Method for Finger Veins Detection

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Abstract. This paper describes a new method for finger veins detection. The method is split into four parts. The first of them consists of basic series of image filters enhancing the vein pattern itself and the other three are sequences of image filters determining the finger contour used for the background masking. The tests were done with a first prototype and their experimental results show a great potential of the proposed method.

1 Introduction

We have done a long time research in the area of fingerprint recognition. However, there was an interesting question, what is beneath the skin (i.e. under the structure of ridges and valleys). In the beginning we used an infrared illumination with a classical VGA (video graphics array) camera. The results were not good, nevertheless acceptable. Hereby we started the research in the field of finger veins recognition.

There are not many systems available for finger veins recognition or scanning in the market. We have done an extensive recherché in the Internet and have found that there is only a limited number of industrial solutions offered to this topic. One of the commercially provided solutions is offered by the company Hitachi [1]; they have a longer period experience in this area. Similar technology is being offered by some other companies, e.g. Sony [2], Bioaccez Controls [3], M2SYS [4] or FDS/AABACS [5].

2 Our solution

We designed the first prototype of a device intended for capturing of the finger veins patterns, their processing and recognition/verification. The device consists of an illumination unit with infrared diodes (recommended wavelengths are around 900 nm), a digital signal processor for video pre-processing, image enhancement and processing and adjustment of the diodes. Then, there is a microcontroller to control the peripherals and USB host connection. The last part of the device is a memory to store the enciphered templates. The housing of the prototype is made of aluminum whereas the final version will be made of plastic. The device is connected and powered via a USB port.

Camera in the first prototype of our sensor provides us a 640×480 pixels image. The image has to be cropped so that there is remaining only a small area (119×354 pixels) containing the image of the finger. This crop is only a basic and non-precise step with a big tolerance. A precise position of the finger is determined in a later stage of the image processing. We use this preliminary step to decrease memory requirements, because the process is intended to run in the sensor due to the security reasons.

The crop is an input image to a sequence of image filters (see Fig. 1). After application of the sequence of the filters there is a structure/skeleton of the finger veins remaining and the position of the finger is marked (left side, right side and top of the finger). The detected position of the finger is used for a more precise crop of the image and for masking of the background noise around the finger. Used filters and their parameters had to be very carefully chosen and put together, because even a small change in size of some of them could propagate itself through the sequence of the filters and could cause much bigger errors and, therefore, inapplicableness of the extracted skeleton.

First, we describe the sequence of filters used for veins detection. This sequence consists of five functional blocks - image filters. The first block enhances specific features of the image. It consists of a median filter (size of 5×5 pixels) and a common smooth filter (size of 3×3 pixels). Size of the individual filters was determined experimentally.

The second block performs a convolution. In this case, we use a special convolution kernel, which causes an effect similar to a side illumination of the finger (see Fig. 1b). This effect enhances relief of the finger veins.

