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Research Paper

Fingerprint pattern recognition from bifurcations: An alternative approach

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Abstract

A pc-based automatic system for fingerprints recording and classification is described, based on the vector analysis of bifurcations. The system consists of a six-step process: a) acquisition, b) preprocessing, c) fragmentation, d) representation, e) description, and f) recognition. Details of each stage, along with actual examples of fingerprints recognition are provided.

Keywords: *Fingerprints; Dactiloscopy; Pattern Recognition; Pc-Based Software; Segmentation.*

1. Introduction

It is well known, that fingerprints recognition and classification allow the unique identification of a person, since his/her fingerprint presents natural patterns in an almost infinite variety of combinations. Even in the case of highly similar fingerprints, these combinations are so unique as to prevent two exactly identical fingerprints as it indicated in different biography as solved elsewhere [1], [2], [3], [4], [5], [6]. The practical applications of fingerprints recognition and characterization ranges from public or private safety, to forensic medicine, legal matters, among other applications, a review of it with a statistical analysis was done by Abraham et al. as solved [5]. In fact, the recognition and classification of fingerprints, either from their minutae or their mutual mathematical correlation, represents a very active area of R&D nowadays and a number of methodologies have been proposed, including hybrid matchers, e.g., as solved by Ross et al. as solved [7] and wavelet transforms, e.g., as solved by Nanni et al. as solved [8]. From the Forensic Science point of view, there exist two main methods for fingerprints identification, based on a standard, and somewhat arbitrary, classification. Indeed, whereas in South America and parts of Europe the Vucetich method is employed, in United States and England the Henry classification scheme is employed.
From the pattern recognition technology standpoint as solved elsewhere [9], [10], either classification is made by surveying the fingerprint, thus assigning a denomination, according to the particular scheme utilized, that will identify the given finger. In this way, by using the ten fingers of the hand, one will have a combination that will identify uniquely a person. It can happen, however, that the combination is repeated and therefore a sub-classification must be devised. This is based on the topological characteristic of the patterns of the fingerprints, such as branching, merging, islands, etc. Nevertheless, this process requires the meticulous examination of experts in dactiloscopy, which turns the classification of fingerprints into a cumbersome and slow process that relies on the skill, mood and honesty of the expert making the identification.

2. Objectives

Accordingly, this work is aimed to describing a pc-based automatic system for digitizing and analyzing fingerprints, by extracting the topologically-essential points that allow to distinguish one fingerprint from another, based on a simple vector análisis of the bifurcations in the fingerprints. These peculiarities within the fingerprint are known as characteristic points, and can be classified into interruptions in the combs, abrupt end, ramifications and fusions. The characteristic points and their relative position are of key importance for the effective the comparison of two fingerprints, and though each fingerprint contains about 100 characteristic points, it is usually enough to analyze a dozen to positively identify a standard.

3. Methods

Fingerprint analysis are usually performed methods using laboratories. However, a case here exists. In the event, that there is to collect information less than 10% of the fingerprint, the process requires a rebuilding process for identification, such as to reduce backlogs, but as a result of this information also, provides a variety of information and verify results, which harms directly results or handle high-profile cases. The following section provides a method of fingerprint identification using at least 10% of the dactilar footprint for reconstruction and is based on a Euclidean distance with its closest neighbors is presented.

3.1. Block diagram of the system

The whole system consists of six stages, schematically shown in the diagram of Figure 1. As can be observed there, the system itself is extremely simple and modular, allowing to update and improve the different stages quite easily.

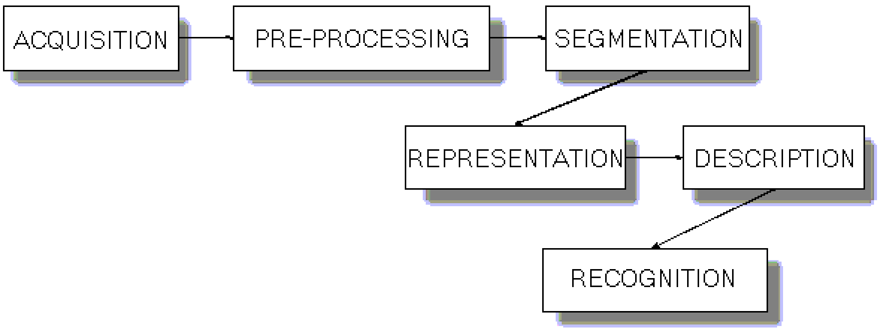

Fig. 1: Stages of the System for Fingerprints Recognition

4. Results

For the description process, a tracking of the fingerprint around the point's interest is performed, analyzing each pixel in relation with two or more of its neighbors. Depending on its vicinity, each pixel belongs to one of the three following cases:

1) The basic type of forking.
2) A step line.
3) A square line.

