Research challenges in automated generalisation and cartographic modelling

Position paper for Think Tank meeting
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When considering research challenges in automated generalisation (as studied within the Section GIS technology, TU Delft), it is relevant to distinguish between two objectives of generalisation (which have some overlap). First objective, realised through cartographic generalisation, is producing aesthetic pleasing maps at reduced scale (with prime goal a high quality (mostly) paper map) and the second objective is providing consistent multi-scale information at several scales (with usable visualisations of the multi-scale information). The cartographic generalisation focuses specifically on the spatial extent of (symbolised) topographic objects, i.e. does the map visualise the topographic situation in an appropriate manner (we will not discuss here what appropriate means and how this can be measured)? Keeping the topology consistent at scale transitions is of crucial importance for cartographic generalisation. Topological consistency is hereby more important to interpret the map correctly, than the shape of objects. Specifically at smaller scales these shapes become more and more abstract (i.e. what is the exact boundary of a forest displayed at a scale 1:250k?). In addition, for digital maps (nowadays more often used than paper maps), the user can zoom in to make the shape less abstract. The research challenges for automated cartographic generalisation are originating in the traditional research area of cartographic generalisation:

- What is the feasibility of achieved research results by applying research theories on real cases of topographic data?
- How to adjust and formalise generalisation specifications used in interactive generalisation to make them suitable for automated generalisation? How to define hard values that can be used with flexibility by cartographers with sensitivity ranges? How to formalise map specifications, i.e. increase completeness of available/known specifications, improve formalisation level of specifications, reduce ambiguity of specifications?;
- Development of algorithms for generalisation problems that have not been solved yet, such as contextual generalisation, generalisation of terrain height information and thinning of artificial networks (roads and water);
- How to weight and prioritise different generalisation specifications to direct the generalisation process as well as to evaluate the generalisation result afterwards?
- How to find the best parameterisation of (existing) generalisation algorithms, e.g. automatically detect situations that can be solved with same parameters; define default parameters for specific situations; improve user interface (i.e. explain effect of parameters to users)?
- Challenges for 3D:
  - How to perform 3D generalisation both to obtain 3D visualisation model at appropriate level of detail (with specific attention for relationship geometry and texture) and to obtain lower resolution data (see second objective of generalisation)?
  - How to support multiple level of details in one 3D view which is specifically relevant in 3D perspective view, i.e. smooth transfer of high level of detail close by to lower level of details further away in the view.
Research challenges to meet the second objective of automated generalisation (i.e. to provide consistent multi-scale information) are driven by an increasing use of topographic (and other geographic) information by users who are more diverse than traditional map users and who might have information demand with an implicit spatial component. In addition, with the upcoming semantic web, the data is not only used by more humans, but very often the data is reused in other systems in different application domains requiring the meaning and content of data to be understood at machine level. To meet this objective maintaining consistency between multi representations of the same real world object at different level of details becomes more important. Generalisation with focus on meeting multi-scale information demands is mostly related to dynamic generalisation processes (i.e. visualisation in Web environment) and is less demanding for the visualisation (i.e. the user can zoom in to obtain higher level of detail). The related research challenges are:

- Semantic rich information models for multi-scale and multi-purpose data that can preferably direct the generalisation process in a MDA approach;
- Useable visualisation of multi-scale and multi-purpose data (not per se on high quality paper maps), i.e. defining user requirements for on demand maps and designing methods to capture these requirements;
- Generalisation of web based on demand maps. Research topics are generalisation according to user requirements captured in user profiles and (meaningful) web generalisation services based on transferring services rather than data.
- Support of integrated multi-scale information provision to meet information demand of users with respect to varying levels of detail. For example a user makes a two day car trip to his holiday address. Understanding the route directions requires overview, but at specific locations (e.g. to rest or to stay overnight) the user needs information at a higher level of detail for example to be able to go for a walk. Research challenges are to provide consistent information at varying level of detail depending on the user interest at a specific location;
- Vario-scale data structures. These enable objects to be stored once and to be displayed at any arbitrary scale (supporting smooth zooming and progressive transfer) and may contain generalisation 'decisions' (computed at pre processing time). Vario-scale data structures have been developed in research. A step-wise process should show the feasibility of such an approach for practical applications and further requirements for the data structures, e.g. embedding symbolisation information and support of multi-representation that are needed in complex situation (e.g. many objects participating in an aggregation or other generalisation operation; costly geometric computations; etc);
- Progressive data transfer of vector data (in server-client/web environment);
- Integrated support for history in multi-/vario-scale environment, i.e. to be able to obtain the data at any scale and any moment in time.
- Efficient maintenance of point clouds (e.g. to provide view of high resolution laserscan data at several levels of detail)

Think tank contribution
Jantien Stoter will attend the think tank meeting. She can contribute to discussion from several knowledge areas:
Project leader of EuroSDR generalisation project (2006-2009) in which commercial software was tested on test cases provided by four NMAs (OS was one of them).
Current position: Integrated function as Associate Professor Section GIS technology, TU Delft and Consultant Process- and Product- Innovation, Kadaster, with research areas:
Automated generalisation
Information modelling
Multi-scale data integration
Vario scale data structures (feasibility for topographic data)