# Union and Division using Technique in Fingerprint Recognition Identification System

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***Abstract*—**Fingerprint Recognition System is made up of Off-line treatment and On-line treatment; the one is registering all the information of there trieving features which are retrieved in the digitalized fingerprint getting out of the analog fingerprint through the fingerprint acquisition device and the other is the treatment making the decision whether the users are approved to be accessed to the system or not with matching them with the fingerprint features which are retrieved and database from the input fingerprint when the users are approaching the system to use.

In matching between On-line and Off-line treatment, the most important thing is which features we are going to use as the standard. Therefore, we have been using "Delta" and "Core" as this standard until now, but there might have been some deficits not to exist in every person when we set them up as the standards.

In order to handle the users who do not have those features, we are still using the matching method which enables us to make up of the spanning tree or the triangulation with the relations of the spanned feature. However, there are some overheads of the time on these methods and it is not sure whether they make the correct matching or not.

In this paper, introduces a new data structure, called Union and Division, representing binary fingerprint image. Minutiae detecting procedure using Union and Division takes, on the average, 32% of the consuming time taken by a minutiae detecting procedure without using Union and Division.

***Index Terms*—**Fingerprint, minutiae, Union and Division, Identification

## I. INTRODUCTION

Highly reliable automatic personal authentication is fast becoming important in our electronically interconnected society, especially for electronic commerce. Biometrics is seen as an important research area that can satisfy the high security requirement and yet easy to use.

There are mainly nine different biometrics such as fingerprint, face, hand geometry, hand vein, iris, retinal pattern, signature, voice print and facial thermograms. The most widely used biometrics is fingerprint for its advantageous including immutability and low false acceptance rate.

In automated fingerprint identification system (AFIS), the fingerprint image is obtained by a sensor or camera. In order to compare two fingerprints, a set of invariant and discriminating features have to be extracted from them. There are several useful features in fingerprints, related to ridge topology, called minutiae, and the most important minutiae types are terminations and bifurcations [1]. In the AFIS, the minutiae are extracted and they are compared with those of the already stored images in order to establish the correspondence.

Unfortunately, noise, contrast deficiency, improper image acquisition, geometrical transformation, deformation and skin elasticity often make reliable minutiae detection very difficult. Spurious minutiae can be produced and valid minutiae can be hidden due to the low image quality of the fingerprint. Therefore, minutiae detection is a very crucial process in the AFIS.

In the field of image processing, some approaches to direct gray scale feature extraction have been proposed [2,13,14], and several approaches that follows the ridge lines on the gray-scale image and detects the minutiae directly from the gray-scale image during the ridge following are proposed [7, 8 ]. The most approaches for detecting minutiae consist of a series of processing operation: preprocessing [ 4, 11, 15 ], binary [ 10, 12, 15 ], thinning [ 1,16 ], minutiae detection [ 2, 3, 5, 7, 8, 9, 13, 14 ] and post-processing [ 5, 10, 13 ], and each operation greatly affects succeeding operations.

In [ 6 ], a fingerprint was represented in the form of a graph whose nodes correspond to ridges in the print, and edges of the graph connect nodes that represent neighboring or intersecting ridges. The graph structure captured the topological relationships within the fingerprint and was used for: (a) repairing fingerprint defects; (b) extracting minutiae and (c) matching.

This paper introduces a data structure called Union and Division (UD). UD considers each run at column of the binary image and stores the information: (a) whether the run is 0's run or 1's run; (b) two values of Y-axis for the run; (c) if two adjacent runs are same run, and they are intersect when they are projected to Y-axis, then the

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stored location of the other party. Some of the functions in abstract date type of UD are related to the operations succeeded in the binary, and some of the functions for repairing fingerprint defects[18].

The device of optical prism method is used to acquire gray level fingerprint image (FPI) of which size is 292*248. To examine the effect of UD, we have implemented two minutiae detecting procedures, on uses UD, and another does not use UD, in C++ running on Windows XP server on a 800 MHz Pentium IV with 512 Mbytes of RAM. Each 1000 fingerprint images of 100 humans is processed by the procedures, and as the result the procedure using UD takes, on the average, 32% of the consuming time of the procedure without using UD[18].

