prace autora w zakresie rozwoju nowego systemu akwizycji wzorców. W porównaniu do innych badań w tym zakresie skupiono się na zwiększeniu jakości obrazów poprzez lokalne dostrojenie jasności świecenia diod LED emitujących światło w zakresie widma bliskiej podczerwieni wykorzystywanych do oświetlenia palca w urządzeniu rejestrującym wzorce. Uzyskano obiecujące rezultaty polepszenia jakości obrazów głównie poprzez bardziej zróżnicowane uwidocznienie obszarów zajmowanych przez układ naczyniowy oraz pozostałe tkanki palca w porównaniu do innych metod. Obecnie trwają prace związane z ulepszeniem stworzonego prototypu urządzenia oraz prowadzone są konsultacje mające na celu określenie jego przydatność w diagnostyce medycznej.

**Słowa kluczowe**: układ naczyniowy, ekstrakcja cech, biometria.

## 1. Introduction

There is a growing interest in the person's biometric identification and verification and the usability of biometric authentication especially in relation to user access management.

A biometric system is an application which uses the techniques of image analysis and processing, pattern recognition and classification for the purpose of accurate authorization. The main topic of the author's considerations in this paper is to introduce methods of finger vein pattern extraction from biometric raw images.

In every biometric system it is necessary to determine the way of pattern extraction for the purpose of processing and achieving a goal which is the proper person's authorization to IT infrastructure systems.

Because veins are internal, visible light cannot discern them. For the purpose of finger vein acquisition in most cases described in the literature the NIR (Near Infrared Light) imaging is used. Different tissues and blood have different absorption coefficients for light wavelengths approximately from 700 nm to 1 000 nm. The light within the specified spectral window is almost completely absorbed by oxidized and deoxidized hemoglobin in veins and arteries. This fact causes the visibility of veins and arteries as darker areas (in comparison with other tissues) registered by a camera - without filters which block the infrared light - images. In Figure 1 the sample of NIR finger vein image is shown. The captured image was made in the grayscale. This type of imaging is characterized by relatively low contrasting. Low contrast of the image influences the computational complexity of proper classification to one of two classes of interest – object or background.

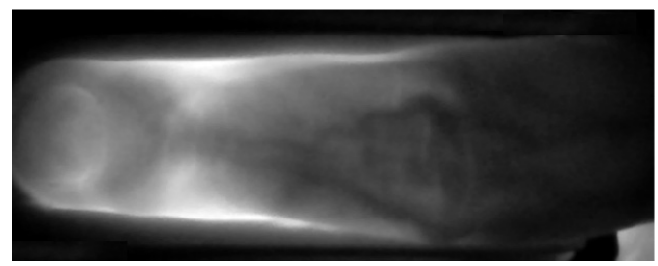

Fig. 1. Sample of NIR finger vein image
Rys. 1. Obraz palca wykonany w bliskiej podczerwieni

In the feature extraction process, if more vein local patterns are extracted, then a better recognition accuracy is obtained. A multitude of different finger vein pattern extraction techniques have been proposed over time. Some experiments on vein pattern extraction described in the literature are based on the curvelets, neural networks, adapted to pattern extraction binarization techniques, region growing methods, end points and crossing points matching techniques, directional-based methods just as dyadic wavelets to transform the image into wavelet coefficient domain.

In this paper selected by the author, commonly used, finger vein pattern extraction techniques are described and the proposition of acquisition device improvement which causes better results obtained by pattern extraction methods is presented.

The figures presented in this paper show the extraction results of the finger presented in Figure 1. Implementation where done by the author using Image Processing Toolbox in the MATLAB environment.

## 2. Finger vein pattern extraction techniques

In [1] the pattern extraction method based on position-gray-profile curves is described. The vein regions are extracted by analyzing the local minima locations for each line of the image.

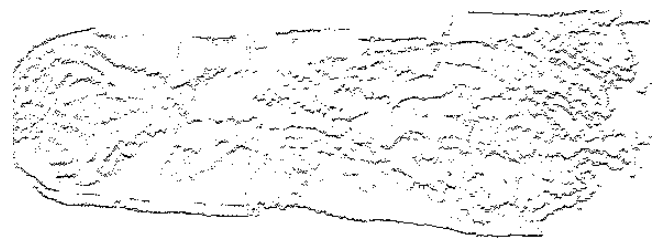

Fig. 2. Sample result of the position-gray-profile vein extraction method
Rys. 2. Rezultat działania metody position-gray-profile

The process of analyzing is repeated within six directions in order to accurately extract the vein points. After that in the end the vein locations of the resulting directions are combined. Figure 2 shows an example of the image obtained by the method [1].

The authors of the first patent of the finger vein image acquisition device – Naoto Miura, Akio Nagasaka and Takafumi

Miyatake [2] present an algorithm starting from randomly taken points that tracks the dark lines which occur in the image. Extraction of the patterns is based on the number of times the tracking lines pass through the points. The sample of the results obtained by the described method is shown in Figure 3. The main disadvantage of the line tracking method is time consumption and computational complexity. Using the parameter of tracking starting points proposed in [2] one obtains an extraction result after the time several times longer in comparison with other methods.

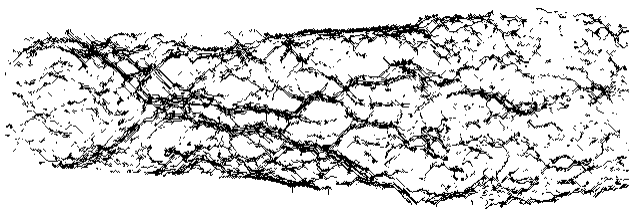

Fig. 3. Result of repeated line tracking method
Rys. 3. Rezultat działania metody powtórzonego śledzenia linii

In [3] there is a proposition of the author's method of finger vein pattern extraction from the image. The algorithm was worked out at the time of writing the M.Sc. thesis at the AGH University of Science and Technology in Cracow on image binarization and quantization techniques in 2011. The block diagram of the proposed method is presented in Figure 4. The algorithm is based on analyzing the image line by line.

