Fingerprint Recognition *

Alfredo C. López, Ricardo R. López, Reinaldo Cruz Queeman
Advisor: Ph.D. Roman López
Electrical Engineering Department - Polytechnic University

ABSTRACT

A fast fingerprint authentication method is proposed, based on the core and minutiae detection of the fingerprint. The relationship between authentication reliability and region size is studied experimentally. A bank of Gabor filters, orientated to different angles are applied to the image to clean it from noises that can result on false alarms or authentication mistakes. Our approach will be the extraction of the core using the flow field and determining the angle that each vector of the flow field has with respect to the horizontal. A function that reduce the image to an specific size and increments one by one will be perform to investigate which type of orientation (e.g., arch, right loop, left loop, and whorl) the fingerprint has, to help us determine the core. From the core, vectors will be trace to the minutiae for the purpose of image alignment and fingerprint matching.

***Index Terms*—**Fingerprint matching, vector field, reference point, embedded system.

I. INTRODUCTION

Biometric recognition refers to the use of distinctive *physiological* (e.g., fingerprints, face, retina, iris) and behavioral (e.g., gait, signature) characteristics, called biometric identifiers (or simply biometrics) for automatically recognizing individuals.

The objectives of biometric recognition are user convenience (e.g., money withdrawal without ATM card or PIN), better security (e.g., difficult to forge access), and higher efficiency (e.g., lower overhead for computer password maintenance). The tremendous success of fingerprint based recognition technology in law enforcement applications, decreasing cost of fingerprint sensing devices, increasing availability of inexpensive computing power, and growing identity fraud/theft have all ushered in an era of fingerprint-based person recognition applications in commercial, civilian, and financial domains.

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Among the many current biometric technologies, fingerprint verification is the oldest and most popular method widely used in different commercial and security application. Unfortunately, fingerprint verification is a time consuming process as a lot of trigonometric computation is required. To accelerate the process, we pursue the solution using smaller fingerprint images region to extract the minutiae. The relationship between the number of matching minutiae and the verification accuracy in order to find relatively small sub-regions of the captured images for use in the matching process is deeply investigated. Obviously, there have to be a priori knowledge of the complete fingerprint image obtained during the enrollment procedure, whether it fit four of the main fingerprint classes (e.g., arch, right loop, left loop, and whorl).

For the realization of our fingerprint authentication algorithm, we use the latest TI DSP C6000 series and SDK (Software Development Kit).

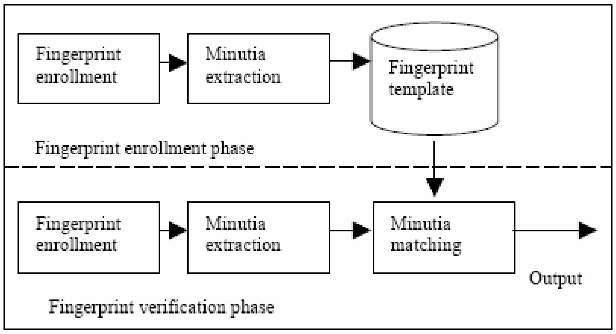
II. FINGERPRINT MATCHING

A. External Procedure

The first phase of the fingerprint verification process is the fingerprint enrollment phase. Is very important to know the size and quality of the image that the fingerprint sensor in use takes, so we can have an idea on how we are going to preprocess it. From this image, minutiae are extracted and stored in a data base. This process repeats, resulting in the generation of a ‘live template’.

The measurement of our success is going to include some steps to achieve our goal:

- Several images are going to be taken of the same fingerprint to cover various aspects of the image. (Position, dryness, humidity, dust, brightness, darkness, etc.)
- There is going to be a limited number of person’s fingerprints in a database to be recognized; if a person enters its finger and its fingerprint is not in the database, it has to be rejected.
- A threshold is going to be set for the acceptance or rejection of a specific fingerprint.