## II. PRELIMINARIES

Our approach for the description of the topology of the fingerprint patterns follows the techniques presented by Kass and Witkins,[11] and Sherlock and Monroe,[17] Our specific contribution is limited to the nonlinear orientation model, which is presented in Section 3. We have also chosen to present the orientation models in the continuous complex plane, even though the image itself is in the real plane and the orientation matrix is discrete, for a number of reasons:

- The zero-pole model, with is the basis for our development, is presented on the complex plane.
- The analysis in the complex domain allows for a comprehensive mathematical treatment of the singularities, instead of just an intuitive approach.
- We are interested in a model that can reproduce the orientation every where, not just in the lattice of the orientation matrix.
- The conditions and limitations of the methods used in the discrete domain of the orientation matrix for the detection of singularities will be better appreciated using this approach from the continuous domain, as shown in Appendix A.

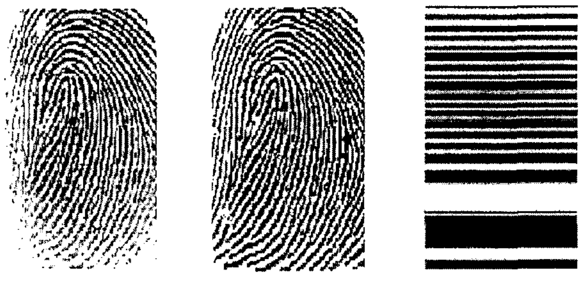
## III. UNION AND DIVISION

### *A. Notation*

The information carrying features in a fingerprint are the line structures called ridges and valleys. At a FPI of Fig. 1 (a), the ridges are black and the valleys are white.

The device of optical prism method is used to acquire A gray level FPI can be considered as two dimensional array consisting of the pixel values represented by 8-bits. T[H][W] denotes the gray level FPI of which size is H*W, and T[i][j] denotes a pixel value at jth column of ith row in T[H][W] for $0 \le i \le H-1$ and $0 \le j \le W-1$.

The binary is for mapping a pixel value at the ridge into 1 and pixel value at the valley into 0. B[H][W] denotes the binary T[H][W], and B[i][j] denotes a pixel value at jth column of ith row in B[H][W] for $0 \le i \le H-1$ and $0 \le j \le W-1$.



(a) FPI (b) Binarized FPI (c) runs

Fig. 1 FPI, binary FPI and runs

Each column of B[H][W] consists of 0's run(s) and 1's run(s). Fig. 1 (c) shows the runs at a column of a FPI in Fig. 1 (b). At Fig. 1 (c), 1's run is black and 0's white.

Let $N_j$ denote the number of the runs at jth column of B[H][W], $R^j_k$ kth run at jth column of B[H][W], $S^j_k$ the starting row of kth run at jth column of B[H][W], $E^j_k$ the ending row of kth run at jth column of B[H][W], and MAX is the maximum number in $N_j$ s for $0 \le j \le W-1$ and $1 \le k \le N_j$ .

### *B. Abstract Date Type*

In Union and Division, $R^j_k$ can be considered as a line segment $[S^j_k, E^j_k]$ such that a value of X-axis is j, a starting point of Y-axis is $S^j_k$, and an ending point $E^j_k$ for $0 \le j \le W-1$ and $1 \le k \le Nj$ . Abstract date type of the union and division is described in the following:

Structure Union and Division is

Objects : A set of pairs <index, line segment, Boolean, index_als> where index is a finite ordered set of two dimensions, and for each value of index there is a line segment, Boolean denoting 0,s run or 1's run, and if two adjacent runs are same run, and they are intersect when they are projected to Y-axis, then index_als is the stored location for row of the other party.

Functions:

Union and Division Create (MAX, W, <ymin, ymax>, run, index_row) ::=

Create and empty two dimensional array UD[MAX][W] whose element contains
<ymin, ymax>, run, index_row.

