

GENERALIZATION OF DIGITAL TOPOGRAPHIC MAP USING HYBRID LINE SIMPLIFICATION

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ABSTRACT

A cartographic line feature is a succession of segments with various geometric and visual properties. Thus, it is useful to segment and enrich the line data in order to apply the best algorithm and the appropriate parameters to each section. In this study, a hybrid method of line simplification that combines two different line simplification methods is proposed and applied to a topographic map. This method consists of three steps. First, it analyzes the relationship between the characteristics of lines and the error resulting from the application of the existing simplification methods. Second, it segments line features based on the analysis and allocates a suitable line simplification method which produces minimal positional errors on each segment by using expandable moving window. Finally, it applies the allocated simplification algorithm on each segment and merges all of the segments. During the test of the proposed method, 1:1000 scale topographic maps are generalized to a 1:5000 scale map. The simplified results are then analyzed by vector displacement. The results show that the hybrid line simplification method outperforms the two earlier line simplification algorithms.

INTRODUCTION

The importance of line simplification method in map generalization has been emphasized in many studies. Cartographic lines consist of sections which have different geometric and visual characteristics. Therefore, it would be useful to segment and enrich the line data in order to apply the best algorithm and the appropriate parameters to each section (Plazanet, 1997; Dutton, 1999; Richardson and Mackaness, 1999; Balboa and Lopez, 2008).

Segmentation methods based on the shape measurements of line feature and the application of it to line simplification have been proposed in the studies of Van der Poorten and Jones(2002), Chen and Chen(2005), and Balboa and Lopez(2009). Recently, line segmentation methods that use artificial intelligence or machine learning have been suggested in order to segment line features more analytically (Mustiere, 2005; Balboa and Lopez, 2008). However there are few studies about the segmentation and simplification methods for linear generalization that considers the relationship between the shape of line feature and the line simplification algorithm.

In this study, we present a segmentation method from the basis of the quantitative analysis on the performances of the simplification algorithms according to the characteristics of linear feature. Moreover, we propose a hybrid simplification method that applies the simplification algorithm which is expected to produce less positional error after simplifying each segment.

SEGMENTATION AND SIMPLIFICATION METHOD

Figure 1. shows the process of segmentation and simplification method proposed in this study.

