An Efficient Quick Thinning Algorithm
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Abstract

A new thinning algorithm is addressed in this paper. The most important feature in this paper is that it thins symbols to their central lines with high speed. This means that the method is rotation invariant. Compared to the method of Ahmed and Ward, it can improve the speed and solve their falls on two-pixel wide lines. The method in this paper contains two steps. The first one uses the concept of weight-value to separate the rules into 6 groups in order to improve the speed of thinning; The second one uses 2 rules to make sure that the skeleton is single pixel and can preserve the connectivity. The results show that this method has good effect on preserving the topology of symbols and letters.

Keywords: Thinning, Template, Two-pixel wide lines, weight-value

1. Introduction

The skeleton is important for object representation and recognition in different areas, such as image retrieval and computer graphics, character recognition, image processing, and analysis of biomedical images. Skeleton-based representations are the abstraction of objects, which contain both shape features and topological structures of original objects. Due to the importance of the skeleton, many skeletonization algorithms have been developed to represent and measure different shapes. In Xiang’s method\cite{1}, the algorithm utilized the DCE to simplify the contour of the image and then used skeleton-growing method to obtain skeletons. The results are very excellent, but it cannot be used to the character. In order to get the skeleton of the character, the proposed method utilizes the thinning algorithm to do it.

The Thinning algorithm of binary images is a very useful topic in the optical character recognition. There are two kinds of the thinning algorithm, the sequential and the parallel. As the parallel thinning algorithm can remove all the contour pixels that should be deleted in one iteration rather than only one pixel like the sequential, now, researchers focus on the former one. In the paper of Lam and Suen\cite{2}, the authors reviewed about 100 thinning algorithms. Moreover, some important and creative thinning algorithms have been mentioned these years, such as Han’s method using the template for thinning\cite{3}, the rotation-invariant thinning algorithm of Ahmed and Ward\cite{4}, and so on. Han considered the weight-value of the pixel to classify the template, but he didn’t show the result of his algorithm. Through analyzing the results following the algorithm, the skeleton is not connected. The main reason is they fail to consider the two-pixel wide lines, so that the algorithm deletes some pixels that should not be removed. In Ahmed and Ward’s paper, they discuss all the conditions of the considered pixel, concentrating on the 8-neighbour pixel. Then, they choose the most reasonable 20 templates to thin the considered pixel. The given results are very excellent and rotation invariant. However, in some cases, there are some two-pixel wide lines that have not been removed, so that they cannot prove that the skeletons are single-pixel wide.

Compared to the methods mentioned above, the proposed method considers the connectivity and algorithm complexity together. Moreover, the skeleton is also rotation invariant. It contains two steps: The first step: the proposed method classifies the pixel based on the weight-value and utilizes the template to thin the image, until the image only contains the two-pixel wide section. The second step: in order to keep the connectivity and prove the skeleton single value wide, the other two templates are used to thin the remained image.

In the following section, we describe our method in section 2 and compare our results with others in section 3. In section 4, we will give out the comparison between our method and others. Finally, some
discussion and conclusion will be given out at section 5.

2. Description of our algorithm

2.1. Basic definition

The binary images only have black and white pixels. In this paper, the black one is labeled as 1 and the white one is labeled as 0. As shown in figure 1, x1, x2, x3, x4, x5, x6, x7, x8 are the 8-neighbourhood of the considered pixel and p, the weight-value, is the number of black pixel in the 8-neighbourhood of it.

<table>
<thead>
<tr>
<th>X1</th>
<th>X2</th>
<th>X3</th>
</tr>
</thead>
<tbody>
<tr>
<td>X8</td>
<td>P</td>
<td>X4</td>
</tr>
<tr>
<td>X7</td>
<td>X6</td>
<td>X5</td>
</tr>
</tbody>
</table>

Fig.1 the 8 neighborhood of p

2.2. The Thinning rules: step one

The proposed method is iterative. At each iteration, the algorithm deletes the pixels that locate on the boundary of the image, until there are only two-pixel wide sections on the image. If the pixel matches the templates in fig.2, it can be concluded that this pixel is on the boundary and should be deleted. The construction of the Thinning rule is very simple: all of the pixels are classified into six sets based on their weight-value and corresponding to each set, there are some templates to judge them. It seems that our templates are similar to Han’s. However, in order to prove that the skeleton is rotation-invariant, the proposed method improves Han’s templates. Moreover, Han didn’t pay attention on the two-pixel wide sections, so that their results are not connected which will be shown in the following sections. Compared to him, the proposed method solves this problem by dividing the algorithm in two parts.

