Design of a support system for cartographic generalization of a topographic reference base

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1. Introduction

A cartographic generalisation of base topographic databases is one of important tasks of contemporary cartography. To ensure interoperability of various thematic maps is an advantage to have common reference base. Due to different resolution demands of thematics above mentioned database should be able to change resolution. Purpose of works described in the paper is to design a simple environment for the cartographic generalisation of DMU-25 (The Digital Model of Territory in scale 1:25000 processed by Military Institute of Geography and Hydrometeorology).

1.1 A topographic reference database and context of works

The DMU-25 is a digital equivalent of the base military map 1:25000 (due to historical reasons in the Czech republic are two national mapping agencies – civil and military one). Geometry of this geodatabase is stored in several (32) layers in a topological-vector form. Some of features are duplicated (shores of lakes are part of water lines layer and polygons of lakes are in separate layer). Content of the database is recorded from analogue maps which are results of terrain mapping. A complete coverage of the Czech republic was finished in 2003 (oldest data sources were from 1990, but data were updated during database creation). The database was transformed from original coordinate system Gauss-Kruger on Krasovsky ellipsoid into UTM on WGS84.

Initial intention of database processing was to derive a reduced and simplified content for reference use in thematic electronic maps. Basic consequences of such direction is to avoid all annotation handling and stronger reduction of the content. According location of our laboratory we were focused on South Moravia region. According to the adaptive zooming, which is supposed to be in electronic maps, we decided to create multiresolution database with fluent change of the scale. By the term multiresolution database we understand a geodabase enriched by additional attributes which will control simple generalisation functions. These functions will rebuild geometry according to scale and purpose. All time consuming parts of cartographic generalisation is done by preprocessing and necessary parameters or description of geometry behaviour are stored. The support system for cartographic generalisation is intended to cover that preprocessing part of the multiresolution geodatabase creation.

2. The support system for cartographic generalisation

This support system is supposed to be kind of amplified intelligence approach to the cartographic generalisation. The idea is to offer bunch of simple generalisation functions for testing, functions for pattern recognition, functions for recognition of spatial conflicts and environment for record of manual corrections. The system is human driven, but offer automated functions, improve an operator orientation in a designed map face and make first evaluation of appropriate simple generalisation function with parameters (or statement of an insolvability).

2.1 A technological background

Development of the system is performed in the JUMP environment. The JUMP is a gis toolbox based on JTS (Java Topology Suite). Both tools were developed by Vivid Solutions and published like open source software. Around JUPM and JTS exists agile communities which continue in their development (actually, JUMP was even forked into several distros). A idea to use JTS for development is not something new (Harrie and Johansson,2003) and is quite frequent in academic community of generalizators. Our reasons for this choice was easy distribution of results, better control of algorithms and relative easy transmition of old algorithms from ESRI AVENUE environment. Another advantage was possibility to test processing algorithms based on JTS in visual JUMP environment.

2.2 Components of the system

The system is composed from four segments of functions which more or less follows usual structure of generalisation model (McMaster and Shea,1992, Weibel,1995). To help with pattern recognition are included auxiliary functions measuring shapes, densities, clusters and statistical character of regions. Results from these functions are used for evaluation of potential solution of recognized spatial conflicts. This proposal is based on flexible rule database which is continuously recorded from user corrections. The system select more likely solution (which was already used) according to semantic and cartometric characteristics of feature or it offer an generic solution based on semantic of feature or make insolvable statement. Third part of the system is list of functions for generalisation processing, we prefer functions producing indexes, segmentation, geometry complements or are feasible for real-time processing. In many cases resulting generalisation trigger is composition of previously mentioned possibilities. Last component is discussed in next paragraph.

As was mentioned before the system is intended for high human interaction. At the base level it allows to user to change parameters of generalisation for groups of objects or to the unique object. We try to make it more user friendly by involvement of graphical control and possible option of preview. Important part is appropriate cartographic visualisation of spatial conflicts.