The first case is so due to the fact, that a forking requires at least of two pixels to represent two ramifications. The second and third case tell us that, the fact of having two pixels do not ensure that a forking will be found, since there exist lines that cannot be made sharper, digitally speaking, without facing the risk of losing connection. Figure 2 shows schematically the three above cases.

To distinguish among these three cases, their corresponding neighbors must be carefully analyzed to characterize each one. As can be observed in figure 2, one can distinguish a forking from an echeloned line or a square, through the analysis of each pixel. In the case of these three types having the same amount of neighbors, the difference is found in the position that they may have with respect to the given pixel. Some connectivity criteria must also, be applied: if the pixel has four neighbors, it can be likely assigned to forke condition.

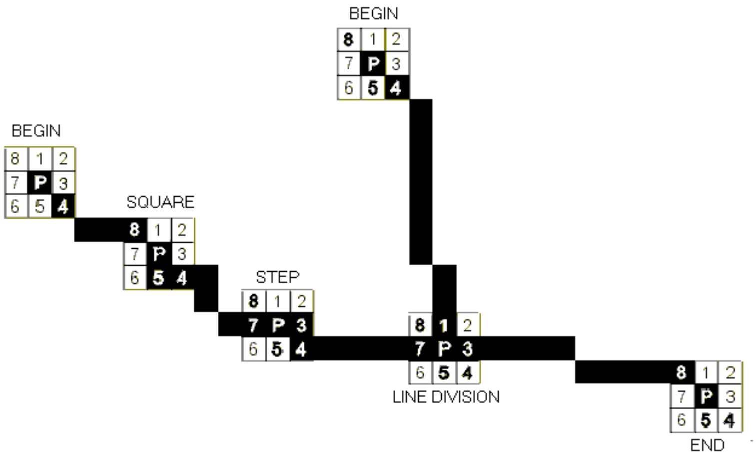

Fig. 2: Diagram Representing the Cases of Two Neighbors within a Region.

The characteristic points play an important role in the identification of a fingerprint, being the principal characteristic taken into account in this work, the forking of the combs. For obtaining the forking within the fingerprint a tracking algorithm (bifur.exe), programmed in C, is employed. This algorithm provides the coordinates of all the forkings found within the fingerprint. A typical set of coordinates is shown in Table 1.

Table 1: Coordinate Data of the Forking Found by the Tracking Algorithm.

No	x	y	No	X	y	No	x	y	No	x	y
1	49	25	16	230	112	31	209	195	46	195	277
2	18	30	17	168	121	32	364	198	47	24	287
3	203	31	18	466	123	33	4	209	48	152	288
4	295	49	19	147	128	34	134	210	49	194	297
5	326	68	20	124	142	35	87	212	50	82	310
6	50	71	21	179	158	36	29	216	51	130	317
7	89	85	22	363	160	37	191	216	52	163	318
8	110	88	23	262	163	38	96	219	53	130	321
9	141	91	24	248	167	39	73	227	54	220	328
10	364	93	25	214	171	40	137	230	55	68	332
11	141	95	26	476	171	41	58	252	56	265	337
12	148	96	27	102	179	42	185	254	57	392	345
13	17	107	28	484	183	43	82	255	58	268	354
14	142	111	29	123	184	44	246	263	59	235	360
15	213	111	30	43	190	45	449	266			

Once the tracking of the characteristic points is carried out and the forking characteristics of the fingerprint are identified (figure 3), coordinates are assigned, represented in the equation 1.

$$H(p) = \left\{ \begin{matrix} p_1(x_1, y_1) \\ p_2(x_2, y_2) \\ p_3(x_3, y) \\ \vdots \\ p_n(x_n, y_n) \end{matrix} \right\} \quad (1)$$

Where H (p) is the set that identifies the fingerprint, being Pi(xi,yi) a set of points and xi, yi being the horizontal and vertical coordinates of the point i, respectively.

