3D-LANDSCAPE-MODELLING AND -VISUALISATION BASED ON DIGITAL TOPOGRAPHIC MAPS

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Abstract

The purpose of this paper is to present a methodology for the automatic and efficient generation of three-dimensional landscape images from digital topographic maps. The aim is to replace the traditional two-dimensional contents of the topographic map by three-dimensional CAD-models. These models can then be integrated into perspective 3D-views of the topographic map.

1 Introduction

The increasing demand for 3-dimensional spatial information has led to a growing need for 3-dimensional geographic information systems (GIS). For such domains as city planning, hydrographic studies, research and monitoring of the ecology as well as in geology, combining the management, computation, analysis and representation of position and height is becoming increasingly important. Because of the high standards of data acquisition on the one hand and the complexity of modelling the data on the other hand, the realisation of a 3-dimensional GIS is very costly and time-consuming. It is therefore essential to find technical aids and partial solutions to meet these demands. One of these solutions, for example, is the 3-dimensional CAD-modelling and representation of 2-dimensional spatial information using implicit or explicit height information. With this method, complex associations are brought into a more comprehensive and interpretable form.

2 Three-dimensional landscape images

This article introduces an automatic and efficient method for generating 3-dimensional synthetic landscape images. Data sources used by the method are the digital maps (pixel maps) and the digital height models (RIMINI and DHM25) of the Swiss Federal Office of Topography. The procedure includes the following steps:

- Automatic extraction of 2-dimensional areal and point objects from the digital map by means of cartographic pattern recognition
- Vectorisation of areal objects
- Generation of central perspective map representation using a combination of digital map and digital height model
- 3-dimensional modelling of the extracted objects
- Representation of the 3-dimensional object models in combination with the central perspective view of the map

2.1 *Extraction of objects from the digital map and vectorisation*

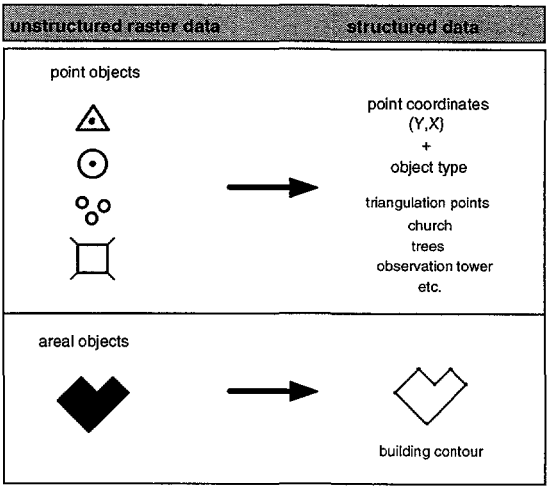

Fig. 1: Extraction of spatial information from digital topographic maps

The topographic map plays a key part in this method. A map is an abstract model of reality and contains structured information in the form of cartographic symbols. Thanks to this property, the topographic raster map can be automatically structured into logical image contents using a cartographic pattern recognition technique described by [1,2]. In this process, knowledge-based template matching is the basis for extracting point objects (such as steeples, trees, triangulation points) and areal objects (for example buildings). The point objects result as accurate spatial information, where the coordinates and the object type are known for each element. The buildings, however, are vectorized using robust algorithms and additional geometric parameters [3].

2.2 *Central perspective representation of topographic maps*

A central perspective view of the terrain is obtained by combining a digital map with a digital height model. Through the introduction of parameters for the perspective view (eye position, viewpoint, field of view, clipping planes) and the illumination model (position of the light source, lighting and surface properties) the synthetic landscape images can be generated. In order to obtain a realistic representation, hill shading models are used to imitate the lighting and the surface structure of the terrain (Fig. 3 and 4).