2.3 Conflicts measurements

Identification and suppress of spatial conflicts is key issue of the generalisation process. Conflicts are in pre-generalisation phase (congestion, coalescence, auto-coalescence, imperceptibility) and also like results of improper generalisation (various inconsistencies, coalescence and auto-coalescence). Logically and according many schools primary conflict is congestion (Ratajski,1973). Is cleat that selection or omition of features decrease number of complex generalisation processes. Selection rules are quite well developed, from basic Topfer law to more specific rules (often based on empiric). In our work we extensively use work of Lauermann (Lauermann,1975) where is collected and analysed huge amount of empiric observation of behaviour of czech “military” maps in various scales. In this work are also mentioned rules for imperceptibility of shapes and their parts (this numbers need to be modified on digital environment, but basically works well).

For coalescence measurement are used various hausdorffian distance measurements. For better evaluation is used term shade which is part of object close to another object. Definition of shade is quite simple – part of border where line to closes point on another object not crossing any part of object self.

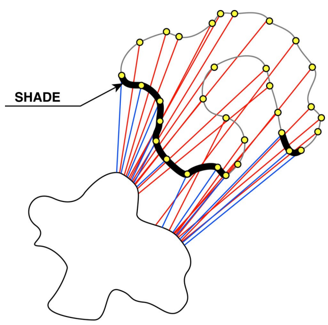

Figure 1. Shade of object

Shades are also useful for amalgamation of the areal features. Especially useful it is for natural features like forest areas. In case of artificial feature is traditional convex hull sufficient.

2.4 Generalisation of the elevation model

The generalization support system ins not composed from tools but also data model was modified. A most significant modification is related to the elevation model. In DMU-25 are elevations described by contour lines. Usual approach to generalisation of elevation model is decreasing of the elevation grid resolution and re-interpolation of contours, more rarely is manipulated TIN. We decided to evaluate generalisation of the elevation model through selection and simplification of contours. Selection self is not so complicated because of homogeneous stepping of contours on czech “military” maps (due to easy slope reading it is always scale denominator thousands divided by five). Simplification is more complicated and there we trace back manual approach to contour lines. First is created terrain skeleton which is basically graph composed from ridge and valley lines. This is generally useful structure for elevation model description and structure recognition. The terrain skeleton can be used for combination of geographic data from different sources and also like base for cell definition for incremental generalisation of natural features (similarly to roads for artificial features). Second step is to draw bends of contours around skeleton lines and the last step is connection of appropriate bends with respect to shape of hill tops and passes.

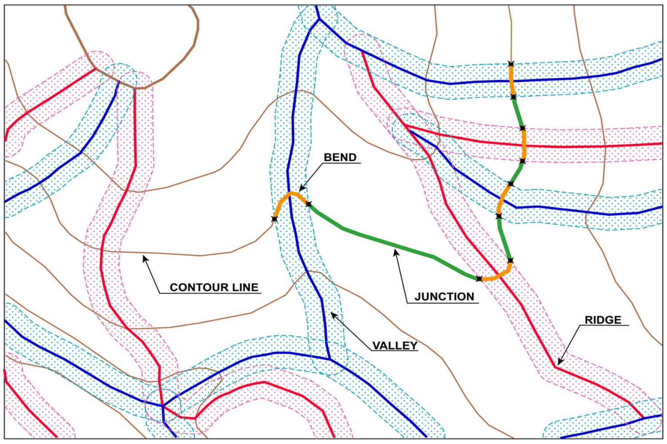

Figure 2. Terrain skeleton and division of contours

In backward processing we establish a graph of the landscape skeleton. Initial intentions was to make it through automated processing, but results was unconvincing and unusable for next use (here is necessary to comment that algorithms for terrain ridge extraction increasing reliability with decreasing of the scale, approx. 1:500000 is a breaking value). Consequently we used manual extraction where at the presence of natural water lines was these lines considered like base for valley lines. Lines was classified and hierarchized according to level, slope, length and relation to neighbour lines (Morley and Rana, 2002). Initial contours was separated into parts – bends and junctions. Simplification of contours is provided through omition of insignificant terrain lines, enhancement of bends (inflating) and strong simplification of junctions (bend of the omited line became part of junction).

