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Usable mobile maps based on a vario-scale data server

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1. Introduction

Despite the growing popularity of geo-information (maps) in all kinds of web services, such as routing, or providing (spatial/context) information for a given object, and also the growing use of mobile applications, there are currently severe problems with respect to the use of mobile maps. One of the main problems is due to the small screens of the mobile devices, not being able to show a lot of map. A user needs to pan and zoom a lot to get a sufficient spatial understanding, that is, a feeling of the sizes, directions and distances between the relevant objects and their context. With current technology in most mobile GISs (or Location Based Services, LBS) it is possible to zoom and pan. However, after a zoom or pan action, nearly in all cases a complete redraw is performed. The user now often looses the 'mental' contact between the two maps. Initial experiences show that the users are getting lost (and do not build a good mental map in order to support their task) and therefore do not appreciate the new solutions based on mobile maps. One of the key solutions to the described problem of user disorientation is vario-scale maps. There are a least two possible ways to use vario-scale maps:

- the first approach presents a map where the feature of interest (location or route) is shown at a higher detail level (large scale) and the surrounding features are shown with less detail (small scale), so this is a non-uniform scale representation within one image;
- the second approach is based on smooth zooming and panning: at a given moment the map has a uniform scale, but in an animation style of visualization, the map is continuously transformed into a target scale or location.

Both approaches try to help the user creating better mental maps, so they do not get disoriented. This is valid for either static (provide information for a certain object/location and its environment) and/or dynamic (provide information for a certain route between two locations and the environment) mobile GIS applications. Two use cases, a static and a dynamic one, are selected in order to investigate the effectiveness of the proposed solution with user tests. Before these tests can be executed, a prototype system has to be developed first. One of the important components of the prototype is the vario-scale data server being able to provide the necessary geo-information to the rendering engine. As the context is a mobile application, care has to be taken to use limited bandwidth. Therefore, the vario-scale data server should provide progressive transfer. That is, when zooming-in, only the refinements (additional detail for a larger scale representation) should be transferred to the mobile client and not a complete new map.

2. The tGAP structure

In earlier research both the theoretical and practical (implementation) aspects of such a vario-scale data server have been described: the topological GAP structure (Generalized Area Partitioning), or tGAP structure for short (van Oosterom, 2005, van Oosterom, de Vries, Meijers, 2006). Purpose of this tGAP structure is to store the data only once, with no redundancy of the geometry, and derive different representations of this same data on-the-fly according to the level of detail needed. It has further to be explored how this vario-scale data server can be put to effective use in a mobile service/client environment.

Data structures supporting variable scale data sets are still very rare. There are a number of data structures available for multi-scale databases based on multiple representations (MRDB's), that is, data to be used for a fixed number of scale (or resolution) intervals. These multiple representations data structures try to explicitly relate the objects at the different scale levels, in order to offer consistency during the use of the data. Drawbacks of the multiple representations data structures are that they do store redundant data (same coordinates, originating from the same source) and that they support only a limited number of scale intervals. Another drawback of the multiple representation data structures is that they are not suitable for progressive data transfer as each scale interval requires its own (independent) graphic representation to be transferred. Nice examples of progressive data transfer are raster images, which are first presented relatively fast in a coarse manner and then refined when the user waits a little longer. These raster structures could be based on simple (raster data pyramid) or more advanced (wavelet compression) principles. For example, JPEG2000 (wavelet based) allows both compression and progressive data transfer from the server to the end-user. Also, some of the propriety formats such as ECW from ER Mapper and MrSID from LizardTech are very efficient raster compression formats based on wavelets and offering multi-resolution suitable for progressive data transfer. Similar effects are more difficult to obtain with vector data and require more advanced data structures.

3. Current research

The tGAP structure can be used in a number of different ways: 1. to produce a representation at an arbitrary scale (a single map), 2. to produce a representation with feature(s) of interest at a larger scale and the surrounding features at smaller scales (a non-uniform scaled map) or 3. to produce a continuous range from rough to detailed representations. These three ways of using the tGAP structure are all useful, but it will be clear that in the context of progressive transfer (and smooth zooming) the third way must be applied. Currently research is being conducted to improve the tGAP structure with respect to the following aspects:

- theoretical aspects: more formal description of the structure (based on axioms), try to remove one of the original, too rigid, principles of the creation of the tGAP-structure 'select the least important object to be merged with its most compatible neighbour' (the global minimum);
- functional aspects: support the updating of the source data, without rebuilding the complete tGAP structure, support the queries for the different types of vario-scale representations (non-homogenous scale, feature centred map, vario-scale animation: smooth zoom/pan);
- practical aspects: storage requirements (try to reduce the 5 times storage overhead of the current implementation) and adaptation of communication protocols (WFS/GML) to enable progressive transfer of vario-scale data.

Crucial for the quality of the tGAP-structure is the assignment of proper importance values to the involved feature classes (and importance function) and the compatibility values between two different feature classes (and compatibility function). More research is needed in this area to automatically obtain good generalization results for real world data. Related to this aspect is finding the relationship between the importance value and the actual scale.

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References

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