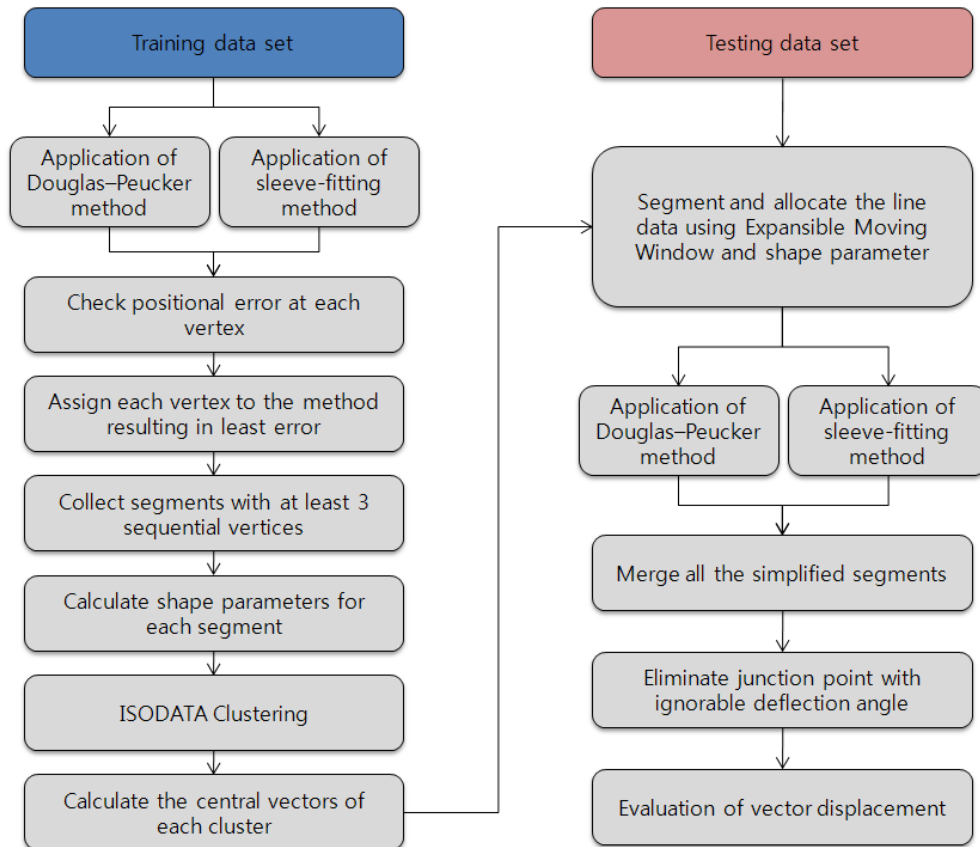


Figure 1. The process of this study.

As the first step, two line simplification algorithms (Douglas-Peucker algorithm and sleeve fitting algorithm), generally known for good performances, are applied to the linear feature data on a digital topographic map. Then, the positional error resulted by two algorithms is calculated at each vertex. Using this error, the segments are extracted which produce the least error when two algorithms are applied to. These segments gathered by algorithms are called exclusive superior segment (hereafter ESS) in this study. From ESSs for each algorithm, the measurements of shape characteristics are calculated and compressed by ISODATA clustering.

For segmenting the testing line data, a segmentation method by using expansible moving window (hereafter EMW) is applied. In this method, moving window is expanded by one vertex until the shape characteristics of vertices in moving window are homogeneous. Figure 2. shows the flow diagram of the segmentation method using EMW.

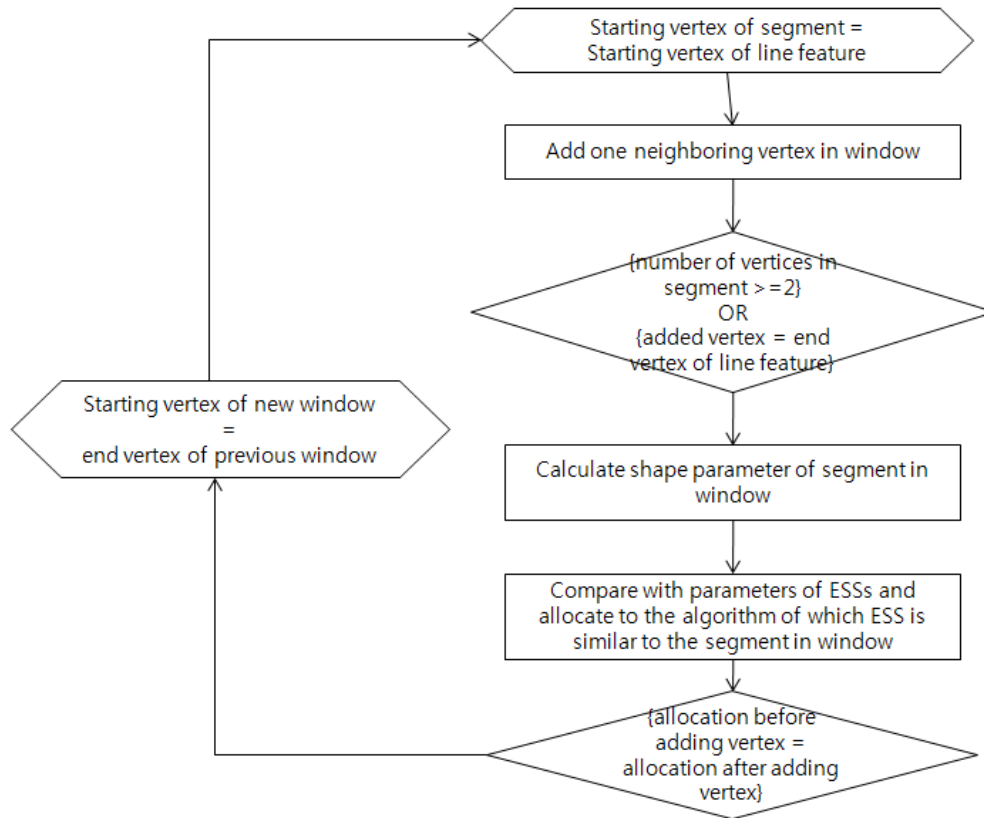


Figure 2. The flow chart of the segmentation method using EMW.

