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Improvement of Cadastral Map Assembling Based on GHT

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Abstract

There are numerous cadastral maps generated by past land surveying. For effective and efficient use of these maps, we have to assemble the set of maps to make them superimposable on other geographic information in a Geographic Information System. We present an automatic solution based on the generalized Hough transformation that detects the common longest boundary between every piece and its neighbors. And we present a high-speed technique for the cadastral map assembling by the segment reduction. The results of the experiment with the French cadastral maps show that the proposed method is suitable for assembling the cadastral map.

1 Introduction

In the process of application development of Geographic Information System (GIS), the core issue is the maintenance of national spatial databases. Cadastral maps are always made individually in each district by using the scale of about 1/2500. When the cadastral maps are made in each district, then they are finally assembled in correspondence with the connected components of information and the surveyed ground information.

In the past research, the cadastral maps have been chiefly assembled according to symbols given to the cadastral map and using prior knowledge available. Techniques for treating the separated cadastral maps as one piece of a huge jigsaw puzzle has been proposed by other researchers in the automation of the cadastral map assembling[1]. These techniques are based on the choice of some characteristics on the boundary of each cadastral map segment [2], and assembling segments by the matching results of the characteristics. Hence the idea has been using fewer boundary characteristics to reduce computational complexity. Although the processing time mighty be low, the drawback is that when the shape of the segment becomes complex, the boundary characteristics cannot be accurately extracted.

Since this problem arises, we therefore propose automatic cadastral map assembling technique by common longest boundary detection based on generalized Hough transformation (GHT)[3].

Detecting a feature from an image, using the Hough transformation is effective when the feature is expressed by the algebraic equation. When the object to be detected is a straight line, Hough transformation is effective to detect it even it is a broken line.

This paper is organized as follows. The next section presents the principle of cadastral map assembling. Section 3 describes the efficiency improvement by segment reduction. Section 4 describes the process of cadastral map assembling with actual map. The experiments and the results are given in section 5.

2 Principle of Cadastral Map Assembling

2.1 Common longest boundary

When two different segments share a part of each boundary, the common part of the boundary line is called a common boundary. In general there is a possibility that two or more common boundaries exist between two segments. It is necessary to decide the true common boundary to connect two segments correctly from these two or more common boundaries. For instance, two or more common boundaries can exist between segment A and segment B as shown in figure 1(showed by the arrow in (c) and (d)). The true common boundary is shown by the arrow in Figure 1 (e).

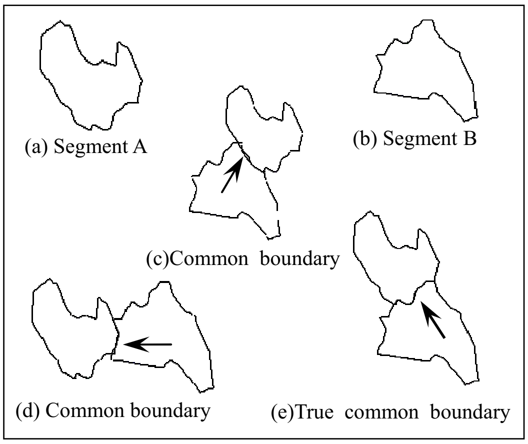

Figure 1. Two segments and common boundaries

In the proposed technique, we assume that when two segments are accurately assembled, the length of the common boundary becomes the maximum. This assumption is always used in the jigsaw puzzle game, and is thought to be generally correct in the cadastral map assembling except in special cases. Among two or more common boundaries that exist between two segments, if we define the longest common boundary as the common longest boundary, the detection of the common longest boundary is the point of the cadastral map assembling.

2.2 Detection of the common longest boundary based on Generalized Hough Transformation

Generalized Hough Transformation (GHT) is used for the detection of the common longest boundary between segments. The flow of GHT for two segments is shown in figure 2. However, the direction of the segment is assumed to be fixed, and the rotation is not considered. The steps for GHT are as follows.

(1) The border of each segment is traced.

(2) The center of gravity of border B is defined as the origin point of border B.

(3) A symmetrical border B' with the origin point is generated.

(4) Sweeping of border B' with the origin on the border A, and generate the image of GHT.

(5) Detection of the point which the crossing count (drawing frequency) is the largest from the image of GHT, and the point becomes the origin of segment B.

