Automated Creation of Road Network from Road Edges

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Abstract: In this paper, a framework for creating road network from road edges is proposed. The present framework mainly includes two modules: road modeler and network generator. Road modeler creates the road polygons from the original road edges, and network generator performs converting road polygons to road network with good connectivity at all intersections. A prototype system is also built, and some experimental results are also presented to demonstrate the effectiveness of the proposed framework.

Keywords: GIS, Spatial Data Analysis, Centerline, Road Network, Automatic Process.

1. Introduction

Nowadays, many digital maps are maintained or created on large scales where roads are usually described by lines. These lines, called road edges below, may be the curb lines or the boundaries of the corresponding road area. Meanwhile, roads are widely defined by road centerlines or road network in a small-scaled map and some GIS (Geographic Information System) datasets for either simplicity or convenient to be analyzed. To create or update road network efficiently, conversion from road edges to road network become necessary.

There are some papers about the processing of road centerlines or generalization of polygonal roads [1,2], but rare researches are found for creating road network from road edges. In the digital maps for our experiments, roads are rep-resented with lines or road edges. Although some efforts have been made to utilize polygons to represent road region, most of real road features are nothing but a set of lines. In other words, we do not know which side of a road edge is inside the corresponding road region.

In this paper, a new framework is proposed to create road network from road edges automatically. The present framework is composed of two modules: road modeler and network generator. With road modeler, road edges are processed to fill road area firstly, and to create road polygons consequently by splitting the filled area to polygons at intersections. On the other hand, network generator converts the road polygons to the road centerlines, and connects all centerlines topologically.

For the convenience of the following explanation, we firstly clarify some key words used in this paper. A road edge means a curb line, which is the right or left side of a road. A road region is the area inside a road between intersections and does not include any intersections. A centerline is a line representing the center of a road, and begins and ends at different intersections. In other words, a centerline does not include any intersection point. Road network is a set of topologically extended centerlines. In other words, every extended centerline is connected with other ones or stops at the end of a road. As compared to road centerlines, road network emphasizes the topology of the road data.

In the following sections, we discuss the details of the framework. Section 2 describes the processing steps in road modeler and network generator. Some experimental results are shown in section 3. Section 4 concludes this paper with discussion.

2. Framework and Its Processes

The proposed framework of creating road network from road edges is shown in Fig. 1. Here, the input data is a set of road edges, and the output includes two datasets: road polygons and road network. Road Modeler works to create road polygons from the input individual road edges, and Network Generator carries out the consequential process to create road network.

Two modules in Fig. 1 include following processes:

(1) Resampling road edges;
(2) Creating TIN (Triangulated Irregular Network);
(3) Analyzing triangles;
(4) Filling the triangles inside the road;
(5) Grouping the filled triangles to create road polygons;
(6) Optionally merging the polygons for main roads by passing through the intersections based on their widths and directions;
(7) Creating centerlines for every road polygon;
(8) Extending the centerlines topologically to create road network.

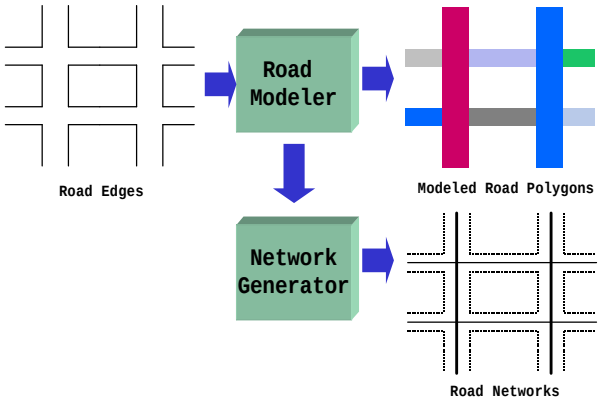


Fig. 1 Framework of Creating Road Network from Road Edges

Here, steps (1) – (6) are included in road modeler, and step (7) and (8) are processing steps of network generator. All steps will be discussed in the following subsections.

1) Road Modeler

The workflow of road modeler is illustrated in Fig. 2. Here, step (1) to (6) are carried out sequentially, and the processed results, marked as (a) to (f), are shown in Fig. 3. Resampling road edges before creating TIN makes it easy to analyze the triangles in the TIN and to find a seed triangle, which is inside the road region with the highest probability [3]. Here, a possible seed triangle should have only one original road edge and two adjoining inverted similar triangles. And the seed triangle is the triangle with the largest area among all possible seed triangles. Filling process can not go through an original road edge and also stops at an edge that links two end points of the original road edges. The filling process may be repeated, if the road regions are not connected with each other.

