Two Demos: 1) Automatic generalization of buildings for small scales using typification 2) Streaming Generalization

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1 INTRODUCTION

In the presentation two demos will be given:

1) an automatic algorithm for the generalization of buildings for smaller scales using typification
2) streaming generalization: progressively transmitting more and more details of spatial data when zoom level is increased

In the following a brief background for both procedures is given, together with some screenshots. More details about the approaches is given in the referenced papers, where also an overview of related work is given.

2 TYPIFICATION

The idea of typification is that a group of similar objects is represented by a group of less objects. This reduction in the number of objects, however, has to take the spatial distribution and spatial density of the objects into account. The algorithm for typification is based on Kohonen feature maps (see Sester [2004]). This algorithm works on a point-basis, i.e. all objects have to be reduced to points. In order to be able to also process extended objects like buildings, the following procedure has to be applied:

1. given a target scale and reduction rate, this leads to the number of buildings in the target scale *nz*.
2. from all buildings in the original data set *nz* are selected randomly; in the selection process, however, larger buildings are slightly prioritized. The buildings are reduced to their centroids.
3. processing of the centroids using Kohonen feature maps leads to re-arranged building centroids.
4. these centroids have to be assigned a building symbol: in the vicinity of the re-arranged object the nearest building in the original data set is searched for. Depending on its size, it is either presented as original shape (if the size is larger than a scale dependent threshold), otherwise it is presented as a square symbol with the orientation of the original building.
5. in order to prevent that the new buildings and the streets overlap, the buildings and the street network are processed with the displacement algorithm PUSH, also developed at the ikg.
6. in the case the required number of objects could not be placed in a mesh, a smaller reduction rate is chosen and the whole process is repeated. This is done

until the buildings could be placed adequately, or a minimum reduction rate is reached.

In the following some results of the processing are shown. Figure 1 shows how the buildings are generalized for the target scale 1:50.000 and to produce a digital topographic map (DTK50).

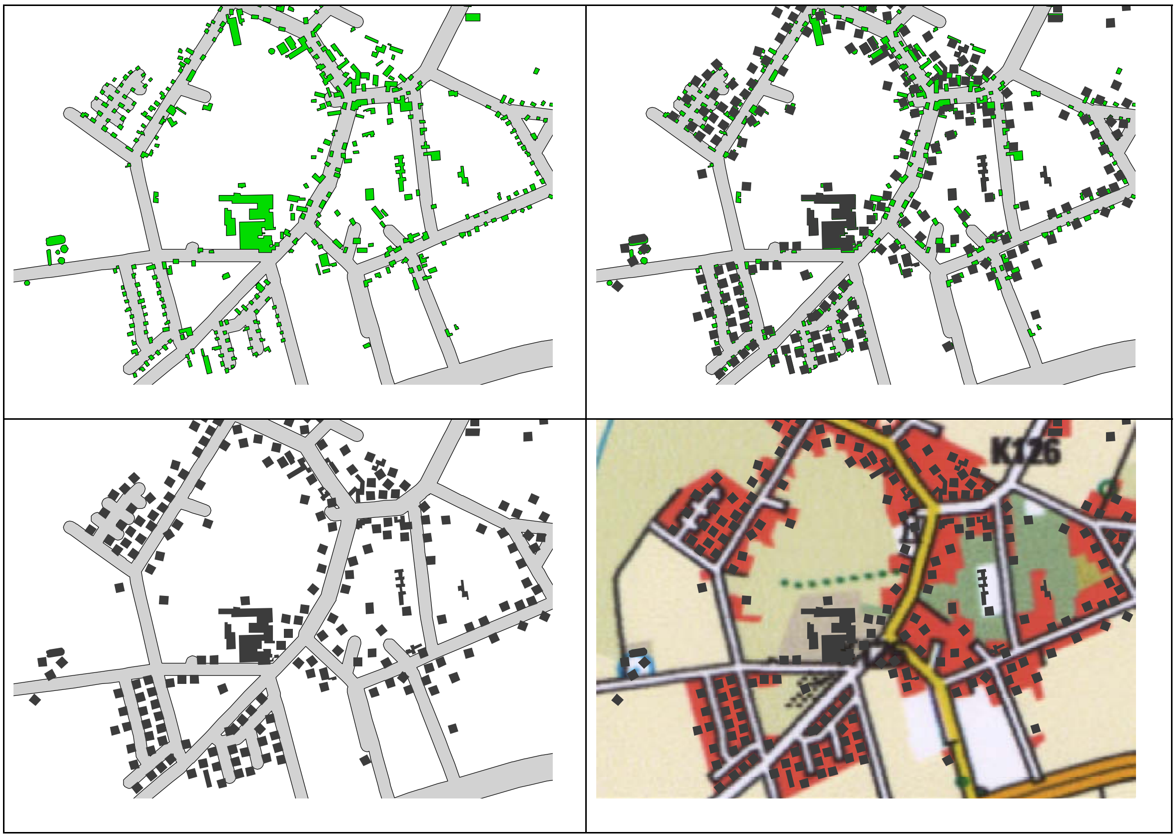

Figure 1: Generalization for digital topographic map 1:50.000 (DTK50): a) simple overlay of cadastral data and topographic roads, b) overlay of result and original data, c) result, d) result in DTK50 map style.