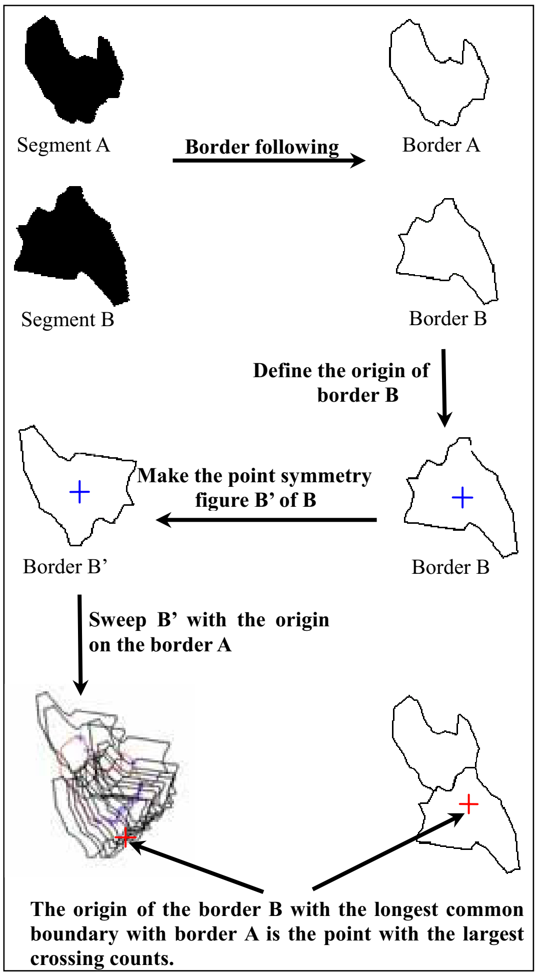

Figure 2. Flow of GHT

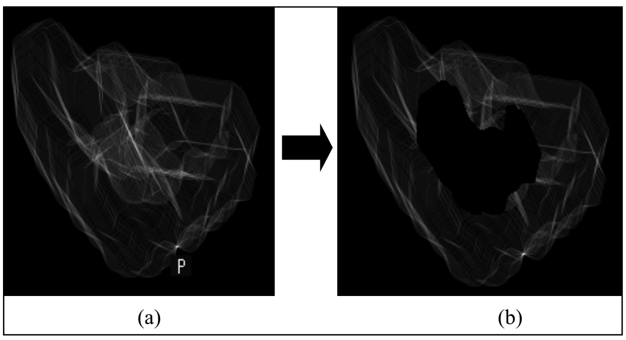

Figure 3. GHT image

This point becomes the origin point of segment B when segment A and segment B is assembled based on the common longest boundary. Figure 3 (a) illustrates the GHT image between segment A and segment B. In this figure, the gray level is higher as much as the crossing counts. The brightest point P in figure 3 (a), at which the crossing count is the largest, becomes the origin of segment B.

2.3 Common area constraint

When two segments are assembled based on the common longest boundary, they sometimes overlap each other as shown in a black area in figure 4(a) (b). On the other hand, such an overlap does not happen when segments assembled correctly as shown in figure 4(c).

To solve this problem, we propose to use common area constraint. When the common area between segments is minimized, it is more likely to have accurate assembling. The image (see figure 3(b)) that paints out the area of segment A from GHT image is used for extracting the maximum point in order of crossing counts. Ratio Rs of the common areas is calculated by expression (1) when two segments assembled with each maximum point.

$$Rs = \frac{s(A \cap B)}{s(A \cup B)} \quad \cdots\cdots\cdots (1)$$

Where, $s(A)$ is the area of segment A, $A \cap B$ and $A \cup B$ are the logical product and the logical addition of the area of segment A and segment B. Two segments are assembled by using the first maximum point of which the value of Rs becomes below the threshold t among the maximum points. This point is only called the maximum point of the crossing count. The value for t (t=0.05) was experimentally decided.

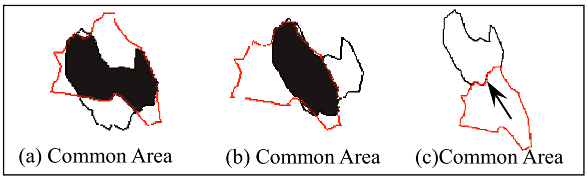

Figure 4. Common area

3 Efficiency Improvement by Segment Reduction

In an actual cadastral map segment, the size of the image is huge. The processing time is long when performing generalized Hough transformation (GHT) with the chain coded segment. It is necessary to reduce the segment to shorten the total processing time of the cadastral map assembling.

The interpolation method is used for the segment reduction. The flow of the segment reduction is described as follows.

(1) Saving the Coordinates of a black pixel of the segment.

(2) Each coordinate is multiplied by a reduction ratio α (0.1≤α≤1), and rounded off to the nearest integer. The same coordinates are removed.

(3) The reduced segment is generated by using obtained new coordinates.

Using above procedure, we obtain new reduced segments and these segments are used in the cadastral map assembling.

