Fingerprint Classification Using Region Partition

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Abstract

Fingerprint classification is a technique that used for supporting of speed in fingeprint identification. Large databases of fingerprint is one of difficult problem in fingerprint research area. The more classes of fingerprint will be increased speed of fingeprint identification process. This paper will be explain results of our reseach in fingerprint classification using Region Partition Method to create sub-classes from existent classes (Left Loop, Right Loop, Twin Loop dan Whorl). Fingerprint data has been taken from NIST databases with 30 sample for each class, total sample is 120 sample. There are three stages that are used in this research: 1) segmentation; 2) Orientation Estimate; and 3) Region Partition. The results is gained new sub-classes where Twin Loop class have many sub-classes than others.

1. Introduction

Fingerprint recognition is the basic task of the Integrated Automated Fingerprint Identification Service (IAFIS) of the most famous police agencies. *Ten-print based identification* and *latent fingerprint recognition* are the two main concerns of an IAFIS. In the former, the system should identify a person by the whole sequence of his/her 10 fingerprints; in the latter, it has to identify a person through a latent fingerprint found on a crime scene. The huge amount of data of the large fingerprint databases seriously compromises the efficiency of the identification task, although the fastest minutiae matching algorithms take only a few tens of milliseconds per matching. Adopting a classification approach, based on common typology of fingerprints, is a valid strategy in order to reduce the amount of matching during fingerprint retrieval and, consequently, to improve the identification process efficiency [2].

Fingerprint identification is computationally demanding especially for a large database. So an effective indexing scheme can be of great help. Fingerprint classification, which classifies fingerprint images into a number of pre-defined categories, faciliates the matching task accordingly. Most classification methods are based on the Henry classes which classify the fingerprint images into arch, tented arch, left loop, right loop and whorl using the accurate position and type of the singular points such as cores and deltas [11]. Fingerprint classification is a coarse level partitioning of a large fingerprint database, where the class of the input fingerprint is first determined and subsequently, a search is conducted within the set of fingerprints belonging to the same class as the input fingerprint [6].

Fingerprint classification is an actively researched field. Many approaches have been proposed. A model-based fingerprint classification technique is presented by Karu et al. [7]. Rao and Black use the syntactic method to represent and classify fingerprints [3]. Andrew Senior proposed a hidden Markov model classifier [1]. Neural Network technique is used in fingerprint classification by Kamijo [10]. In [9], a relational graph compactly summarizing the macro-structure of the fingerprint is derived to classify the fingerprints. In this paper we proposed region partition method for fingerprint classification. The method created sub-classes from existent classes (*Left Loop*, *Right Loop*, *Twin Loop* dan *Whorl)*. Fingerprint data has been taken from NIST databases with 30 sample for each class, total sample is 120 sample. There are three stages that are used in this research: 1) segmentation; 2) Orientation Estimate; and 3) Region Partition. The results is gained new sub-classes where Twin Loop class have many sub-classes than others. Based on results of the research, the fingerprint classification have new sub-classes that can improve classification and identification in fingerprint classification area and it is a contribution of this research.

2. Classification Stages

2.1. Segmentation

There is two pre-processing in classification stages: Segmentation and Orientation Estimate. Region Partition method will be processed after two process before has been done. The following is a segmentation algorithm:

1. Choosed a desire threshold (T) value
2. Grouped of both G1 and G2 class grayscale image based on the threshold value
3. Average grayscale group: $m_1 = \mu(G_1)$ and $m_2 = \mu(G_2)$ Defined a new threshold base on m_1 and m_2, $T' = \dfrac{m_1 + m_2}{2}$
4. Compared old T (threshold) with new T', if $T \neq T'$ then $T' = T$ repeat step 1 to 4 until both thresholds have same value
5. compute image variant used block W x W:

$$V(k) = \frac{1}{W^2} \sum_{i=0}^{W-1} \sum_{j=0}^{W-1} ((i,j) - M(k))^2$$

Where, V(k) is variant of k-block
W is size of block
M(k) is grascale mean of k-block
(i,j) is image coordinates

6. If V(k) > T then set pixels as a background colour (black) else set as a foreground (stay colour)

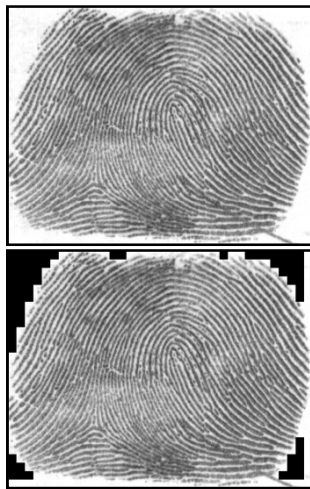Following is the result of *Right Loop* image processing after applied the algorithm:

Figure 1. Result of segmentation process

2.2. Orientation Estimate

Given normalized image G, the main step of the algorithm are as follows:

1. Divide G into blocks of size w x w (16 x 16)
2. Compute the gradients $\partial_x(i,j)$ and $\partial_y(i,j)$ at each pixels (i,j)
3. Estimate the local orientation of each block centered at pixels (i,j) using the following equation:

$$V_x(i,j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{u=j-\frac{w}{2}}^{j+\frac{w}{2}} 2\partial_x(u,v)\partial_y(u,v)$$

$$V_y(i,j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{u=j-\frac{w}{2}}^{j+\frac{w}{2}} (\partial_x^2(u,v) - \partial_y^2(u,v))$$

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

$$\Phi_x(i,j) = \cos(2\theta(i,j)) \text{ and}$$
$$\Phi_y(i,j) = \sin(2\theta(i,j))$$

There $\theta(i,j)$ is the least square estimate of the local ridge orientation at the block centered at pixels (i,j).