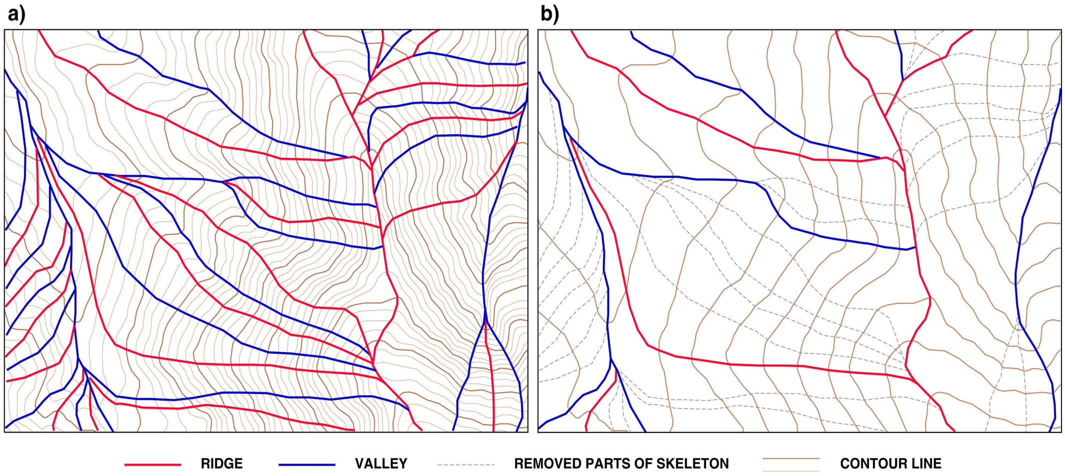

Figure 2. Simplification of terrain model

Results of process are in scales between 1:100000 - 1:1000000 different to the map works which used generalisation through the elevation grid. We would like to compare results of terrain modelling with use of both elevation models, in case of visual interpretation of terrain shapes is our approach subjective more correct. Other possible development in this direction is to simplify contours by parametrisation of smooth curves, because is obvious possibility to transform bends and junctions into smooth curves.

3. Conclusion

Development of our system for support of cartographic generalisation continuing. Basic idea, to store human solutions, offer rather simple generalisation functions which cover not all but significant amount of conflicts and provide good spatial pattern measurement with clear visualisation, represent, according our opinion right way. The system is now our main environment for experiments with processes of cartographic generalisation. We started to work on user friendliness which is base condition for distributing this environment.

4. Acknowledgements

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References

McMaster, R. B., Shea, K. S. (1992): *Generalisation in Digital Cartography. (A*merican Association of Geographers:Washington D.C)

Ratajski, L (1973): *Metodyka kartografii spolecno-gospodarczej*. (PPWK:Warzsawa) (In Polish)

Morley, J., Rana, S.(2002): *Surface networks.*(Centre for Advanced Spatial Analysis, University College London), paper no. 43

Lauermann, L. (1975): *Technical cartography* (scriptum VAAZ:Brno) (In czech)

Weibel, R.; (1995): *Three essential building blocks for automated generalization*. J. C. Mueller, J.-P. Lagrange and R.Weibel (eds.), *GIS and Generalization: Methodology and Practice*. (Taylor & Francis: London), pp. 56-69.

Harrie, L., Johansson, M. (2003), *Real-time data generalization and integration using Java.*(Geoforum Perspektiv), pp. 29-34

Konecny, M., Friedmannova, L., Stanek, K. (2005) *Open regional atlas of south Moravia***.** (Joint ICA Commissions Seminar: Internet-based cartographic teaching and learning: atlases, map use and visual analytics, Universidad Politecnica de Madrid),pp. 93-98, 228