4 Assembling of Actual Cadastral Map

Various connected component such as roads, border-lines, exist together in an actual cadastral map. They are chiefly included in an internal area of the cadastral map, and it is preferably to delete these elements as much as possible because they mighty cause noise in the common boundary detection of the cadastral map. Because each segment was made individually in each district, the direction of the north arrow of each segment is different. Every segment has a north arrow, it is necessary to extract this north arrow, and to regularize direction of the north arrow of each segment.

As therefore, the procedure of the actual cadastral map assembling is as follows.

(1) Preprocessing of cadastral map including removing noise in the internal area and the extraction and regularization of north arrow for each segment.

(2) Automatic cadastral map assembling based on generalized Hough transformation (GHT).

4.1 Preprocessing of Cadastral Map

Various connected component such as map symbol, number and character (refer to figure 5(a)), and etc, are included in an internal area of the cadastral map. Moreover, the north arrow of each segment is assumed to be isolated in an external area of the cadastral map. The result of painting out the internal area and extraction and regularization of the north arrow is shown in figure 5(b).

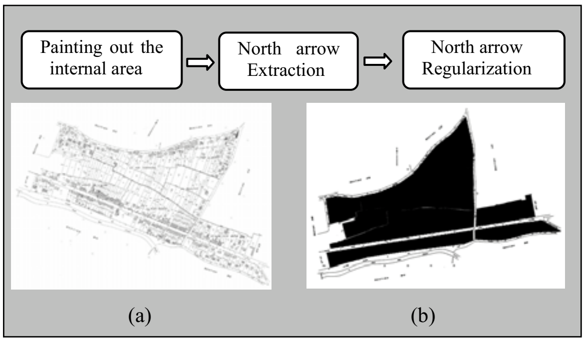

Figure 5. Preprocessing of cadastral map

4.2 Cadastral Map Assembling Based on Generalized Hough Transformation

This subsection explains the process of the map assembling based on GHT. Table 1 shows the process of the assembling that consists of five segments (refer to figure 6(a)).

An arbitrary segment (Here, segment A) is selected, and it is assumed as the starting segment. GHT is done between segment A and each segment, and the maximum point of crossing count is requested from the GHT image. The crossing count of the first maximum point by which the ratio of the common areas becomes below the threshold is assumed to be the maximum crossing count of this segment. When the ratio of the common areas becomes more than the threshold by all the maximum points, the maximum crossing count of this segment is set to 0. The segment with the largest crossing count is connected to segment A and it is assumed to be a new segment. In this example, because the crossing count of segment A and segment E is the largest, so, segment A and segment E are connected as a new segment. Next, GHT was done between the new segment and the rest segment. The above procedure is repeated, and the cadastral maps are assembled.

In this example, the assembling order is A→E→C→D→B.

Table 1. Assembling process

Crossing count	Segment				
	A	B	C	D	E
A	×	811	888	0	1064
A∪E	×	811	886	720	×
A∪E∪C	×	1033	×	1191	×
A∪E∪C∪D	×	1033	×	×	×

5 Experiments And Results

5.1 Experiments Data

The experimental data included images of the cadastral maps generated by a scanner. A total of 127 segments of French cadastral map were used from 24 cities for the experiments. Table 2 shows the number of segments of each city.

5.2 Experiments for Map Assembling based on Generalized Hough Transformation

The experiments for map assembling were done using cadastral maps of 24 cities. Figure 6(b) shows the experimental results for five segments of Villiers city. Table 3 shows all the experimental results. The success rate in table 3 was visually judged.

6 cities failed according to the experiment result of the map assembling without common area constraint. The reason of this failure is that when two segments assembled based on the common longest boundary, find from

Table 2. Data used in this research

City	Segment number	City	Segment number	City	Segment number
Baily	5	**A**	4	**Vioflay**	5
Buc	8	**Villiers**	5	**Toussue**	5
Bourg	2	**Chavenay**	5	**LesLoges**	4
Bios	7	**FeucheroA**	6	**Montesson**	6
Bougival	5	**Houilles**	6	**Fontenay**	6
Boul	3	**HOUI**	6	**CelleSaint**	6
Carrieres	7	**Jouy**	5	**LesClayes**	5
Chesnay	5	**Noisy**	5	**FeucheroZ**	6

Table 3. Average success rate of map assembling

Success Rate	
Without Common Area Constraint	With Common Area Constraint
75.0% (18/24)	100% (24/24)

the GHT image, they overlapped each other. This problem can be solved by the common area constraint. The example of the failure assembling becoming a success assembling is shown in figure 7 with common area constraint.