Figure 2 shows how different generalization levels can be produced with the same process, by simple changing the target scale. In this case, the scales 1:25.000, 1:50.000 and 1:75.000 were produced fully automatically.

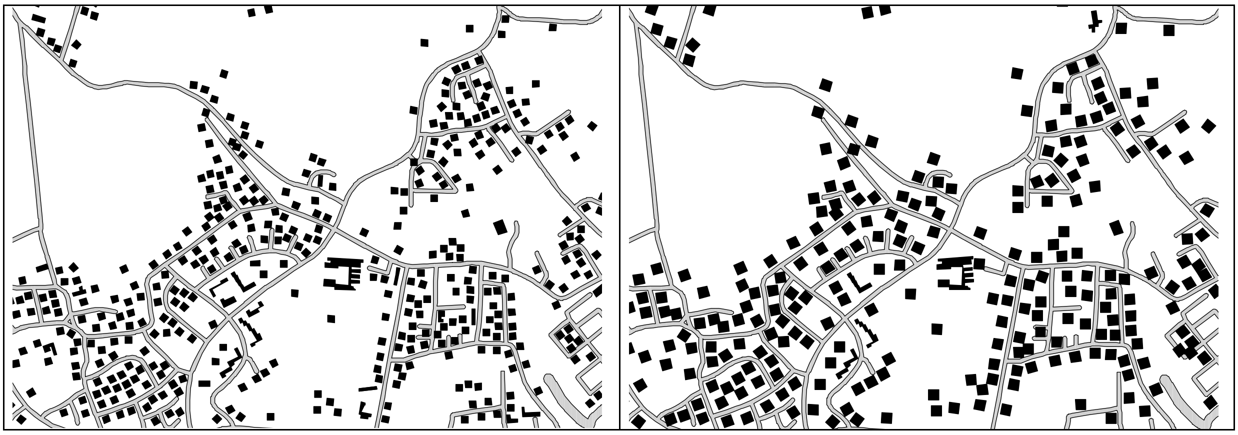

Figure 2: Buildings in different target scales: start situation: cadastral data (upper left), scale 1:25.000 (upper right), 1:50.000 (lower left), 1:75.000 (lower right).

Evaluation of the method

The process of generalization using Kohonen Feature maps is not deterministic, as is is based on a random selection of the buildings, thus leading to different results when the program is run a second time. However, in all cases the spatial density of the objects is preserved. The process can also be extended to generalize other types of objects: for point-objects (like wells), it is straightforward. For the generalization of areal objects of different size like some lakes, the main question is the re-assignment of the original objects after the process.

3 STREAMING GENERALIZATION

With the increasing availability of small mobile computers, there is also an increasing demand for visualizing cartographic objects on those devices. In order to be able to offer both detail and overview of a spatial situation, the devices have to provide flexible zooming in and out in real-time. The presentation of spatial data sets in different zoom levels or resolutions is usually achieved using generalization operations. When larger scale steps have to be overcome, the shape of individual objects typically changes dramatically, also objects may disappear or merge with others to form new objects. As theses steps typically are discrete in nature, this leads to “popping effects” when going from one level of detail to the other.

In this presentation, an approach is described to decompose generalization methods into elementary operations that can then be implemented in a continuous way. In the case of simplification of building ground plans, the elementary operations e.g. care for removing extrusions or intrusions of buildings, as well as offsets. Details about this approach can be found in [Sester & Brenner 2004].

The following simple operations (SOs) are defined – they can also be inverted, which allows for an incremental zooming in and out.

Opcode	Description	Parameters	Inverse Operation
`IV`	Insert Vertex	`IV` <edge id> <rel. position>	`RV` <edge id + 1>
`DV`	Duplicate Vertex	`DV` <vertex id>	`RV` <vertex id + 1>
`MV`	Move Vertex	`MV` <vertex id> <dx> <dy>	`MV` <vertex id> <-dx> <-dy>
`RV`	Remove Vertex	`RV` <vertex id>	–

Existing generalization operations have been adapted to describe the generalization in terms of these simple operations.