The first step involves separating the area occupied by the finger from the input image. This is made by determining the gradient magnitude. After this operation, the gradient image is obtained and binarized using the static pre-specified threshold value. This value depends on the image quality. In the next stage morphological operations (dilate and erosion) are performed. This is done in the purpose of noise reduction without affecting the characteristics of the region of interest. In the process of separating the area occupied by the finger both original and gradient images are needed. The next stage consists in the position-gray-profile curve examination for each line of the image - computing of auxiliary functions for which the shift between their local minima corresponds to the area occupied by veins and arteries.

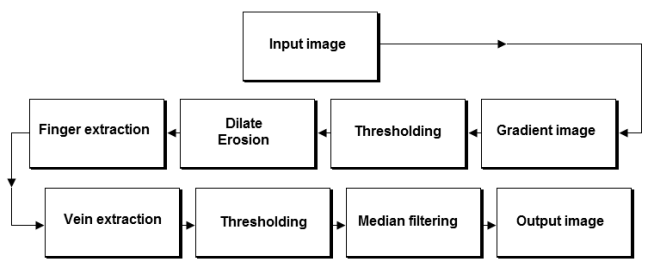


Fig. 4. Block diagram of the finger vein pattern extraction algorithm
Rys.4. Schemat blokowy algorytmu autora

The main task of the described functions is to determine the object area – thicknesses of veins - in a particular line. Those functions are also responsible for the value averaging of the position of gray profile curves in order to eliminate the cases where small differences of pixel intensities may generate ghost objects – vein locations where actually they do not exist. The example of the image obtained by this algorithm is shown in Figure 5. The main advantage of this algorithm compared to other techniques presented in the literature and also discussed in this paper are: better continuity of the extracted vein pattern, less noises resulting from the low contrast of images, less computational complexity and easiness of implementation.

Fig. 5. Result of the author's algorithm
Rys. 5. Rezultat działania metody autora

Very promising results could be achieved using standard local thresholding binarization techniques [4] (for example using Niblack thresholding). One of disadvantages of this approach during the acquisition process is the necessity of obtaining a better quality of the input raw images for processing.

## 3. Image quality improvement by auto-adjustment of LEDs intensities

Regardless of which method of the vein pattern extraction will be used, a very important issue is to acquire the best quality of raw biometric image data. In the case of finger vein biometric samples using NIR imaging this could be done using adoption of each NIR emitting light sources. Because human fingers are not uniform and in different parts have different thickness, adoption of light intensity emission is one of the matter which could and should be improved. The imaging of finger veins is done using lighting the finger near infrared emitting LEDs and from the other side image acquisition using a CCD matrix camera [5 – 10]. Various techniques of imaging are shown in Figure 6.

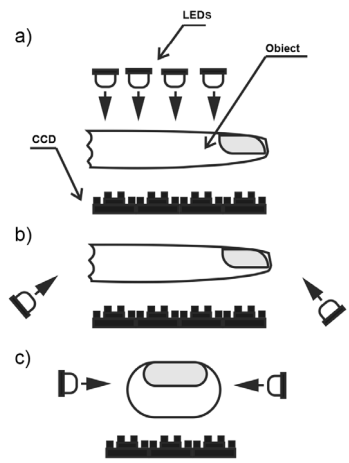


Fig. 6. Different set-ups of the vision system
Rys. 6. Różne sposoby usytuowania elementów oświetlających, kamery oraz obiektu

The light intensity control of each LED causes local improvement in the vein visibility which directly is reflected in the better quality of pattern extraction. Preliminary tests of the prepared prototype system showed the increased proper identification factor. As was stated before, the more information is contained in the raw image, the better effects could be achieved. Figure 6 shows an example of LED auto-adjustment achieved by the author using the prototype device.

Currently, the author performs further work related to the improvement of the created prototype device and will consult with experts about applications of this device to medical vein illness diagnostic such as the occurrence of collateral circulation after the heart attacks and neoplastic lesions.

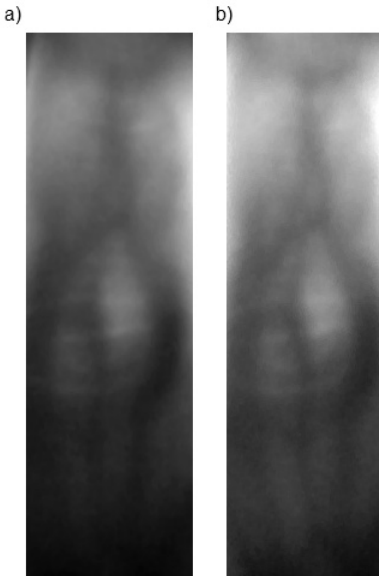


Fig. 6. Example of LED auto-adjustment a) before, b) after adjustment
Rys. 6. Przykład dostrojenia intensywności diod świecenia diod LED a) przed, b) po dostrojeniu

## 4. Conclusions

Independently of the used pattern extraction technique, the main disadvantage of this type of methods is the necessity of providing input raw images acquired with relatively high diversity between veins (object) and other tissues (background). The presented techniques despite their pros and cons cannot receive proper recognition without the use of different adjusting methods. Researchers around the world insist on post-processing methods. The proposed system faces this disadvantage. The preliminary tests showed the application potential of adjusting the raw image quality by manipulating the acquisition device parameters. In the future further research are planned in this domain.

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