Simplifying Lines for the Creation of a Space-Scale Cube

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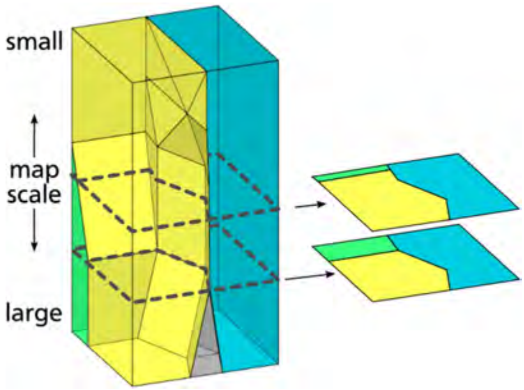

To provide real smooth changes of zooming, the concept of the space-scale cube (SSC) was developed. The bottom of the SSC is a detailed topographic map of area objects, then all the area objects extrude along the z-axis. In the SSC, an area on the map becomes a polyhedron, and the common boundary of two areas is a vertical 'wall'. Whenever a generalization operation happens, the extrusions of the involved areas stop; then, the newly generated areas take the place and start to extrude. On this basis, the map at any scale can be generated by slicing the SSC with a horizontal plane at a corresponding z-coordinate. Also oblique slice planes can be used (perspective view), resulting in a map with different embedded levels of detail.

The SSC model is created based on an automatic generalization process of a 2D map (pre-process), which tracks and stores the modifications that each generalization operator makes to the map (either to the areas or lines of the map) in a data structure, which we call topological Generalized Area Partioning (tGAP). A valid planar partition is maintained to simplify development of generalization operators (valid meaning: all areas cover whole extent of the map, without gaps nor overlap and without segment-segment intersections of boundaries of the areas). This partition is modified continuously throughout the map generalization process. For example, boundaries between areas are removed when areas are merged, new boundaries are inserted when an area is split over its neighbors, lines are simplified, which in turn removes vertices and changes the extent of features. The modifications are stored, and based on this the SSC is constructed in a separate step. The data structures we use to represent the planar partition allows efficient spatial search, neighborhood determination, correct storage of explicit topological relationships and flexible updates.

Currently, we are investigating how to best represent lines and linear networks (roads, water) in the SSC. Many cartographic line simplification algorithms have been proposed. Often lines are taken out of the map and simplified in isolation. Most algorithms therefore ignore relations with other features.

In the pre-processing this leads to the following questions:

- How to track efficiently which poly-lines are eligible for simplification?
- How frequently to simplify the lines?
- How to deal with thresholds that are unique for different algorithms?
- How to make sure that lines are considering neighboring features? E.g. not too close to other lines (make narrow area parts), not create intersecting geometries with other lines, making sure that parallel lines are simplified in a similar way (e.g. two sides of river should be simplified in turns to keep balance).
- How to detect and resolve narrow area features (or parts of areas) that may appear due to line simplification?

In the conversion to / using the SSC for rendering a map this leads to the question:

- How to represent the line segments of the simplified lines in the SSC, so that it is also efficient to render them?