Line Simplification

In order to apply it for line simplification, the Douglas Peuker algorithm has been adapted by generating a BLG – an incremental refinement of a line, until at the leaves of the tree the original line is represented. At inner nodes, the scale levels (in terms of distances of the point from the line) are indicated (see Figure 3).

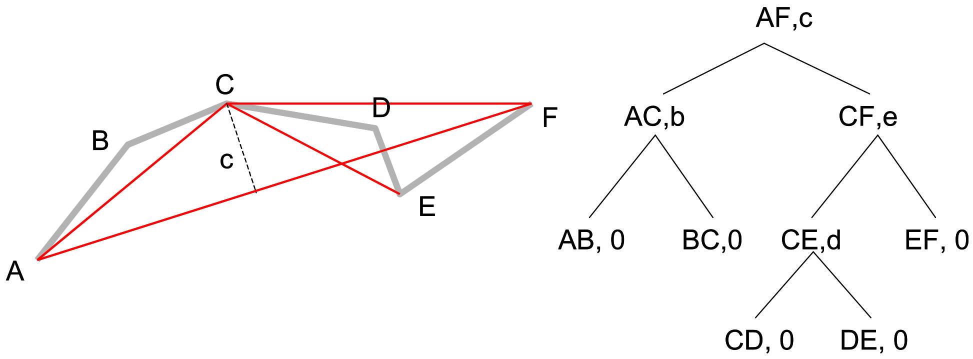

Figure 3: Original line (left) and corresponding BLG-tree (right); the scale levels are indicated in the nodes of the tree. At the leaves, the scale levels are zero.

This structure can be transformed into the simple operations. This is the basis for incrementally visualizing the data in different levels of detail, for which a client software has been established. The following Figure 4 shows incremental stages of the polygon representations in different increasing levels of detail.

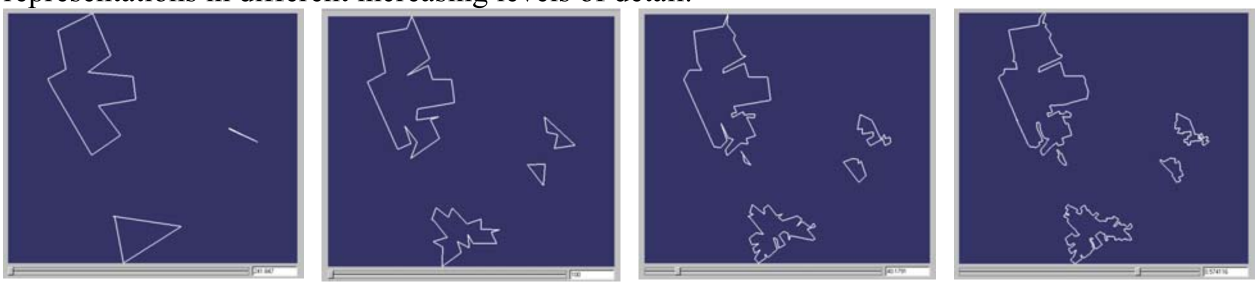

Figure 4: Screenshots visualizing increasing refinement of the polygon-visualization (from left right).

Figure 5 shows that the Douglas-Peuker algorithm is not appropriate for the generalization of structured objects such as buildings. Therefore, an algorithm for building generalization and the corresponding decomposition into SO's has been developed.

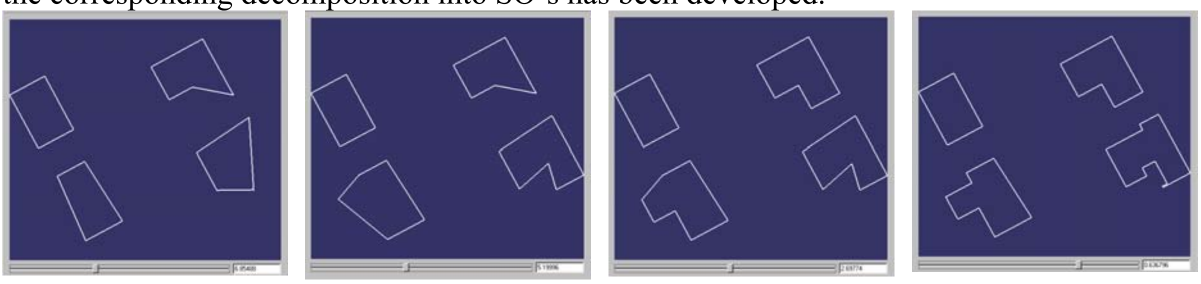

Figure 5: Sequence of images of using DP-algorithm to building generalization – which is obviously not suited for the generalization of such structured objects.