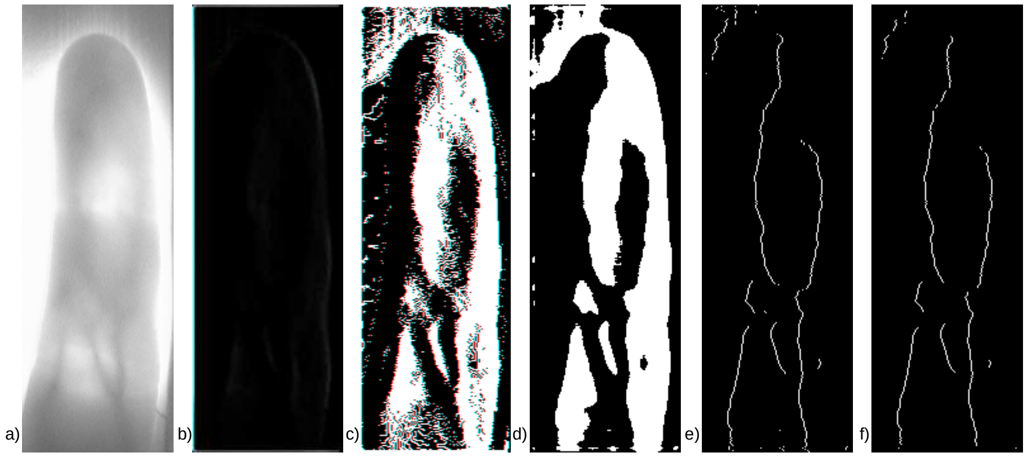


Figure 1. A sequence of processed images: a) original image, b) image after applying a convolution, c) threshold image, d) image enhanced by a median filter, e) extracted vein skeleton, f) filtered image by the "special median" without the noise pixels.

After disclosure of the relief of the veins, it is necessary to process the image again, which is purpose of the third block of filters. First, a binarization is performed with a threshold T=0 (so that values greater than 0 are converted to 255). Then, small inaccuracies are fixed by a median filter (size of 7×7 pixels).

The fourth block consists of a special skeletonization algorithm. The algorithm is simple but very efficient. It just goes through all image rows and looks for a special pattern (three black pixels followed by three white pixels). If this sequence of pixels is found, then a white pixel is written in an initially black output image. The result of this procedure is one pixel thin skeleton of finger veins.

Last block of the image filters consists of so called "special median" filter, which is a special filter with a kernel of size of 3×3 pixels removing all undesirable isolated points (the noise on the background) from the image.

To create a template it is important to locate the finger – hence, to determine its position. One important part of the finger useful for the localization of the finger is the top of it. Position of the top provides us all necessary information about the finger position and orientation since the finger is more or less fixed in a vertical position. The only one direction the finger could be shifting is the vertical one because different people have fingers of various lengths or they do not put the whole finger into the camera view, which can cause vertical shift of the finger.

The top of the finger is detected simply as the first occurrence of a horizontal line in the image, which is reached in the stage of the image preprocessing done in the basic process described before. Namely, it is the part of the image smoothing by median filtering with the kernel size of 5×5 pixels. The smooth with the kernel of size 3×3 pixels is the second filter that is applied afterwards.

The half of the Sobel edge detector is applied after the image preprocessing. The horizontal version of the Sobel kernel was chosen (see Fig. 2).

-1	-2	-1
0	0	0
1	2	1

Figure 2. Kernel used before the top detection.

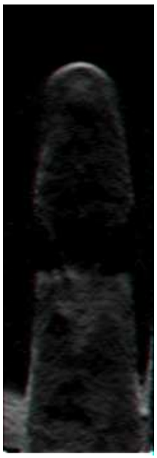
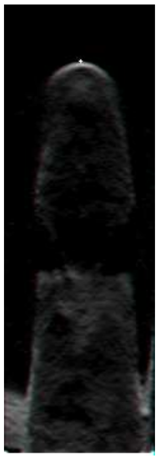
a)  b) 

Figure 3. a) The image after applying the filter (see Fig. 2); b) the image with the detected finger top.

The top of the finger can be then easily found as it is the first occurrence of the white pixels or sequence of white pixels in a row. In the current version we use the sequence of three points in one row that are brighter than the selected threshold. The example of the detected top of the finger is shown in Fig. 3b.

Additional information that can be included into the finger vein template is a contour of the finger. It can help to erase false detected veins in the image lying outside of the finger. The incorrectness is caused mainly by the lighting condition.

During the contour detection we are trying to use results of the previously used sequence of filters as much as possible in order to reduce the overall computational cost. Hence, we are trying to use already computed values. We are detecting the left and the right part of the contour separately beginning from the top of the finger.

