A Novel Thinning Scheme for Reducing Thinning Distortions

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1. Introduction

Thinning is one of the fundamental binary image processing methods. It deletes some dark points marked with value '1' in binary image and transforms the pattern into thin representation without changing its connectivity properties. This processing is used frequently in character recognition and understanding line drawings.

This paper describes a novel thinning scheme for reducing thinning distortions. The proposed thinning algorithms consist of two main procedures: thinning and recovering. The thinning procedure searches for the deletable candidates satisfying thinning conditions. The recovering procedure is used to check the distribution of deletable candidates resulted from the thinning procedure in the same iteration and to recover some of them which may cause distortions into undeletable ones.

2. Thinning Distortion Problems

Most of thinning algorithms assume a 3*3 operator for each picture element, and use the values of the eight neighbors of a central pixel to decide whether the central pixel can be deleted or not. Although different thinning algorithms adopt different calculation equations as deleting conditions, all of them lay stress on preserving connectivity of original input images and improving processing speed. But there seems no proposal of conditions that try to look out optimum 'midline' [1-4].

As a result, thinning processing inevitably causes distortions at crosses, junctions or bending positions. It often separates one cross into two junctions, creates a Y-shape branch at a T-junction, rolls an obtuse angle into a curve or creates a tail near an acute angle. The larger the width of stroke is, the more serious the above distortions become.

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3. A Novel Method

As described in the above section, all of the reported thinning algorithms can't provide optimum 'midline' due to the limitation of a 3*3 operator's information. Naturally, it may be believed that extending the operator size will help solving such problems in some degrees. But, how to choose an operator size suitable for the different input data, and how to make out deleting conditions corresponding to the operator size are very difficult tasks. Now, we propose a novel thinning method that deals with thinning distortion problem by developing a recovery procedure in addition to the thinning procedure, instead of extending the operator size.

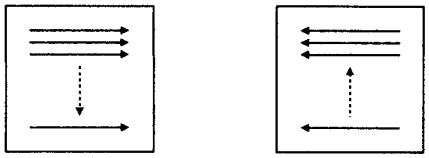
The thinning procedure searches for the deletable candidates. It may apply any of the reported thinning algorithms proceeding in iterative manner. Here, the obtained candidates are no longer deleted immediately, that is, their values are not converted from '1' to '0' directly. They are marked with '2' and transferred to the recovering procedure.

In the recovering procedure, pixels marked with '2' are classified into isolated points, horizontal, vertical and diagonal queues. They are matched with the corresponding distortion templates. If a point or a queue coincides with one of the distortion templates, it will be protected and recovered from value '2' to value '1'; otherwise, it will be deleted and changed into value '0'.

The thinning processing stops when no further deletion occurs.

3.1 Scheme for Sequential Thinning

For sequential thinning algorithms, the deleting conditions of a pixel depend on its current neighbors' values, and patterns are deleted from all sides. In order to prevent from endless cycles of thinning and then recovering in certain positions, the thinning and recovery procedures should be carried out in TV raster scan in odd iterations and in reverse TV raster scan in even iterations (Fig. 1). The flow chart of sequential thinning is shown in Fig. 2.



(a) TV raster scan in odd iteration (b) Reverse TV raster scan in even iteration

Fig. 1 Scan Sequence of Sequential Thinning.

```
begin
  repeat
      thin in TV raster scan;
      recover in TV raster scan;
      thin in reverse TV raster scan;
      recover in reverse TV raster scan
  until no pixel changed
end
```

Fig.2 Processing Scheme of Sequential Thinning.

3.2 Scheme for Parallel Thinning

For parallel thinning algorithms, the deleting conditions of a pixel at the n-th iteration depend on its neighbors at the (n-1)-th iteration. Thus all of pixels of the pattern can be processed simultaneously. In order to avoid vanishment of a pattern completely, parallel thinning is usually carried out only in restricted directions in one iteration; for example, deleting north and east sides in odd iterations and then south and west sides in even iterations. Such two subiteration thinning algorithms are convenient for recovery processing. It only needs to perform recovery procedure after every subiteration (Fig. 3). However, as will be illustrated in the next section, recovery procedure is hard to realize in parallel fashion owing to the searching of deletable candidates and the checking with distortion templates; it has to adopt sequential recovering procedure.

```
begin
  repeat
      thin in north and east directions;
      recover in north and east directions;
      thin in south and west directions;
      recover in south and west directions
  until no pixel changed
end
```

Fig. 3 Processing Scheme of Parallel Thinning.

4. The Distortion Templates

Thinning distortions have been analyzed for various patterns. If thinning a pattern from its boundary in iteration manner, deletable candidates resulted after each iteration will be a continuous queue or an isolated point. It is found that there are common characteristics as to the both ends of a queue, when distortions exist.

(1) The length of a possible distortion queue is shorter than the double of the stroke width.

(2) If a unit-width segment of two or more dark pixels lies at each end of a queue in the longitudinal direction of the queue, deletion of the queue may cause a distortion at a junction.

(3) If only one end satisfies the above condition and, at the other end, no more segment exists near around, deleting such a queue may cause an angle distortion.

Distortion templates are developed based on the above characteristics. Each distortion template is composed of two parts which correspond to the both ends of a queue. For example, for a horizontal queue, one possible distortion template is shown in Fig. 4.

```
0 0              0 0
1 1 2 ••••• 2 1 1
0 0              0 0
left end point   right end point
```

Fig. 4 A Distortion Template for a Junction.

5. Conclusions

We have presented a novel thinning scheme that will make the thinning processing more natural and flexible, and be able to deal with the thinning distortion problem. Although it is time consuming, it can provide desirable thin representation of the original image. It will find applications in the prepocessing of understanding engineering drawings or charater recognition.

References

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