The outline of the proposed thinning algorithm is as follows:

Step 1. Calculate the weight-value of the black pixels;

Step 2. According to the weight-value, each black pixel is examined by the corresponding templates. If it is matched, we remove this pixel;

Step 3. Iterate Step 1 and 2 until there are only two pixel wide section in the image.

2.3. The Thinning rules: step two

As mentioned above, if we do not stop at the two pixel wide sections and continue to delete the pixel based on the templates in fig.2, though it can eliminate boundary pixels, some pixels that should be kept are deleted. If a symbol has two pixel wide sections in the horizon or perpendicular direction, these sections may be removed. For example, in fig.3, the lines that should not be deleted are removed.

Fig.2 Thinning rules

Fig.3 The surprising deletion of two-pixel wide lines
Compared to Han’s method, Ahmed and Ward’s algorithm considered about it and their method can prove the connectivity of the skeleton. However, as mentioned in [5], some parts of Ahmed and Ward’s results are not single pixel wide. Though Rockett solved the problem, it is not suitable for our method to use it. The proposed method builds up the following templates in fig.4 to thin the two-pixel wide sections.

![Fig.4 Thinning rules for two-pixel wide sections](image)

Fig.4 Thinning rules for two-pixel wide sections

In fig.5, it is clear that the result can solve the mentioned problem. The motivation of these two templates is very simple. As the reason of wrong deletion is the templates in the first step thin the image from both sides, we just thin the remained image from one side. Moreover, as the second step is also parallel thinning algorithm, it will not influence the speed of the algorithm.

![Fig.5 The result of deleting two-pixel wide sections](image)

Fig.5 The result of deleting two-pixel wide sections

3. The result

The results in fig.6 and fig.7 represents that the proposed method can get the skeleton from different symbols, no matter they are characters or handwritten symbols. Moreover, the results in fig.7 can further prove that our algorithm is rotation invariant.

![Fig.6 The results of thinning different symbols](image)

Fig.6 The results of thinning different symbols

![Fig.7 Results of thinning rotated symbols](image)

Fig.7 Results of thinning rotated symbols

4. Comparison

![Fig.7 Comparison of different methods](image)

Fig.7 Comparison of different methods

Fig. 7(a) is the original symbol, (b) is the result of Ahmed and Ward’s method, our result is (c) and Han’s result is (d). It is clear that the skeletons in (c) and (b)
are better than the one in (d), especially in the connectivity. A bigger one was given in fig. 8.

![Comparison of Results of Thinning Bigger Image](image)

Fig. 8 Comparison of results of thinning bigger image

The left image is the original character and the middle skeleton is the result of Han’s method. It is clear that our result, the right one, can preserve the connectivity and prove that the skeleton is single-value wide.

Besides, the complexity of our algorithm is much lower than Ahmed and Ward’s method. As the proposed method has classified the templates based on the weight-value, at each iteration, the algorithm only need consider the templates in one class instead of the Ahmed and Ward’s method to consider 20 templates. For example, if the pixel p’s weight-value is 2, we only need use 8 templates to thin it rather than 20 templates.

5. Conclusion

Good thinning algorithm is very important for character and symbol recognition. If the skeleton can keep the topology of the symbol, it will be very helpful for character recognition. The results of the proposed method show that it can obtain the skeleton of symbols, characters and letters in different language. Moreover, our method has the advantage of rotation-invariant: if the original image rotated, the resultant thinned image is also rotated the same angle.

Moreover, the skeleton in our method is single-pixel wide and connectivity in most cases. But, it may have a few interceptions in the skeleton. Besides, though the proposed method can tolerate some noisy symbols, when there is too much noise, the result will be not so good. It’s the subject of further research.

6. References