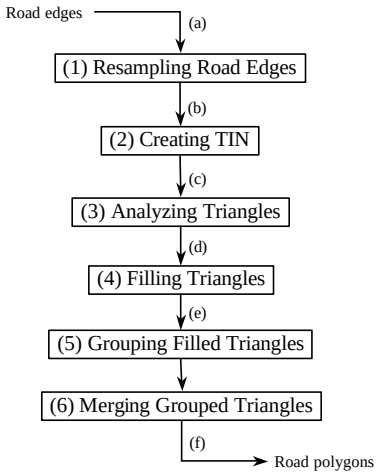


Fig. 2 Workflow of Road Modeler

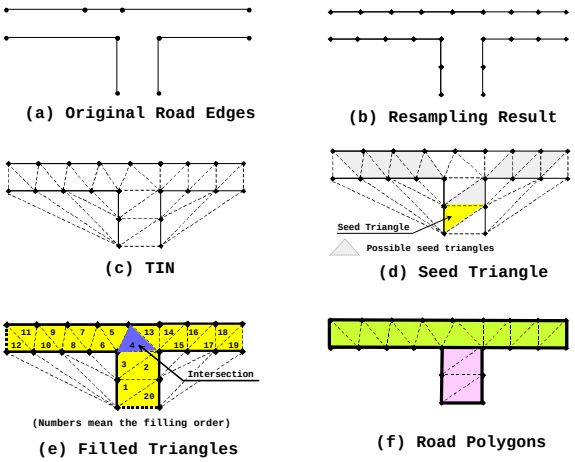


Fig. 3 Step Results of Road Modeler

Grouping the filled triangles works to gather the connected filled triangles and extract their outline as a road region. A road region does not include any intersection triangle. Merging road regions is an optional process and functions as an operator to connect adjoining road regions to create a road polygon by passing through some intersections. The widths and directions of two adjoining regions at the same intersection determine whether they can be merged or not.

2) Network Generator

Network generator includes two processing: (7) creating centerlines and (8) extending the centerlines to create road network. To create a centerline for a road region, the turning points must be determined firstly for all road polygons. For a road polygon, a turning point means the position where its centerline will begin or end at. The turning points are identified by analyzing the relationship of all adjoining road regions. Fig. 4 shows the relationship of some real road regions. Here, road regions are shown in different colors, A to J represent merged road polygons (result of road modeler), and a to i are intersections. As an example, the turning points of road polygon G are inside intersections c and d respectively. In detail, the left turning point is the middle point of the common edge between D and G, and the right one is the middle point of the common edge between G and E, as shown in Fig. 4. Therefore, the centerline of road polygon G should be the line linked two turning points in intersection c and d respectively. As to road polygon D, its centerline should neither begin nor end at intersections a, c and e, which are passed by the polygon D.

After the turning points are fixed for every road polygon, the calculation of centerlines is straightaway. Two turning points split a road polygon to two polylines. Then, a centerline is calculated by connecting all middle points of the perpendicular lines from vertexes to their opposite polyline, as shown in Fig. 5. Here, some attentions must be paid to avoid the crosses between and the order of perpendicular lines.

