COMPUTER-AIDED ANALYSIS OF DERMATOGLYPHIC DATA IN DIABETIC PATIENTS

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Abstract: A computer program was developed for automatized collection of dermatoglyphic data. It uses an office flatbed A4 scanner for data input.
The procedure of fingerprint recognition included: 1) the segmentation of the scanned palm images to find the zones of interest (fingers' distal phalanges);
2) evaluation of the papillary lines assessment at the peripheral areas of the zones of interest; 3) classification of the papillary lines patterns in each of the zones of interest.
The accuracy of fingerprint pattern classification (arch, ulnar/radial loop, whorl) on the test group of 194 patients (106 diabetic and 88 non-diabetic) was 91%.
The comparison of the obtained data has revealed certain dermatoglyphic differences between diabetics and non-diabetics (e.g. higher prevalence of arches in diabetic women).

Introduction

The palmar dermatoglyphs (fingerprint patterns) are constant throughout the whole life and have significant likelihood in twins [1], while they demonstrate clear differences in different races or even nations, or between the sexes [1, 2]. It leads to the conclusion that dermatoglyphic presentations are genetically based, and therefore might be an easily assessed genetic marker for certain diseases with known or presumed genetic basis. One of the most demosrative examples is trisomy XXI, when the genetic defect leads to formation of the transveral crease on the palm [1], not seen in people with absence of such a gene defect.

A significant number of dermatoglyphic studies was conducted on the patients with diseases of non-chromosomal origin, but where genetic basis can play a certain role, e.g. diabetes mellitus [3-6].

For more than a century, fingerprint data were collected using ink and a sheet of paper. To obtain dermatoglyphic data, most of medical researchers had to follow the methods resembling the criminal police procedures. Despite of relative simplicity of the fingerprint collection method, the evaluation of the results was not simple at all.

Moreover, taking the fingerprints in the literal meaning of the word did cause certain negativism in the examined people, who did not see much difference between the procedure they underwent and the criminal police methods.

Active development of computer technologies during last 10-20 years has simplified the collection of fingerprints data significantly [7]. Nevertheless, few dermatoglyphic data evaluation systems used the full range of modern computer technologies, as the attention of the specialists was focused rather on the problems of identification of a person, not on the problems of fingerprint pattern classification, which are essential for dermatoglyphic data assessment in medicine.

The aim of our work was to fill the above-mentioned gap, creating a computer system enabling convenient collection and analysis of dermatoglyphic data, with intention to use the system for dermatoglyphic patterns assessment in diabetic patients.

Materials and Methods

Totally, 106 diabetic patients were examined (50 female and 56 male patients with type II diabetes), as well as 33 women and 50 men without diabetes.

For each person three digital images were obtained using flat-bed A4 scanner Mustek BearPaw 2448TA Pro: two images for left and right palms respectively, and the third separate image for both thumbs, as it is rather hard to get thumbs picture at the general scanned image of a palm. The resolution was 300 dpi, the images were saved as Windows bitmap files (BMP).

A computer program for fingerprint recognition was created using Object Pascal (Delphi 6.0 Professional).

The following tasks had to be fulfilled, to create a computer program able to evaluate the fingerprints patterns autumatically:

1) The segmentation of the scanned palm images to find the zones of interest (fingers' distal phalanges)
2) Classification of the papillary lines patterns in the zones of interest
3) Testing the program on the real scanned images of the diabetic patients and healthy people.

Segmentation. As the human palm is an object with rather specific geometrical and optical features (brightness, colour, and surface texture), its segmentation on digital images may hardly pose any significant hardships. The procedure might be even simplified if some limitations are made for the palm

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positioning on the scanner (e.g., if the hand should always be placed in parallel with the longest side of the scanner window).

Nevertheless, multiple variants of the palm and fingers positions were possible (see Figure 1).

Three different methods of segmentation, or differentiation of the palm surface from the background were tested: a) basing on brightness assessment; b) basing on colour assessment; c) basing on texture heterogeneity.

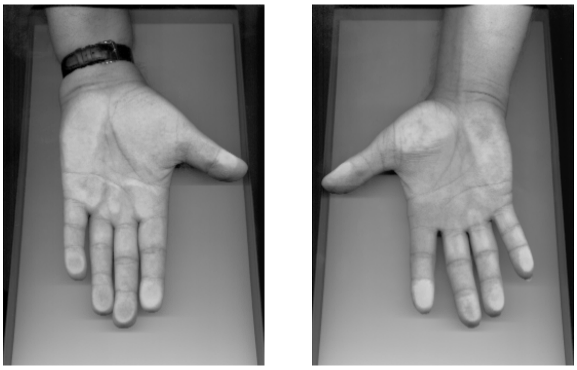

Figure 1: Some variants of palm position on scanned images

Though two first methods were extremely easy to implement, they worked well only if the background was black (see Figure 2).

