Data processing and optimisation for rendering tiled raster maps with country-wide coverage

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Abstract

This paper describes the development process of an automated tiled raster map making system for generating three different types of terrain maps. The maps are composed of integrated raster and vector data produced by multiple government agencies in Finland. Resource optimisation methods are necessary as each map consists of twelve resolution levels and covers the whole area of Finland (338 424 km^2). Free and open source software tools are used in the system, both for data processing and for building the tile rendering system.

Keywords: automatic, raster, map, tile, multi-scale, optimisation

1 Introduction

Recently, government agencies of many countries have begun to offer their geospatial datasets openly and for free. For example, in Finland, topographic datasets in multiple scale levels and high resolution digital elevation models (DEMs) are available openly without charge, among many other geospatial datasets.

The past decade has also seen rapid development of free and open source web mapping tools [4]. High quality web maps can now be made by anyone, without data or software acquisition costs [5]. In current web mapping, map tiles are the standard way of storing raster maps [1].

This paper presents data processing needs and optimisation of map rendering in the development of an automated map generation process that was built using free and open source software (FOSS). Data for the maps were collected from three Finnish government agencies. The process generates three different types of multi-scale tiled raster maps with country-wide coverage of Finland.

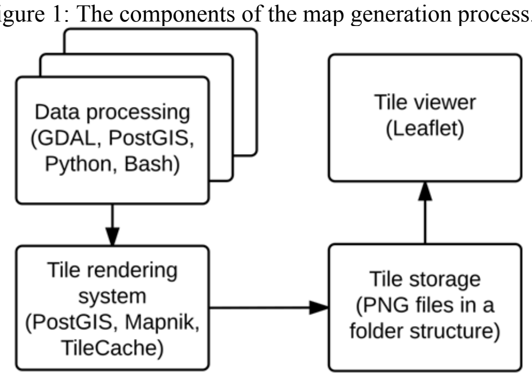
2 Software components and source data

2.1 Software components

The whole map generation process was built using FOSS components. Geospatial Data Abstraction Library (GDAL) is used for processing raster data. PostGIS database tools are used for processing vector data. The processed vector data is stored in PostGIS databases and raster data is stored in GeoTIFF files. Tiles are rendered to PNG files by combining the use of Mapnik and TileCache.

A map viewer was built with Leaflet for displaying rendered tiles. Also, QGIS was used for visual analysis and manual management of source data during the development. Python and Bash scripting was used to automate the process. The Finnish public recommendation JHS 180 provided guidelines for map and tile properties, such as tile grid scheme, resolution levels (2-13) and pixel size of the tiles.

Figure 1: The components of the map generation process.

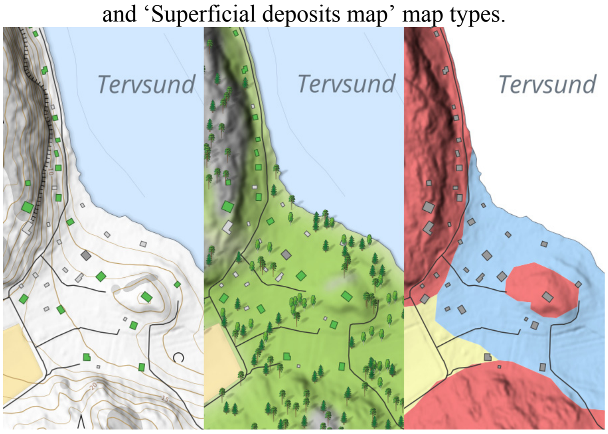


2.2 Map types and source data

The three map types are called the 'Topographic map', 'Forest map' and 'Superficial deposits map'. All the three maps contain relief shading at all 12 resolution levels.

The 'Topographic map' uses roughly the same data as the topographic map series of the National Land Survey of Finland (NLS) but uses different styles. Topographic datasets in five scales (1:10 000, 1:100 000, 1:250 000, 1:1 000 000 and 1:4 500 000) and geographic names datasets for multiple scales were received from the NLS in PostGIS databases that are used for tiled topographic map making [3]. The 'Forest map' includes, in addition to some topographic features, forest covered areas from the Corine Land Cover 2012 raster (CLC2012r) that was acquired as open data from the Finnish Environment Institute (SYKE). Within forest covered areas, tree symbols are placed in evenly distributed random locations. The 'Superficial deposits map' includes polygons from superficial deposits datasets in five scales (1:20 000, 1:50 000, 1:100 000, 1:200 000, 1:1 000 000) acquired as open data from the Geological Survey of Finland (GTK).

Figure 2: Examples of the 'Topographic map', 'Forest map' and 'Superficial deposits map' map types.



3 Data processing

Most of the source data was directly usable for rendering. Inconsistencies in datasets, such as geometries from two datasets not matching, revealed to have a minor impact on the quality of the maps. However, the process still requires significant data processing. Building the required data processing pipelines was the most time consuming part of the development.

Relief shading and contours are generated from the highest resolution DEM available, the NLS Elevation model 2 m. The Elevation model 2 m is incomplete, covering roughly half of Finland and has to be complemented with the NLS Elevation model 10 m. For representation of protected areas, buffers inwards from the polygon borders were needed. The borders had to be generated in advance. Names in the geographic names datasets are stored as individual letters. To use custom text properties such as font and size, names are reassembled before rendering to avoid large gaps between letters and overlapping text. Points within forest areas that indicate the location of tree symbols do not exist and are thus generated by first polygonising the forest areas in the CLC2012r, and then placing random points within the polygons. The three higher resolution superficial deposit datasets have partial coverage of Finland. At higher resolution levels, lacking areas are complemented with a lower resolution dataset. To make a clear distinction at the border of two different resolution datasets, buffers inwards are generated from the polygon layers to indicate the boundaries of datasets.

4 Optimising map rendering

Although setting up the tile rendering in the development is a relatively fast process, rendering millions of map tiles can be time consuming without proper optimisation. Initial rendering tests of smaller areas suggested that rendering the whole 'Topographic map' could take up to several weeks, so optimisation methods were needed.

Six variables were identified to have an effect on the speed of rendering tiles: format of the data; indexing in PostGIS tables and columns; use of meta-tiling; stylesheet optimisation; optimising SQL queries for fetching data; and hardware. Multi-threading can also be effectively used for rendering tiled maps [2].

The full area of Finland (338 424 km^2) was divided into 40 smaller square areas of same size. These areas are allocated evenly to 16 threads so that the overall rendering time for the full area is minimised. As large meta-tiles are used as possible because increasing size of a meta-tile was found to make the rendering faster. The capabilities of the rendering system and the used tile scheme limits the size of meta-tiles to 8448 x 8448 pixels, resulting in 1024 tiles (with a buffer around the meta-tile).

By addressing all the identified optimisation variables, in the current phase of work, the rendering of the whole 'Topographic map' is achieved in approximately 23 hours with an 8-core processor with hyper-threading capabilities.

5 Conclusions

As available datasets are often produced for specific use cases or products, they may not be well suited for custom topographic and thematic maps. Also, many available datasets only have partial coverage of the area of Finland. Using these types of datasets for producing maps while pursuing high cartographic quality may require extensive data processing. On the other hand, integration of different types of datasets in the maps appears to have less impact on the cartographic quality.

The optimisation of map rendering requires adjustments of multiple variables in different parts of the rendering system. Implementing these optimisations can importantly enhance the performance of rendering.

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