Building Simplification

The generation of the simple operations for generalizing the buildings shape relies on an algorithm presented in [Sester 2000]. To this end, elementary generalization operations (EGOs) have been defined as aggregations of simple operations, e.g. an EGO for offset, extrusion and corner. Figure 6 shows how, with increasing scale level, more and more objects appear, and also more details of their shape appear. Figure 7 shows a larger extent of a city area.

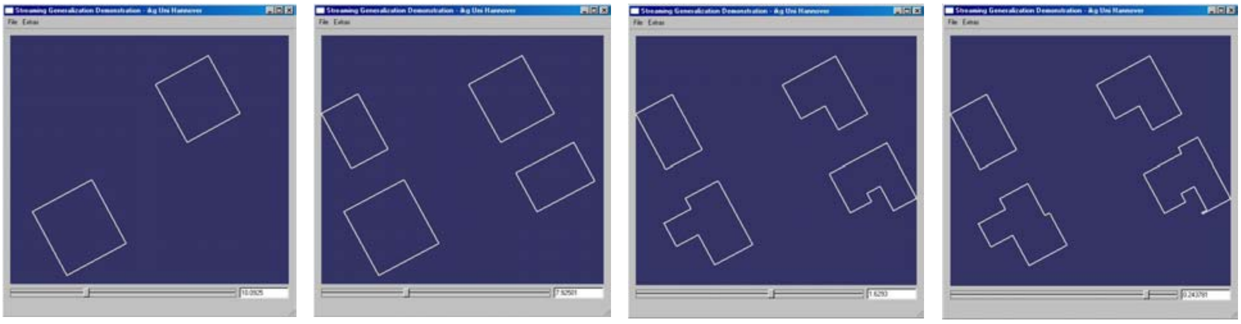

Figure 6: Presentation of four buildings in different levels of detail.

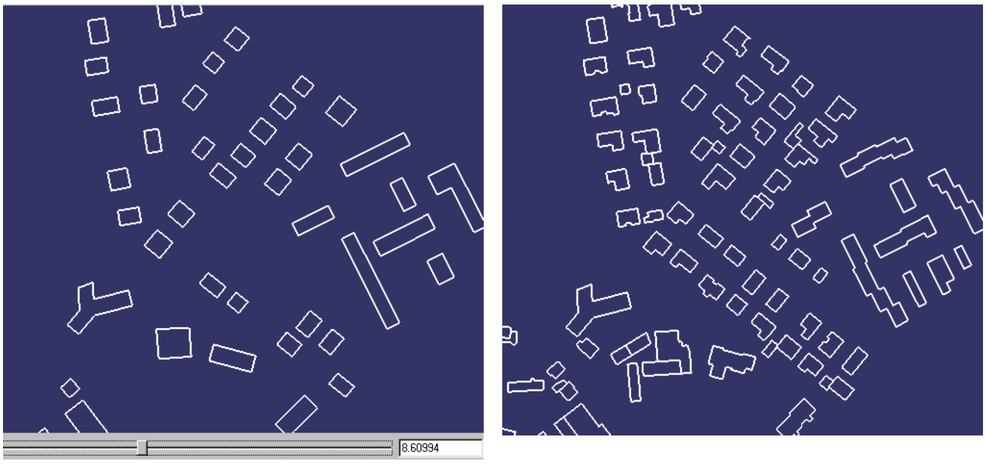

Figure 7: Two screenshots with different generalization levels of buildings in city.

Continuous Generalization

When a map representation is switched due to generalization, this usually leads to a visible "popping" effect. Compared to switching between different, fixed levels of detail, the use of the simple operations is already an improvement, since it gradually modifies the polygon rather than just replacing it as a whole.

However, one can still improve on this. Intermediate states can be defined which continuously change the object in response to an EGO. For example, a "collapse extrusion" EGO would be interpreted as "move extrusion until in coincides with the main part, then change the topology accordingly". We term this approach *continuous generalization* as it effectively allows to morph the object continuously from its coarsest to its finest representation. It is realized by decomposing the movement into a number of intermediate steps that give the impression of smooth changes. For more details see [Sester & Brenner, 2004].

4 LITERATURE

Sester, M., 2000, Generalization Based on Least Squares Adjustment. In: International Archives of Photogrammetry and Remote Sensing, Amsterdam, Netherlands, Vol. XXXIII, Part B4, pp. 931-938.

Sester, M. & Brenner, C., 2004: Continuous Generalization for Visualization on Small Mobile Devices, to appear: Proceedings of the SDH, Leicester, 2004.

Sester [2004]: Optimizing Approaches for Generalization and Data Abstraction, accepted for publication in: International Journal of Geographic Information Science.

(for reviews on related work see the references in these papers).