HAND GEOMETRY FEATURE EXTRACTION THROUGH CURVATURE PROFILE ANALYSIS

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ABSTRACT

In this work a complete access control system based on a biometric code formed by invariant geometric features extracted from the hand's image, a hardware key and a vital sign detector. The feature extraction process is based on the analysis of the curvature profile of the image, making the system invariant to the rotation and translation of the hand. This makes unnecessary the use of any kind of restriction devices such as pins or pegs to position the hand. FAR rates as low as 0.8% was obtained by the use of simple weighted geometric features on a database of more than 360 hand images.

Introduction

Differently from most of other biometric systems, this work provides a new approach to the way hand geometry features are extracted. Data is read and processed independently of the position of the user hand. This is done by analyzing the curvature profile of the hand contour and segmenting the fingers according to the sequence of curvature maxima obtained, turning the feature extraction process into a rotation and translation invariant system.

The main goal in this project was to be able to acquire the images free from any restriction by allowing the user to put his hand in virtually any position inside the scanning area of the input device. The biometric system is completed by two other hardware modules: A hardware key reader, used to identify the user, and a heartbeat detector, used to avoid fakes during the data input. In this article we focus on the segmentation and feature extraction processes involved.

Image Segmentation

After the acquisition of the image, done through a common desktop scanner, the contour of the hand is obtained. For this a binarization process takes place by the use of a thresholding method responsible for choosing which pixel belongs to the background and to the hand [1] and a neighborhood frequency analysis is done in order to extract the border of the hand.

To ensure a uniform border part of the wrist area is automatically cut off and is substituted for a curve with constant curvature in order not to influence the techniques used for biometric features extraction. The result is a one-pixel-wide closed contour of the hand image.

The curvature profile of the contour is then estimated by the use of the DOS (difference of Slopes) technique [3] which is a method that consists basically in roaming the hand contour with two vectors of the same size ω, calculating the angle formed by these two vectors. The difference between the angles represents the curvature profile. Further processing needs to be done in order to equalize the results obtained by DOS [3]. Figure 1 shows the original acquired image and the resulting segmented contour with its extremity points identified. The fingertips and the base of the fingers are located within these points.

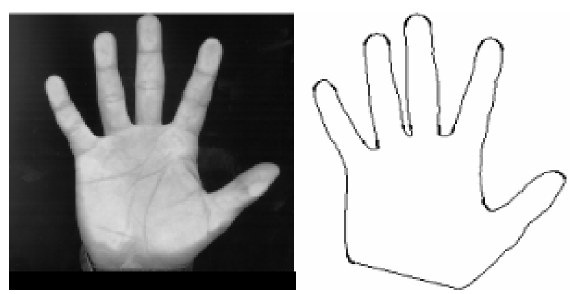

Figure 1 – Contour with the high curvature points marked

In order to individualize the fingertips, a Gaussian filter with a kernel of *2 x ω* and a common average filter were applied to the curvature profile. This smoothes the profile generating single curvature peaks that correspond either to the tip of the fingers or to the base of each finger.

Feature Extraction

Each point obtained represents the central point of the corresponding high curvature area. To find the length of each finger an imaginary triangle is drawn among tree consecutive points.

The main line of the triangle is then sampled into twenty equal size parts a perpendicular line is drawn from the main line of the triangle to the edge of the finger. The average of all the perpendicular lines will result in the finger width. At this point we have five measures of width and five measures of length for each hand. In order to create a biocode for each user, we need to somehow extract a subset of information valuable enough to assure the individualization of the user on the system.

Based on the data samples collected for each user the between-class and within-class variation of length and width of each user's fingers were measured in order to find an equation able to account for such variations. We have found two single weighted measures representing the average length and width of the fingers in one hand image and used them as the individual biocode for this user. The best results were obtained by completely eliminating the thumb influence since the measurements obtained presented a great deal of variation and were consequently unreliable.

Classification

A simple Euclidean distance classifier was used. We have stipulated that for a candidate to be accepted it should have the calculated biocode – represented by the average fingers width and lengths for each hand – within a region that comprised two times the standard deviation of the features obtained from the training user's samples.

In order to calculate the standard biometric code for a given person we have used three out of four different hand images. The image having the most distant biocode value from the average was discarded and the average was then recalculated.

Results

Right hand images of 80 people (male and female - 17 to 38 years old), were acquired with a simple flatbed scanner. At least four readings of each hand were done. The voluntaries were asked to change the position of their hand and the degree they opened their fingers between each reading in order to generate completely different images. Next, the feature extraction and standard biocode calculation was done as described before.

Figure 2 show several sample images processed by the proposed algorithm. They show clearly the flexibility of the method in relation to the rotation and translation of the hands.

The false rejection rate (FRR) was determined based on the average rejection rate for each one of the users considering all the authentic images available for that user. The false acceptance rate (FAR) was determined by averaging the results obtained by fixing a user and using all the other user's images for testing. A false acceptance rate of only 0.8% and a false rejection rate of 3.8% were obtained with the proposed method.

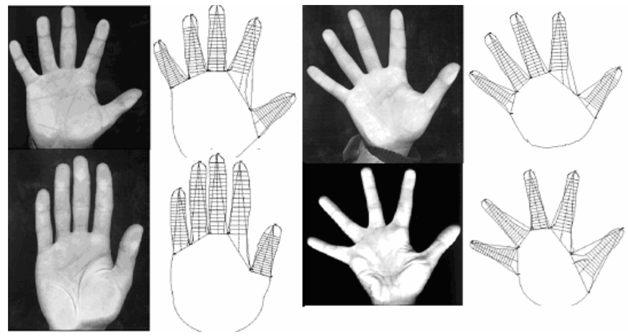

Figure 2 – Several images with its processed counterparts

Conclusion

In this work we developed a new approach to hand geometry feature extraction by using curvature profile analysis. In this way we could extract features without imposing any restriction during the acquisition process.

The algorithm makes it possible to identify and process the hand placed in any position within the reading area of the input device.

The results were impressive since we got an FAR of 0.8% and a FRR of 3.8%, meaning that less than one person out of 100 was wrongly accepted by the system.

This project is part of a control access system that uses a hardware key for the user's identification and confirms the readings from the scanner against a vital sign detector.

The system is currently being improved by the addition of the analysis of the palm print.

Reference

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