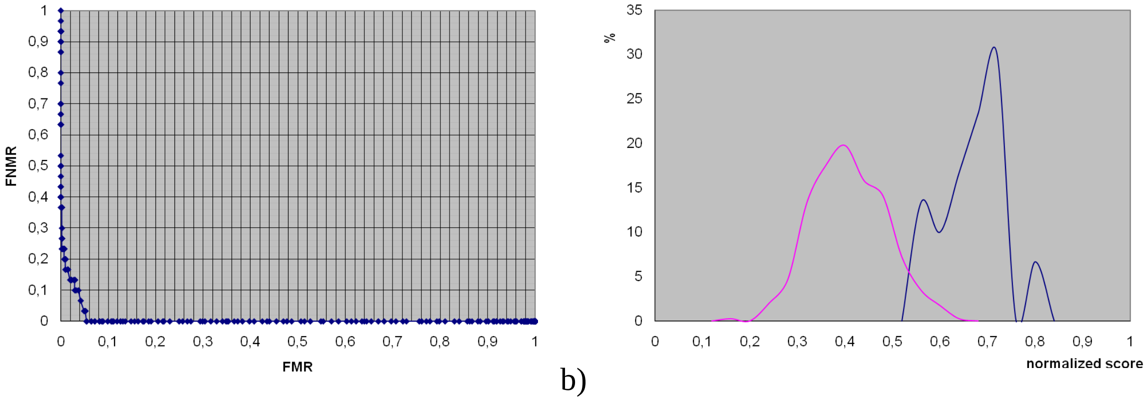
During the detection of the finger contour the errors arise due to the noise and the overall quality of the image. The errors are of a form of shifted pixels or group of pixels in a horizontal direction. If we assume that the most part of the detected contour is correct (in the all tested cases the bigger part of contour was detected correctly) and if we take into account that the contours are continuous, then we can relatively easily make the contour correction.

In the first stage, the longest continuous part of the left (right) contour part is determined. The parts smaller than a given number of pixels are marked as wrongly shifted and they are corrected accordingly.

3 Experiments

The described prototype was used for the preliminary tests. We had five volunteers at the disposal. The database contains ten different fingers; each was scanned three times.

You can see the resulting DET curve in Fig. 4a and the corresponding impostor/genuine curves in Fig. 4b, respectively. As you can see, the results are very promising even in the case of preliminary scans. The minor inaccuracies were caused by an imperfect illumination of the finger top. This problem has already been solved at the present time. We work on a new prototype at the moment which will be suitable for testing of a larger group of volunteers. The range of the tests we are planning to do is in order of hundreds of volunteers.



a) b)

Figure 4: a) Finger vein comparison – DET curve; b) Finger vein comparison – genuine and impostor curves.

4 Conclusion

We designed, implemented and tested a new method for the finger veins detection and recognition. The results of our experiments prove that the promised potential of the proposed method is big. In the future, we are planning to perform much more detailed tests with hundreds of volunteers. We proposed a method for quality setting and we will apply it to the database of templates in order to improve accuracy of the device.

We are also planning several enhancements of the described algorithms. The first of them is reduction of the template size in order to lower the computational cost and memory requirements. The next improvement is the speedup of database searching. The basic idea of this improvement is based on the division of the templates into few specific groups with similar vein structures. The last one refers to finger veins correction during and after the detection process.

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References

[1] Hitachi Finger Vein Authentication Technology [online]. 2009 [cit. 2009-07-25]. Available at <http://www.hitachi-america.us/products/business/smart_solutions/finger_vein/index.html>.

[2] Sony morfiria finger-vein biometric system [online]. 2009 [cit. 2009-07-25]. Available at <http://www.slashgear.com/sony-mofiria-finger-vein-biometric-system-announced-0232716/>.

[3] Bioaccez Controls Bio-Veinz finger vein reader [online]. 2009 [cit. 2009-07-25]. Available at <http://www.bioaccez.com/en/articles/22/3/biometrics-products/Page3.html>.

[4] M2SYS M2-FV finger vein reader [online]. 2009 [cit. 2009-07-25]. Available at <http://www.m2sys.com/finger-vein-reader.htm>.

[5] Aabacs finger vein authentication reader [online]. 2009 [cit. 2009-07-25]. Available at <http://aabacs.com/main/p_ai200.php>.