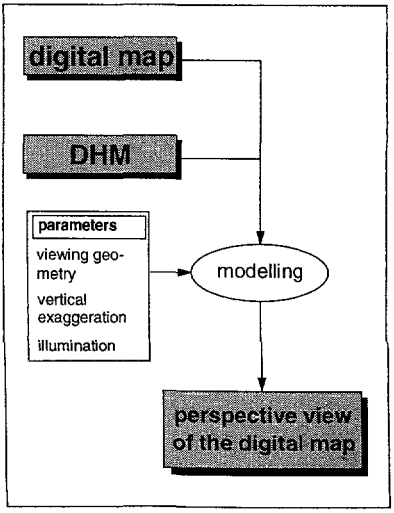

Fig. 2: Central perspective representation of topographic maps

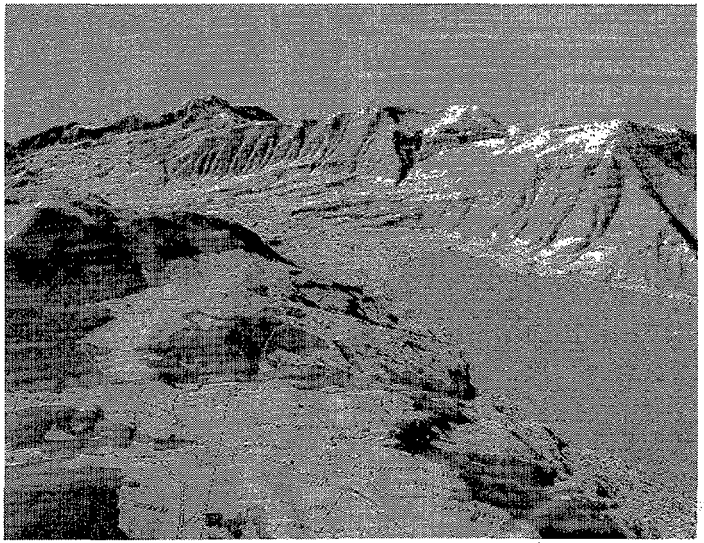

Fig. 3: Central perspective representation of the map 'Rigi' (map 1:25'000)

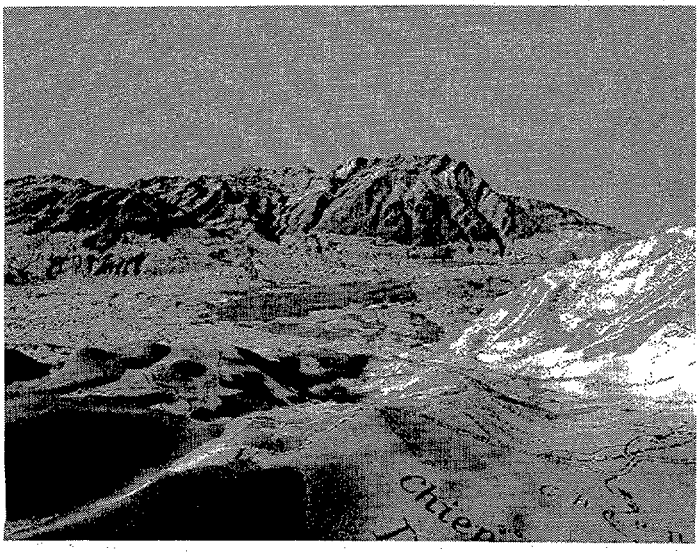

Fig. 4: Central perspective representation of the map 'Alpnach' (map 1:25'000)

2.3 Three-dimensional modelling and visualisation

Two-dimensional structured objects can be obtained through the extraction of spatial information from topographic maps. A 3-dimensional landscape image is then generated by replacing these data with 3-dimensional models and combining them with the central perspective representation of the topographic map. The recognised point objects are replaced by 3-dimensional CAD models, and buildings by simplified representations (blocks). The height values of these models either correspond to standard values or are derived from other processes (such as photogrammetry) or other information sources (for example attributes, number of floors, etc.). In cases where the actual object heights are unknown, their are implicitly derived based on the type of the 2-dimensional object. Standard values for height estimation are applied to represent certain object types, for example 50 m for church steeples or 10 to 15 m for trees.