4. Compute the local ridge orientation at (i,j) using,

$$O(i,j) = \frac{1}{2} \tan \left(\frac{\Phi_y(i,j)}{\Phi_x(i,j)} \right)$$

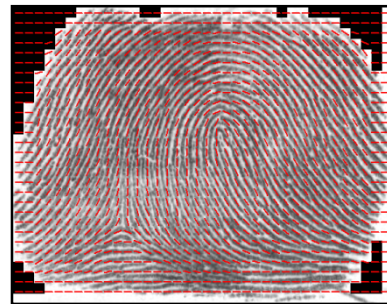Figure 2 shows an example of the orientation image estimated.

Figure 2. Result of orientation estimated process

2.3. Region Partition

After orientation estimated process there are values for each block area $O(i,j)$. For example, if $0 \geq O(i,j) \leq 5$ then class of the block is class 1 with colour of the region is RGB (255,0,0). The region can be partitioned based on region partition table belows:

Table 1. Region partition table

CP.	Min-Degree	Max-Degree	Red	Green	Blue
1	0	5	255	0	0
2	6	45	0	255	0
3	46	90	0	0	255
4	91	135	255	132	0
5	136	175	192	0	255
6	175	180	255	0	0

CP or Class of Partition is class of region has been partitioned, Min-Degree is maximum degree of the region, Max-Degree is minumun degree of the region. RGB is colour of region. Figure 3 is result of region partition with six partition.
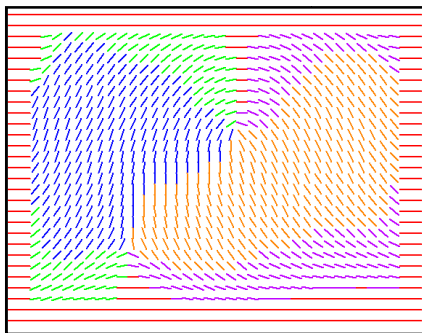

Figure 3. Result of region partition process

3. Results

This research used four classes by NIST (National Institute Standart Technology) database to indentified of sub-class from each classes. This all of classes are Left Loop, Right Loop, Twin Loop and Whorl. Every class have 30 fingerprint images for tested and classified. Tabel 2 shows information of new sub-classes for each defined classes and table 3 shows details of sub-classes.

Table 2. New sub-classes from each defined classes

CP.	Classes	Images	New Sub-classes	Regions
1	Left Loop	30	4	5, 6, 7, 8
2	Right Loop	30	4	5, 6, 7, 8
3	Twin Loop	30	5	4, 6, 7, 8, 9
4	Whorl	30	3	7, 8, 9

Table 3. Details of sub-classes

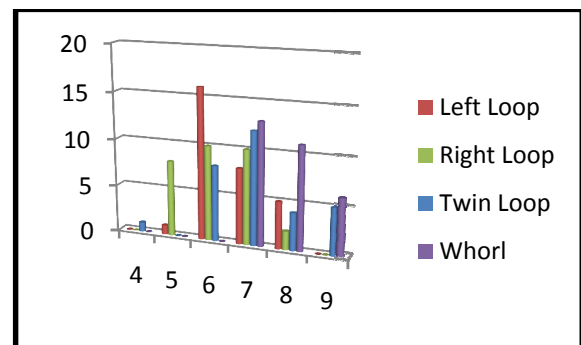| CP.	Classes	New Sub-Classes & Regions					
		4	5	6	7	8	9
1	Left Loop		1	16	8	5	
2	Right Loop		8	10	10	2	
3	Twin Loop	1		8	12	4	5
4	Whorl				13	11	6

Figure 4. Information sub-classes from each defined classes

Based on figure 4, we can looked that every defined classes have base region. For example, region 5 is base region and 6, 7 and 8 region is sub-classes of Right Loop.

4. Conclusions

Fingerprint classification is a technique that used for supporting of speed in fingerprint identification. Large databases of fingerprint is one of difficult problem in fingerprint research area. The more classes of fingerprint will be increased speed of fingerprint identification process. This paper will be explain results of our reseach in fingerprint classification using Region Partition Method to create sub-classes from existent classes (*Left Loop*, *Right Loop*, *Twin Loop* dan *Whorl)*. Fingerprint data has been taken from NIST databases with 30 sample for each class, total sample is 120 sample. There are three stages that are used in this research: 1) segmentation; 2) Orientation Estimate; and 3) Region Partition. The results is gained new sub-classes where Twin Loop class have many sub-classes than others.

5. References

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