The segments of testing line data resulted from the above method are simplified by the allocated simplification algorithm. In this simplification process, two algorithms are applied to the segments which have high probability to produce less positional errors. The whole simplified line feature is obtained by combining the simplified segments. Figure 3. shows the result of segmentation and simplification by the above process.

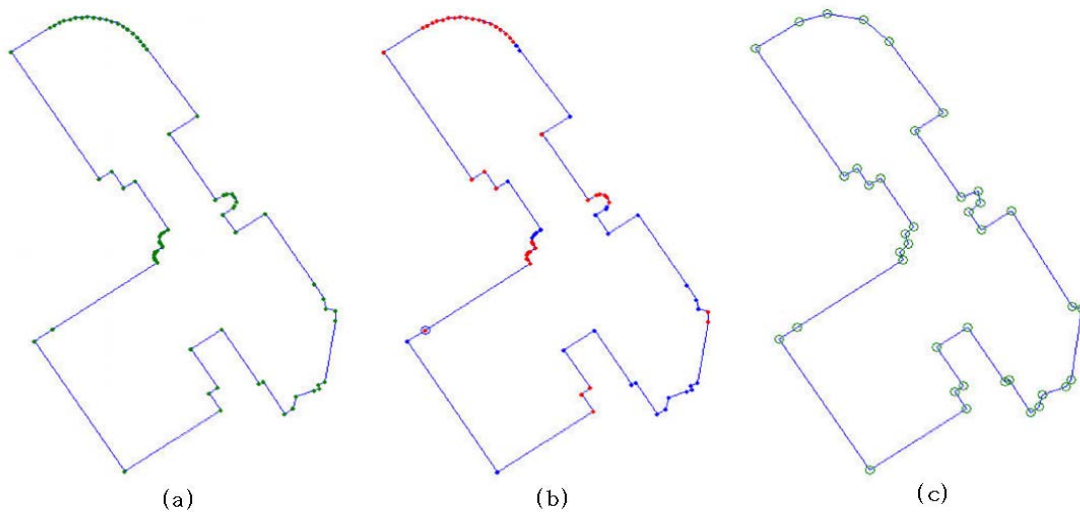


Figure 3. An example of the segmentation and simplification. (a) the original line feature, (b) the result of segmentation using EMW, red points are allocated to the Douglas-Peucker algorithm and blue points are allocated to the sleeve fitting algorithm and (c) the result of hybrid simplification method.

TEST AND RESULT

4 pieces of 1:1000 digital topographic map of Daejeon city are used for dataset. Building outlines, road boundaries, river boundaries are extracted for the test. Training dataset is composed of 22 Building outlines, 20 road boundaries and 10 river boundaries and validation dataset consists of 66 Building outlines, 60 road boundaries and 30 river boundaries. ArcGIS 9.0 and Matlab 7.0 are used for applying and validating suggested process. Next figure is an example result of the hybrid simplification method, Douglas-Peucker algorithm and sleeve-fitting algorithm applied to a building outline.