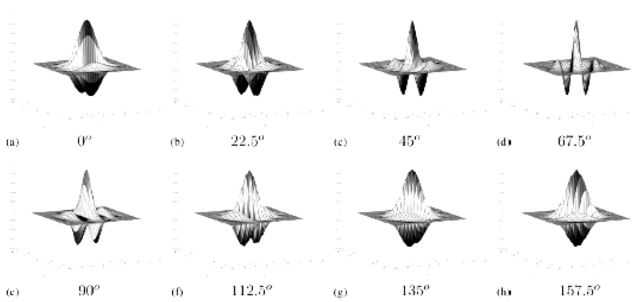
B. *Image Enhancement*

The performance of minutiae extraction algorithms and other fingerprint recognition techniques relies heavily on the quality of the input fingerprint images. Hong, Wan, and Jain proposed an effective method based on Gabor filters. Gabor filters have both frequency-selective and orientation-selective properties and have optimal joint resolution in both spatial and frequency domains and Jain and Farrokhnia. Gabor filters is defined by a sinusoidal plane wave. The even symmetric two-dimensional Gabor filter has the following form:

$$G(x, y; f, \theta) = exp\left\{\frac{-1}{2}\left[\frac{x'^2}{\delta_x^2} + \frac{y'^2}{\delta_y^2}\right]\right\} cos(2\pi f x'),$$

$$x' = xsin\theta + ycos\theta,$$

$$y' = xcos\theta - ysin\theta,$$



To apply Gabor filters to an image, the four parameters (?, f, sigma(x), sigma(y)) must be specified. Obviously, the frequency of the filter is completely determined by the local ridge frequency and the orientation is determined by the local ridge orientation. The selection of the values sigma(x), and sigma(y) involves a tradeoff. [8]

C. *Fingerprint matching overview*

The idea in this paper is to shorten minutiae extraction process in the verification of phase using a small sub-region of the live image. The minutiae extracted from the sub-region must be 'trustable enough' to authenticate a person accurately. In the past, a family of vectors were traced between a minutia and the minutiae found, but this process imply more computational time and the risk that the magnitudes of those vectors in a fingerprint with few minutia repeats in a fingerprint with more minutiae, and the process of verification would be affected.

Thinning Bifurcations Extraction

III. VECTOR-FIELD COMPUTATION

A. *Orientation Estimation*

"Identity authentication Using Fingerprints"

An orientation field/image represents the local ridge orientation at pixel.

1. Divide input fingerprint image into block size WxW
2. Computer gradients Gx and Gy at each pixel in each Block
3. Estimate the local orientation at each pixel (i,j)

$$V_x(i, j) = \sum_{u=i-W/2}^{i+W/2} \sum_{v=j-W/2}^{j+W/2} 2G_x(u,v)G_y(u,v)$$

$$V_y(i, j) = \sum_{u=i-W/2}^{i+W/2} \sum_{v=j-W/2}^{j+W/2} (G_x^2(u,v) - G_y^2(u,v))$$

$$q(i, j) = \frac{1}{2}\tan^{-1}\left(\frac{V_x(i, j)}{V_y(i, j)}\right)$$

4. Compute the consistency level C(i,j) of the orientation field in the local neighborhood of a block (i,j)

$$C(i, j) = \frac{1}{N}\sqrt{\sum_{(i',j')\in D} |q(i', j') - q(i, j)|^2}$$

$| J' - q | =\{$ d if(d=?')

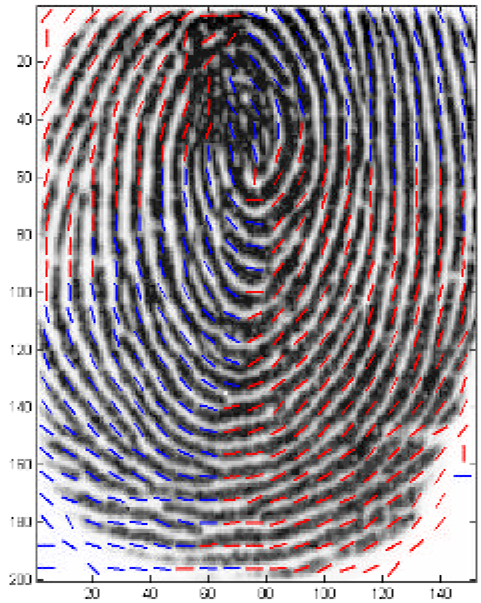
(?+360)mod360)<180

d-180 otherwise }

D – local neighborhood around the block(i,j)