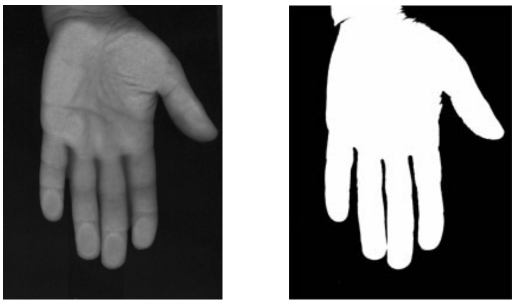

Figure 2: An example of brightness-based segmentation

In case of white background brightness-based or colour-based segmentation was far less effective (see Figure 3).

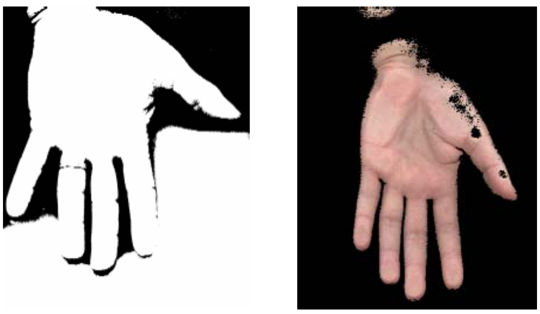

Figure 3: Improper brightness-based (left) and colour-based (right) segmentation

The method based on the assessment of texture heterogeneity turned out to be the most effective; it allowed accurate segmentation in 95% cases. The evaluation of image heterogeneity was made using comparison of the relative brightness of each of the pixel with the brightness of 8 surrounding pixels.

Hand geometry assessment. Using the texture heterogeneity evaluation procedure, palm and fingers areas can easily be found on the scanned image. To find out which area represents what finger, a number of procedures was elaborated:

1) The III finger's position is determined (the longest finger).
2) Left and right borders of finger III are determined.
3) The whole area of III finger's distal phalanx is determined.
4) From both sides of finger III fingers II and IV are determined.
5) Fingers I and V are determined, as Finger I (thumb) has its specific geometry, it is easy to distinguish it clearly from the finger V and, therefore, made a conclusion if it is a right hand or a left hand on the analysed image.

Finally, the areas corresponding to all 4 distal phalanx are determined for fingers II-V (Figure 4).

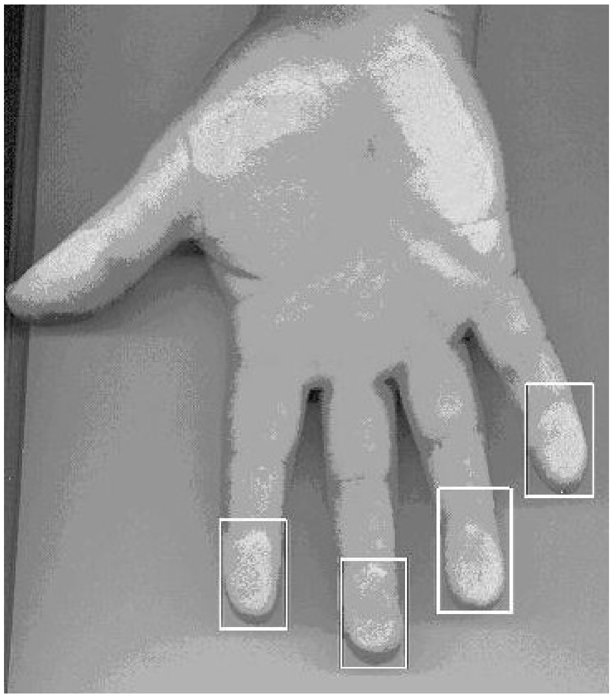

Figure 4: The result of the segmentation procedures

The images of thumbs still have to be scanned separately, as its position does not allow obtaining their proper images with flatbed scanner.

Classification of the dermatoglyphic patterns. The main dermatoglyphic patterns (arch, radial/ulnar loops, whorles – see Figure 5) can be distinguished using a great variety of "standard" procedures [7].

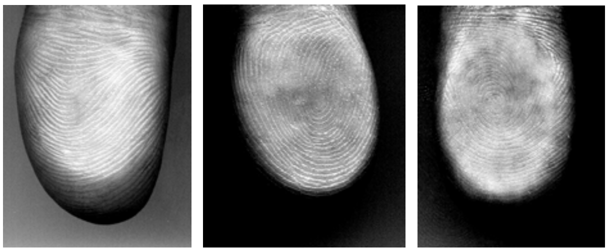

Figure 5: Main fingerprint patterns (left to right) – arch, loop, whorl

We have chosen evaluation of the papillary lines orientation [7], which, according to our estimation, led to accurate evaluation of line directions in 194 cases of 200 tests (97%). The example of lines direction assessment is demonstrated at Figure 6.