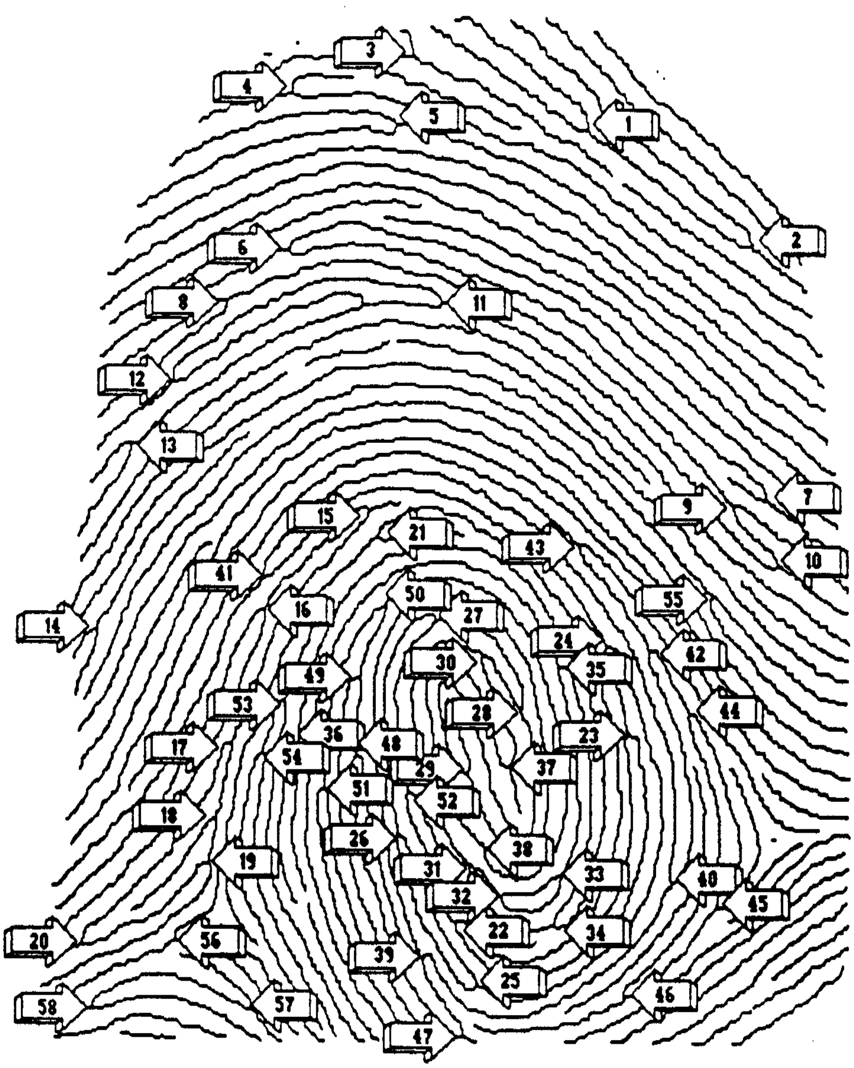

Fig. 3: Image Form with Their Detected Forking.

Next, once the position of the first point P1(x1, y1) in the fingerprint is established, the nearest five points are located, as is observed in figure 4.

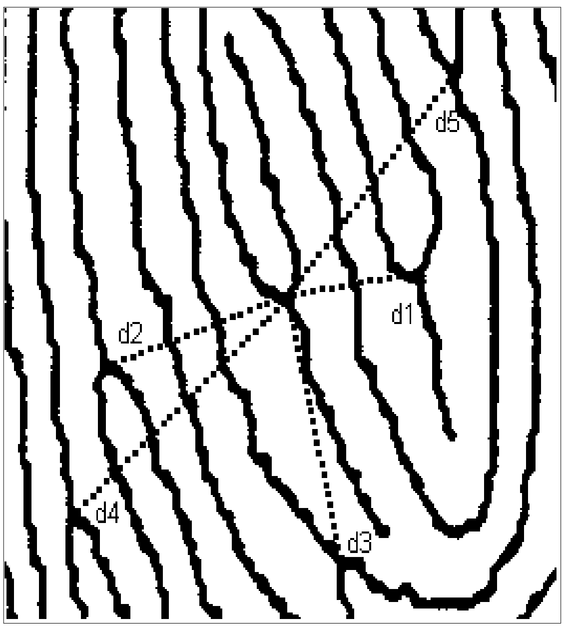

Fig. 4: Image of the Relationship of Distances between the Characteristic Points

Based on the Euclidian distance between points, the values of the five distances to a group that will be identify to the point p1 are assigned. This group of distances defines the standard vector that determines t the first point (i.e p1) and will be identified as D1.

By reproducing this process for each point of H (p) we will obtain a standard vector for each one. As a rule for each point i, the corresponding vector is represented for equation 2.

$$D_i\left[p_i\left(x_i, y_i\right)\right] = \begin{Bmatrix} d_1 \\ d_2 \\ d_3 \\ d_4 \\ d_5 \end{Bmatrix} \tag{2}$$

Where d1, d2, d3, d4 and d5 are the minimal distances from the Pi position (xi, yi) towards the five nearest points. The distances are ordered so that d1 < d2 <d3 < d4 < d5.

Once the five vectors are defined, their total length in 5 dimensional space is calculated, according to the equation 3:

$$L\left[p_i\left(x_i, y_i\right)\right] = \left\{\sum_{j=1}^{5}\left(d_j\right)^2\right\}^{1/2} \tag{3}$$

5. Conclusions

Effective identification of fingerprints can be achieved by means of a pc, provided the proper software is utilized. The topological characteristics of each fingerprint are key for a successful identification, therefore it is recommended the use an optical system with enough resolution for the acquisition of the fingerprint, instead of digitizing a printout. The vector technique provides a useful tool to make invariable the system to adjournments of the images of the fingerprints.

The test performed on our system show that it constitutes a reliable tool and some work towards addition of some mathematical morphogenesis concepts, is under way.

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