N- the number of blocks within D; ?(i`,j`) and ?(i,j)

5. If the C(i,j) is above a predetermined level then the local orientations around this region are re-estimated at a lower resolution level, until it is below.[1]



IV. Core Detection or Reference Point Extraction

Most of the approaches proposed in the literature for singularity detection operate on the fingerprint orientation image. The most commonly used reference point is the core point. A core point is defined as the point at which maximum direction change is detected in the orientation field of a fingerprint image or the point at which the directional field becomes discontinuous. An elegant and practical method for the core point extraction is based on the Poincaré index. Such method is very sensitive to noise and cannot guarantee the detection of a core in type of fingerprints like the arch, that lack a discontinuous of its directional field. The method we are going to use is based on the computation of the orientation field described before, and the application of a filter to detect the maximum direction change of the ridge flow. This approach can even locate an imaginary reference point in an arch type fingerprint image. [12]

The algorithm steps are as follow:

- Divide a fingerprint image, I, of NxN pixels into (N/w) x (N/w), where w is the grid size. Apply to the image the orientation field algorithm explained before, to obtain the matrix of angles A'.
- Compute the sin component ?(i , j) = sin(A'(i , j))

The sin component possesses an attractive characteristic that it reflects the local ridge direction. A perfectly horizontal ridge has a sin component = 0. On the other hand, the ridge's sin component = 1 if it orientates vertically. Due to the discontinuity property, the sin component value always changes abruptly in areas near a reference point. Because of such finding, the following procedure is added.

- Initialize a 2D array Bi and set all its entries to 0.
- Scan the sin component map in a top-to-bottom, left-to-right manner. For each sin component ?(i,j),

if $A'(i,j) < A_{threshold}$ and $A'(i-1,j) > p/2$ and $A'(i+1,j) > p/2$ then

i) Compute the difference D.

ii) Compute the Bi(i,j)

End

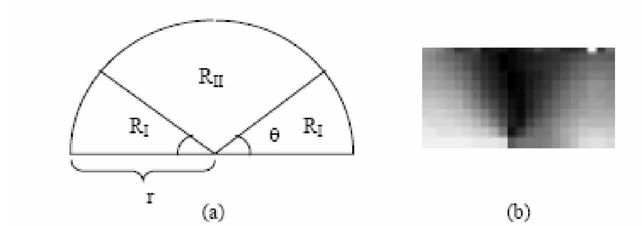
The difference D of the sin component in the region R1 and R2 is defined by a circular mask.

$$D = ?_{R1}\, ?(i,j) - ?_{R2}\, ?(i,j)$$

The Bi[i][j] entry is used to compute the continuity of a possible reference point candidate and is defined as:

$$Bi(i,j) = 1 \; ; \quad \text{if } i == 1$$

$$Bi(i,j) = Bi(i-1,j-1) + Bi(i-1,j) + Bi(i-1,j+1) \; ; \quad \text{otherwise}$$



V. Conclusion

In this paper, a novel fingerprint representation technique that uses minutiae extraction and core detection has been presented. Experiments indicate that the computation of the orientation field performs much better than a purely minutiae-based matching scheme. Currently, core information is being used to align the image and then trace vectors to the bifurcations; the magnitude of the vectors are use also as characteristics from the image along with the extracted minutiae. The following areas of improvement are also being studied:

(1) New matching methods for comparing the ridge feature maps of two images of the same fingerprint.

(2) Constructing the ridge feature maps, using adaptive methods for optimal selection of the Gabor filters.

(3) State of the art applications of the fingerprint matching algorithm

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Alfredo C. Lopez – Undergraduate Electrical Engineering student, with minor on Communications and Control Systems.

Ricardo R. Lopez - Undergraduate Electrical Engineering student, with minor on Communication and Control Systems.

Reynaldo Cruz **-** Undergraduate Electrical Engineering student, with minor on Computer Systems.