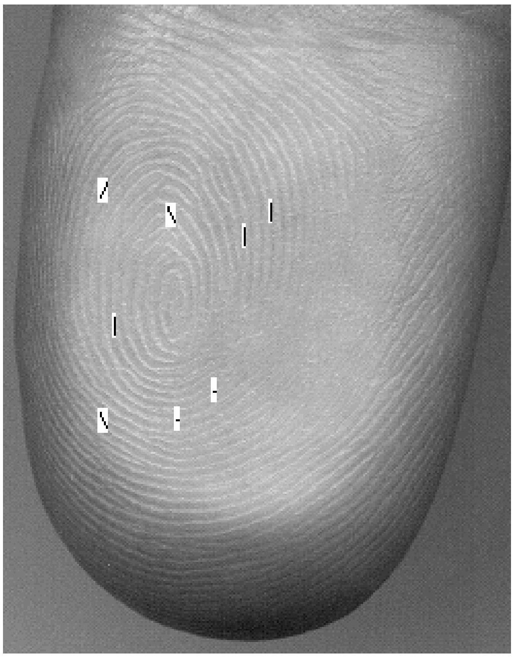

Figure 6: Example of the lines direction assessment at randomly selected points of the scanned image

To classify the images, we have elaborated a modification of known method, based on line directions evaluation exclusively at peripheral areas of phalanx images (15% of total phalanx width or length from each side). It simplifies calculations and provides to some extent better input data, as the central part of the phalanx can be strongly pressed to the scanner's glass and, therefore, the lines might not be well recognized. It is obvious that even the peripheral parts of the phalanx image carry enough information to recognize the pattern (see examples of typical line directions for arch and whorl at Figure 7).

The Euclidean distance had to be calculated in 200-dimensional space, where each dimension represented a papillary lines direction at a separate point of the phalanx peripheral area.

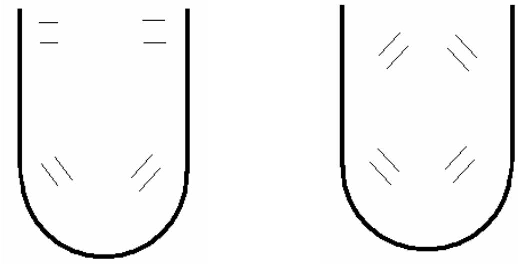

Figure 7: Examples of typical line directions for arch and whorl

To provide proper "standards" for each pattern (arch, left and right loop, whorl) we used 50 images selected as arch, loop, whorl by the experts. The recognition procedure was performed using comparison (by calculation of Euclidean distance) a given image with 4 patterns, the smaller distance was, the more likelihood with a specific pattern the sample image presented.

Results

The computer program evaluation. When tested on real scanned images, the program has demonstrated that 1412 of total 1552 finger images (eight images for each of 194 persons) were recognized accurately (91%). Most of the found recognition problems were connected with oblique hand position and with 2 cases of amputated distal phalanges.

Comparison between diabetics and non-diabetics. It was found that the diabetic women had higher prevalence of arches at their left palms (0.45 vs 0.25 in non-diabetic women, $p<0.05$). Diabetic men demonstrated differences the patterns of left II finger (higher arch rate and lower ulnar loop rate, 0.19 and 0.25 vs 0.07 and 0.44 in non-diabetics respectively, $p<0.05$ in both cases).

Discussion

The created computer program has demonstrated that it can be used for rather easy collection of dermatoglyphic data using a computer and an affordable flatbed scanner. Some limitations, such as failure to recognize the fingers if one of them is amputated, were predictable and could be avoided in the future, e.g. by using special devices, to prevent oblique hand position.

The most challenging problem could be to achieve the adequate thumb surfaces scanning. Probably, in certain cases the researchers might not be interested with thumbs fingerprint patterns, otherwise an additional device should be created which might enable easier collection of the thumbs data.

The collected fingerprints data revealed slight but differences between dermatoglyphic patterns in diabetics and non-diabetics. The obtained data were different from what was found in other countries [3-6], which might reflect known national specificity of dermatoglyphs. Further investigations in this field (probably including other types of dermatoglyphic data) might lead to better understanding if there could be a possibility to use dermatoglyphs as a genetic marker of diabetes mellitus.

Conclusions

The developed computer program for automatized palmar fingerprint recognition has demonstrated its ability to recognize the fingerprint patterns rather effectively (91% accuracy).

Still, few differences were found in dermatoglyphic patterns of diabetics and non-diabetics.

Further investigation on a larger group of people is suggested, to make a decision on possibility to use certain fingerprint data as a marker of diabetes.

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