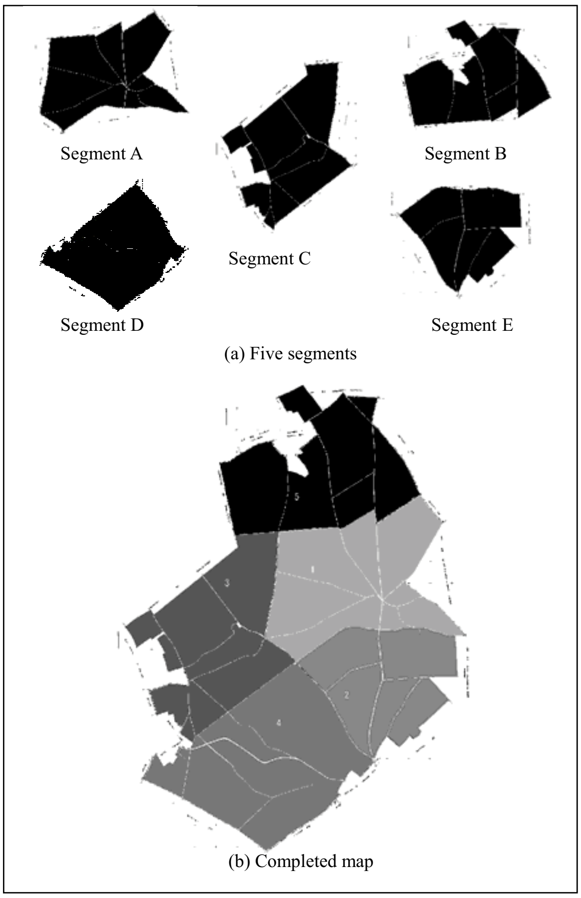

Figure 6. Result of assembling the Villiers City

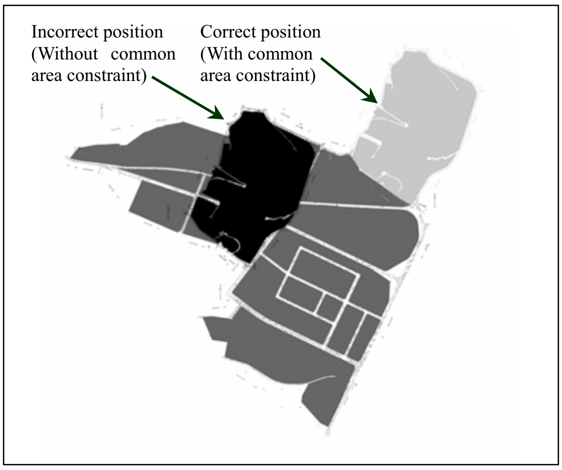

Figure 7. Example of map assembling improved by common area constraint

5.3 Experiments of Efficiency Improvement by Segment Reduction

Experiments were done while changing reduction rate α (0.1≤α≤ 1) with 24 cities' segment cadastral maps. Figure 8 shows the result about the success rate and the processing time with α. In the figure, the bars show the processing time and the line shows the success rate of the map assembling.

According to the experiment result, the experiment of the map assembling was done correctly at α=0.3. It can be noted that the processing time could be six times less than when α=1.

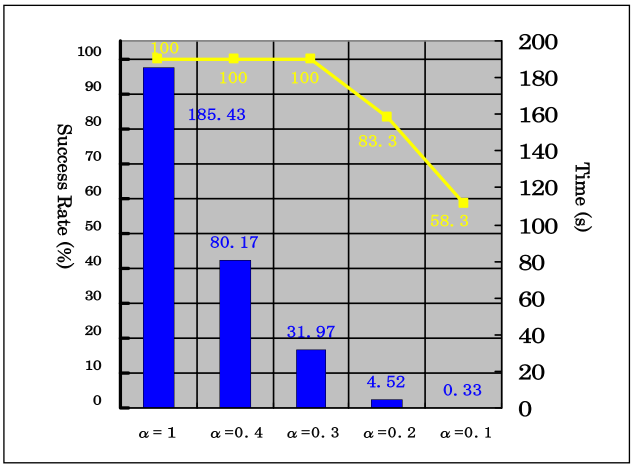

Figure 8. Performance efficiency

6 Conclusion

In this paper, a technique of the cadastral map assembling that uses generalized Hough transformation (GHT) and the efficiency improvement based on segment reduction have been proposed. Experiments were done with French cadastral maps. By the experiment result, GHT is an effective technique for cadastral map. And we could improve the processing efficiency by segment reduction.

Our future work will focus on (1) Performance evaluation for large amount of cadastral maps, (2) Introduction of recognition systems of other information included in cadastral maps such as characters and numbers.

References

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