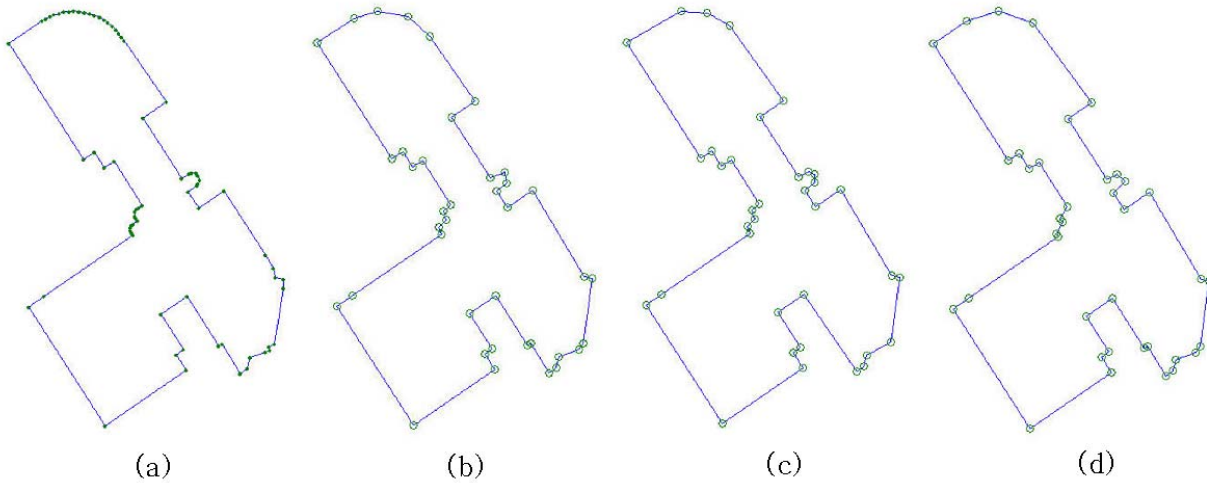


Figure 4. Results of simplification, (a) the original line feature, (b) hybrid line simplification method, (c) Douglas-Peucker algorithm and (d) sleeve fitting algorithm.

It shows that the simplification results have some differences between four results, especially in the curvy or winding area. In this study, we measured the vector displacement between before and after the simplification using TLVD((Total Length of Vector Displacement) for quantitative evaluation. As a result, applying hybrid generalization method performs better than applying other generalization algorithm separately. In particular, value of vector displacement was the lowest in not only total data but also in each subclass (buildings, roads, rivers).

Table 1. Vector displacement. DP is Douglas-Peucker algorithm, SF is sleeve fitting algorithm and HY is hybrid simplification method

	DP	SF	HY
All	0.048325	0.062772	0.038489
Building	0.053246	0.058393	0.039679
River	0.073657	0.113292	0.067125
Road	0.032965	0.043968	0.024769

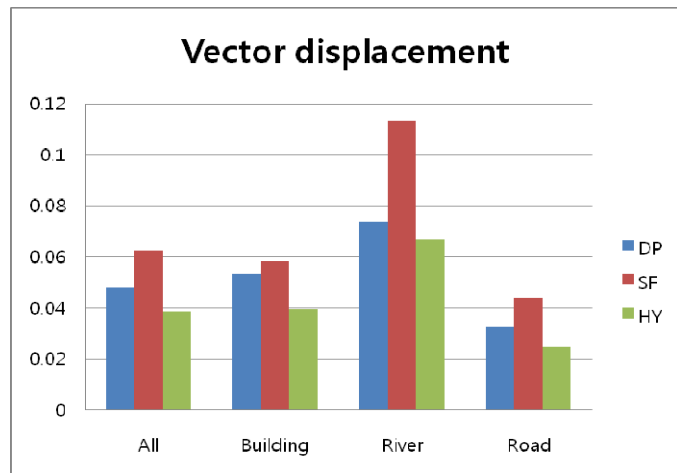


Figure 5. Vector displacement.

CONCLUSION

In the generalization of digital topographic maps, it can be useful to segment linear feature with proper criterions and apply the optimum generalization algorithms considering shape characteristics of each segment can be useful. In this study, we propose the hybrid line simplification method, which is fused with some line simplification algorithms. For this, we, first, analyzed the effect of the single simplification algorithm and segmented the linear data with EMW segmentation based on the previously analyzed results. Divided segments are applied to the hybrid simplification method, and gathered up to the whole generalized linear data. When we applied these methods on the linear data of the digital topographic maps, we found that the hybrid simplification method is averagely more outstanding than the single simplification algorithms in terms of the vector displacement. Also, this is same when we compared the results to the classes of linear features. According to these evaluations, the EMW segmentation method and the hybrid simplification method can be valuable in generalization procedure of digital topographic maps.

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