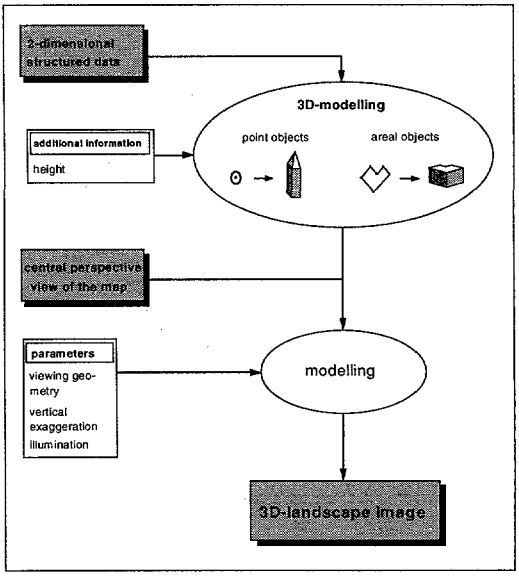

Fig. 5: 3D-modelling and -visualisation of spatial information

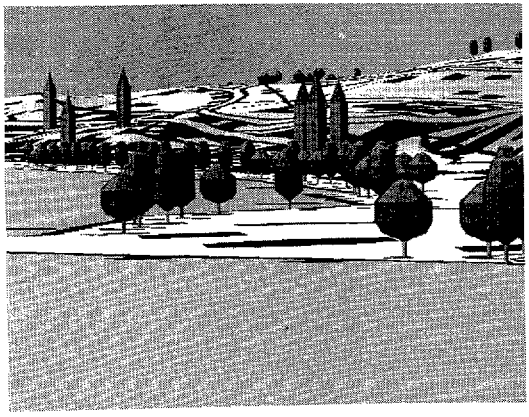

Fig. 6 : 3D-landscape image with automatically extracted objects from digital map

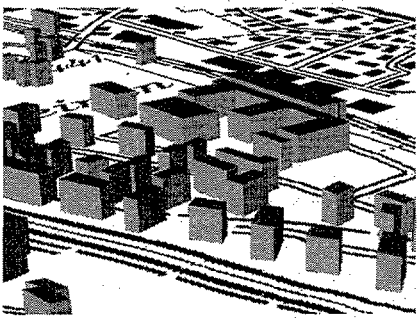

Fig. 7 : 3D-landscape image with automatically extracted buildings

3 Software

The central perspective representation of topographic maps as well as the 3-dimensional modelling and representation of topographic elements are implemented in the program package RaVis. This 2D- and 3D-visualisation program was developed at the Institute of Geodesy and Photogrammetry at the Swiss Federal Institute of Technology in Zurich. The program was developed on workstation of the type IBM RS/6000.

4 Applications

Three-synthetic-dimensional landscape images can be used in the following applications:

- Visual verification and assessment of the compatibility and repercussions of planning measures on the topography (ecology, architecture, construction, etc.)
- Visibility and propagation analyse in communications
- Production of relief models, panorama maps and 3-dimensional city maps
- Cartographic applications
- Military applications (e.g. radar simulation)
- etc.

5 References

[1] Stengele, R., 1993. Kartographische Mustererkennung durch Template Matching. Bericht Nr. 230, Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology, Zurich.

[2] Stengele, R., Carosio, A., 1994. Cartographic Raster Data and their Use by GIS. Proceedings, FIG, XX. International Congress Melbourne, Australia, pp. 550 ff.

[3] Nebiker, S., Carosio, A., 1994. Automatic Extraction and Structuring of Objects from Scanned Topographical Maps. International Archives of Photogrammetry and Remote Sensing, Vol. 30, Part 1, pp. 180ff.

Figure 3, 4, 6, 7: Data source: digital topographic map (PK25) and digital height model (DHM25)