Union and Division Store(UD[MAX[W], <k,j>,<ymin,ymax>, run, index_row::=

If (k is in MAX and j is in W for $R^j_k$ and $R^j_k$ is r's run) then run=r, ymin= $S^j_k$ and ymax = $E^j_k$;

for $[S^{j-1}_{k'}, E^{j-1}_{k'}]$ and $[S^j_k, E^j_k]$, if they are same run's line segment and intersected when they are projected into Y-axis, then index_row of <k,j> is k', and index_row of <k',j-1>is k.

Line Segments Union(UD[MAX][W], (<k1,j>,<r1,-y1min,y1max>),(<k2,j>,<r2,y2min,y2max >),(<k3,j>,<r1, y3min, y3max>))::=

let <r1, y1min,y1max >,<r2 ,y2min,y2max > and <r1, y3min, y3max >) be three consecutive line segments and y1max $\leq$ y3max, updates <r1,y1min,y1max to <r1,-y1min, y3max>and deletes<r2 ,y2min,y2max >and<r1, y3min, y3max >.

Line Segment Division(UD[MAX][W],<k,j>, <r,ymin,ymax>)::=Partition<r,ymin,ymax >into<r1, y1min,y1max >,<r2 ,y2min,y2max >,< r1 ,y3min, y3max >.

Line Segment Extension(UD[MAX][W],<k,j>,<r, ymin,ymax >)::=

Ymin=ymin- $\alpha$ or ymax=ymax+ $\beta$ for positive real numbers $\alpha$ and $\beta$.

Line Segment Reduction(UD[MAX][W],<k,j>, <r ,ymin,ymax >)::=

Ymin=ymin+ $\alpha$ or ymax=ymax- $\beta$ for positive real numbers $\alpha$ and $\beta$.

Integer(s) Tracing(<k,j>,<r,ymin,ymax>)::=

if $[S_k^{j-1}, E_k^{j}]$ and $[S_k^{j}, E_k^{j}]$ are same run's line segment and intersected when they are projected into Y-axis, then k', and if $[S_k^{j+1}, E_k^{j+1}]$ and $[S_k^{j}, E_k^{j}]$ are same run's line segment and intersected when they are projected into Y-axis, then k''.

At the abstract data type described above, Table 1 shows that how the functions are related to minutiae extraction.

Table 1 Relation between the functions and AFIS

| | The roles of the functions in AFIS |
|---|---|
| Union | Related to the repairing B[H][W], that is, Union removes a noise that partitions a line segment into three line segments. |
| Division | Related to the repairing B[H][W], that is, Division removes a noise that combined two line segment. |
| Extension | Related to the thinning. |
| Reduction | Related to the thinning. |
| Tracing | Related to the minutiae extraction, that is, if two induces at (j+1)th column of UD are stored at one element at jth column of UD, then a bifurcation is extracted, and if same index at (j+1)th column of UD is stored at two consecutive elements at jth column of UD, then a terminations is extracted. |

There is no need to consider post-processing in the techniques using UD to extract minutiae, because the functions Union and Division remove the noise.

We can see that UD is easily constructed by similar way with merge procedure in merge sort.

The device of optical prism method is used to acquire gray level fingerprint image (FPI) of which size is 292*248. To examine the effect of UD, we have implemented two minutiae detecting procedures, one uses UD, and another does not use UD, in C++ running on Windows XP server on a 800 MHz Pentium Ⅳ with 512 Mbytes of RAM. Each 1000 fingerprint images of 100 humans is processed by the procedures, and as the result the procedure suing UD take, on the average, 32% of the consuming time of the procedure without using UD.

## IV. CONCLUSIONS

We have presented a new data structure called Union and Division for extraction minutiae efficiently. Proposed data structure saves the consuming time to extract minutiae dramatically. We think that the data structure can be used to removes the noise inserted in a fingerprint image. Each 1000 fingerprint images of 100 humans is processed by the procedures, and as the result the procedure suing Union and Division take, on the average, 32% of the consuming time of the procedure without using Union and Division.

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