Improvement and Application of Median Filter Algorithm

Zhenzhong Wang[1,a], Pengcheng Zhu [2,b], Yao Wang [3,c]

[1]Yancheng Institute of Technology Teaching and Education Assessment Department, Jiangsu Province Yancheng City and 224051, CHINA

[2]Nantong Univesity Xinglin College, Jiangsu Province Nantong City and 226000, CHINA

[3]Yancheng Biology Engineering Higher School Numerical Control Department, Jiangsu Province Yancheng City and 224000, CHINA

[a]email:hanserwzz@126.com, [b]email, [c]email

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Abstract. For improving the effect and efficiency of image enhancement, an improved version of median filter for binary fingerprint image is realized. First, the times of compare during ordering process is reduced by the divide-and-conquer method. In addition, it makes the best use of direction of fingerprint and builds some reasonable template, which reduces the complexity of algorithm and increases the processing speed.

Introduction

To attribute to some noise, the low quality fingerprint image is caused in accessing and transferring. Therefore, for improving the efficiency of fingerprint identification, it is necessary to fingerprint preprocess before the characteristics of the extraction and matching. There are many filter algorithms used to image enhancement. The median filter is simple in structure and easy in implementation and gains confidence.

The Conditional Median Filter Algorithm

Median filter[1] is one of the order of the filter. The value of one point in the digital images or figures sequence is the value of the point whose neighborhood consists of the other median points' value:

$$y_{ij} = \underset{A}{Med}\{x_{ij}\} = Med\{x_{(i+r),(j+s)}, (r,s) \in A\}$$

y_{ij} is the median filter output by x_{ij} centered, A is a filter window. Median filter algorithm is an essentially a sort algorithm and the process follows. Firstly, select a $(2n+1) \times (2n+1)$ filter window which is slides from left to right, top to bottom along the image data rows and columns in the direction. Secondly, it substitutes median value for the centre gray value of pixels in window after each slide.

The Improved Median Filter Algorithm

Improvement of Divide-and-conquer method.

Divide-and-conquer method[2] divides the larger problem into several smaller problems, and the solution is merged by the smaller solutions. Median filter algorithm is designed to quickly find the grey value, such as divide-and-conquer method sorts each row elements first. Then each column elements is compared, and the final result can effectively reduce the compare times[3]. It can instead of bubble algorithm which need much work to sort filter window.

Improved algorithm is as follows:
- Firstly, sort each row elements and get the maximum, median, and minimum value;

- Secondly, comparing the three groups of data, the result is the minimum value of the smallest value among the three maximum values, and the median value is the median value among the three median values, and the maximum value is the biggest value among the three minimum values.

For example, a 3×3 window, bubble algorithm requires more than 30 times before it can eventually result in divide-and-conquer method needs only 21 times.

Oriented weight improvement.

Because of the direction of the fingerprint ridge lines, median filter algorithm make the outputs are the same to the each points of window, and lead to breaking and adhere of the fingerprints. It is necessary to base on edge directional information if you want to pay attention to the each point of the ridge lines, which is to utilize the direction of fingerprint ridge lines to guide the median filter algorithm which is the oriented weight median filter algorithm. The algorithm divides window into four categories: 00, 450, 900, 1350, which is based on the different direction of the ridge lines. The direction of the ridge lines is based on its direction of the rotating weight value.

W_4	W_3	W_2
W_1	W_0	W_1
W_2	W_3	W_4

Fig. 1 Window of weights

We introduce the concepts of the fuzzy theory[4] method, adopting the 3×3 widow of weights in figure 1. When set of the weight value to be fuzzy, the closer direction of the ridge lines in the current window, the bigger the weight value.

The weight values are chosen as follows. A θ is the direction of the fingerprint ridge lines, 0<θ<π, each bracket in the express is the value range of θ.

$$W_1 = \begin{cases} 1 & (3\pi/8, 5\pi/8] \\ 2 & (\pi/8, 3\pi/8] \ or \ (\pi 5/8, 7\pi/8] \\ 3 & (0, \pi/8] \ or \ (7\pi/8, \pi] \end{cases}$$

$$W_2 = \begin{cases} 1 & (5\pi/8, 7\pi/8] \\ 2 & (3\pi/8, 5\pi/8] \ or \ (0, \pi/8] \ or \ (7\pi/8, \pi] \\ 3 & (\pi/8, 3\pi/8] \end{cases}$$

$$W_3 = \begin{cases} 1 & (0, \pi/8] \ or \ (7\pi/8, \pi] \\ 2 & (\pi/8, 3\pi/8] \ or \ (5\pi/8, 7\pi/8] \\ 3 & (3\pi/8, 5\pi/8] \end{cases}$$

$$W_4 = \begin{cases} 1 & (\pi/8, 3\pi/8] \\ 2 & (3\pi/8, 5\pi/8] \ or \ (0, \pi/8] \ or \ (7\pi/8, \pi] \\ 3 & (5\pi/8, 7\pi/8] \end{cases}$$
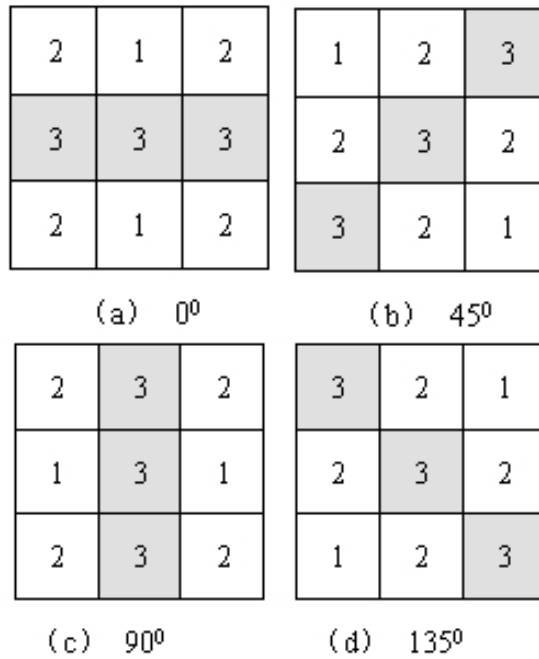
Fig. 2 Window of oriented weight

According to the rules, we can get four windows of oriented weight in the figure 2, and choose the corresponding window based on the direction of the ridge lines, after such filtering as the fingerprint ridge lines will be more coherent and better.

Results and analysis

As the table 1 shows, we have been implemented the improved median filter algorithm in MATLAB, and the speed becomes fast obviously.

Table 1 Contrast of two algorithms

Algorithm	Count of Experiment	Average of Exchange	Average of Time	Accuracy Rate
not Improved	100	18723490.2	1.836	95%
Improved	100	264952.3	0.087	94.3%

As the figure 3 shows, the experimental results more accurate and ocular, the original image in figure 3-1, the filtered image in figure 3-2, the improved image in figure 3-3.

Fig. 3-1 Original image	Fig. 3-2 filtered image	Fig. 3-3 improved image

In this paper, a new algorithm is supposed, which mainly contains the following two aspects. Firstly, divide-and-conquer method reduces the compare times in the sorting process to improve the speed of an algorithm. Secondly, oriented weight is directional information in the filter expressions, which will eliminate the holes, breachs, and knobs of ridge lines, and clear and smooth after filtered fingerprint image. At the same time, the improved algorithm utilize the direction of the fingerprint ridge lines and the fuzzy theory to construct the median filter algorithm, which is simple to give a correct result in time and to improve the anti-interference ability. Therefore, the algorithm is an ideal improvement fingerprint image method.

References

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