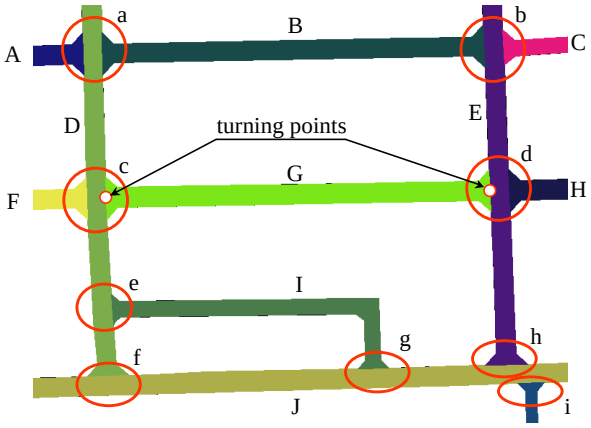


Fig. 4 Relationship of Adjoining Road Regions

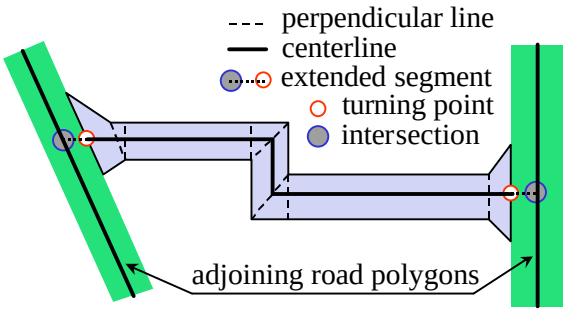


Fig. 5 Calculation of Centerline

The centerlines created above are from a turning point to another turning point (Fig. 5). Extending centerlines process works to connect each turning point of a centerline with its near intersection, which will be inserted on the adjoining centerline if there is no intersection point.

3. Experiments

We developed a prototype system to confirm the principle and the effectiveness of the present framework. Fig. 6 shows the prototype system with an original dataset of road edges, and the experimental results are shown in Fig. 7. The result shows that the present framework can cope with individual road edges well.

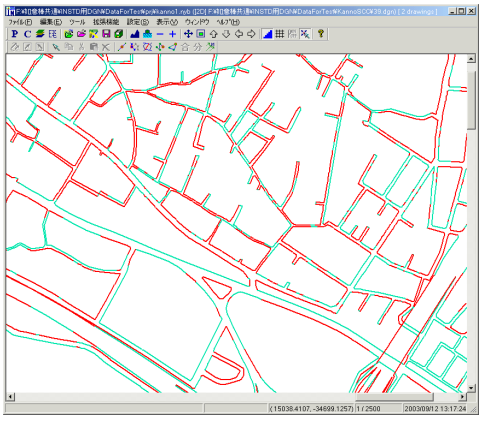
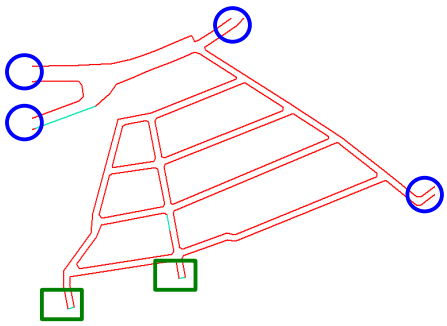
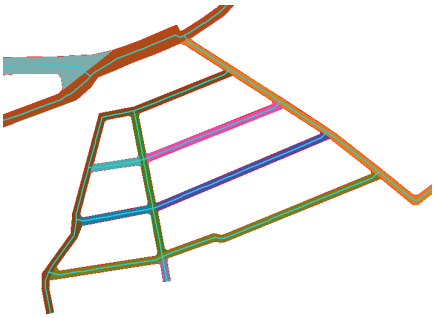


Fig. 6 Prototype System



(a) Original road edges, where there are both opened road areas (blue circles) and closed ones (green rectangles)



(b) The created road polygons (different colors for different polygons) and network (light blue).

Fig. 7 Experimental Results

4. Discussion and Conclusions

We have presented a new framework for creating road network from individual road edges. The framework is composed of two modules, road modeler and network generator. Whether the original road edges are marked as right or left curb or not, road modeler works well in creating road polygons from the input edges. Consequently, the road polygons are collapsed to road network by the network generator. We also concluded that the present framework runs very well though the experimental results.

The performance of an automatic process usually varies with the quality of the input data. The proposed framework here is also limited by the input road edges. For example, one-side or crossed road edges will influence the processing results of the proposed framework. One-side road edges mean that there are only right or left curbs for some road region. This case can not be processed and the corresponding data should be deleted before automatic processing. Crossed road edges may exist for overpasses or underpasses, such as a bridge over the other road. In the current prototype system, the process of crossed road edges is limited by the TIN creation procedure, which can only cope with two-dimensional geometric data. This limitation will be further discussed in our future works.

References

[1] Kreveld M. and J. Peschier, 1998. On the automated generalization of road network maps, *Proc. 3rd Int. Co nf. on GeoComputation (CDROM)*. Available at: http: //divcom.otago.ac.nz/SIRC/GeoComp/GeoComp98/21/gc _21.htm.

[2] Annita N. Wilschut, Roelof van Zwol, Jan Flokstra, Nick Brasa, and Wilko Quak, 1998. Road Collapse in Magnum. ACM-GIS 1998: 20-27.

[3] Wang P., T. Doihara, K. Oda and W. Lu, 2000. 3D city modeling with laser range data and 2D maps, *Proc. of MVA2000*, Tokyo, pp.