Geovirtual Urban Environments as Media for the Communication of Information related to Managing Urban Land

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ABSTRACT:

This contribution outlines a research project targeting at the utilization of virtual 3D city models in the context of urban land management. It explains the projects background and the research concept as well as basic methods, which will be applied during the project runtime. The project will build upon findings in environmental and urban planning, computer graphics science, and geoinformation science; it contributes to a German research framework (REFINA) aiming at the development of guidelines, best practice examples, and tools for the reduction of land consumption.

Introduction

Managing urban land requires dealing with complex ecological, economical and social needs, which in general are related to spatial structures and phenomena. In order to fit these needs, state of the art management strategies make use of information technology such as Geographic Information Systems (GIS), internet-based information services, 3D visualizations, and simulations to support decision-making and improve the communication fluxes between authorities, citizens and companies.

Geovirtual environments (GeoVE) are computer-generated depictions of our common environment, which are based on geoinformation and can be operated in real-time. Thus, they offer an intuitive, innovative, and challenging media to interactively explore, analyse and present spatial information in its three dimensional context. Typical occurrences of GeoVE are virtual 3D city models, which are increasingly established as one part of modern spatial data infrastructures (SDI).

The project "Land Information Systems based on 3D-City Models" ("Flächeninformationssysteme auf Basis virtueller 3D-Stadtmodelle) is a joint venture of the Hasso-Plattner-Institut Potsdam, Berlin Technical University, and 3DGeo GmbH. It aims at developing an information and communication system for land management on the basis of geovirtual environments. More specifically it addresses the development of techniques, tools and methods needed to successfully deploy virtual 3D city models for decision support in the context of urban land management. It builds upon existing virtual 3D city models and technology (Fig. 1) and high expertise of the partners with the set up and utilization of GeoVE in the context of urban and environmental planning, real estate management, and consultancy of investors.

Figure 1 goes somewhere here

Four case studies in the Berlin and Potsdam area will be conducted in close cooperation with regional and local authorities and other stakeholders to identify potentials and restrictions. During the studies decisive parameter and geoinformation related to the specific management tasks have to be identified, integrated into the model database, processed, and visualized. The cooperation with authorities, the choice of prominent and sensitive urban development areas for the case studies, and participation during planning processes ensures a problem-oriented approach.

Background

The project is part of the German research framework REFINA, which is funded by the federal ministry of education and science. The aim is to develop methods, tools, and guidelines to reduce the consumption of previously undeveloped land by housing, industry, and transportation networks.

Key strategies for the reduction of land consumption are land recycling, inner city redensification, and the adoption of sustainable land management concepts by administration departments. During the recent years much effort has been made to develop sustainable land-management concepts and decision support tools (e.g. the project "*Regeneration of European Sites in Cities and Urban Environments*" – RESCUE: www.rescue-europe.com/html/project.html; or the project "*Integriertes Management und Revitalisierung der Brachflächen*" – Integra Sites: www.um.katowice.pl/strony/integrasites/de/) as well as to formulate best-practice guidelines (e.g. LfU 2003a & LfU 2003b). The results of the research activities show that the sheer amount of data involved and the complexity of land recycling tasks as well as the multi-stakeholder perspective often complicate urban land management. As a solution often a set of methods and techniques is proposed or combined. These incorporate among others GIS, 3D visualizations, public participation methods, and assessment methods to value economic, ecologic as well as socio-demographic aspects of land management.

Since land management is per se spatial, GIS obviously offer an appropriate technique to support land management and decision-making. At present GIS-based brownfield cadastre and empty-site cadastre are used in many municipalities to support the management, assessment and regeneration of brownfields or to allocate suitable sites for potential investors. Besides GIS, 3D visualizations are commonly used in participation processes regarding brownfield regeneration and urban planning. They support the cognition of the spatial impacts of proposed projects or policies on the visual landscape, respectively cityscape. Public participation methods such as 'round tables', stakeholder meetings, or incorporation of the public during planning phases are methods to access multi-stakeholder planning issues. If they are well prepared, these techniques can lead to better acceptance of plans. Participation processes often make use of GIS and 3D visualizations regularly to provide information and visual input. Assessment methods finally provide basic methodologies to value land management related issues. They are the 'every-day tools' planners apply in planning processes.

The project partners expect that by combining and integrating these techniques under the metaphor of virtual 3D cities, innovative information systems can be realized which on the one hand provide real-time 3D visualizations, features for digital participation, and features for data exploration and analyses.

Research Concept and Methods

The principle questions include: How can information related to land management be integrated into virtual 3D city models? Which tools for analysis and evaluation of land situations can be implemented using the 3D city model? Which information can be communicated by means of the 3D city models? And what are the benefits and potentials of using 3D city models? Attempts to solve these questions satisfactory result in the conclusion that they can be answered only in the context of the specific application domain. While in the context of finding a suitable site for a potential investor factors such as the size of the site, the land-clearing costs, socio-demographic information on the neighbourhood, and the situation in terms of traffic routes can be of primary interest, public participation during planning phases may call for different requirements such as realistic 3D visualizations or interactive features for modification of plans to involve participants. For this reason domain specific requirements have to be taken into close consideration during system design, which provides the framework for the following work (Fig. 2). The following sections describe the main work packages (WP) in detail.

Fig. 2 goes somewhere here

System Design

The design of the 3D city model system has to be extended by additional classes, attributes, methods, and relations to adapt the 3D city model to the needs of land-information management. Based on the extended system design, task-specific 3D analysis, presentation, simulation, and exploration tools can be developed. Since they rely on the available data, a strong correlation between data model and tools has to be ensured. Requirement analysis and design of features will be accomplished in close cooperation with local authorities and potential users for each use case. This step encompasses identification of project-related (geo-)information, definition of features or tools to support the defined management tasks, concepts of data integration, and clarification of data access rights.

City Model Extensions

Data modelling and data integration represent crucial steps for the success of the project. Basically three possibilities for data modelling and integration are considered:

(a) Direct integration of georeferenced data and geodata in the GeoVE.
(b) Embedding data into city model objects.
(c) Integration of pre-processed data.

In case (a) we integrate georeferenced data and spatial data, e.g., given in vector or raster formats, directly as information layers into the GeoVE. Examples are thematic data sets or topographic data, which can be visualized as textures of the digital terrain model.

In case (b), we embed thematic data in the GeoVE by means of attributes provided by the objects that constitute the virtual 3D city model. This method is used for data that can be related to individual city model objects. The attributes can be evaluated and interpreted for the 3D tools and for 3D presentation purposes. Therefore, we will extend the underlying data model, including systematic definitions of required attributes, attribute domains and strategies for missing information to ensure a consistent and stable model schema on which the planned tools can operate.

In case (c) we facilitate the aggregation of data from various data sources and scales: thematic and geometric pre-processing is needed to combine these data sets to useful information. For example one feature might be a tool to visualize the traffic situation. Base data might be public transportation networks and stations, street networks, and walking times. To present an overall traffic situation these data sets have to be combined. One possible solution might be to define a cell size as basic spatial unit and calculate a 'traffic situation indicator' for each cell. As a result the traffic situation could be displayed as a height field used as terrain model, where the terrain height is an indicator for the traffic density.

Tool Development

After formulating application scenarios and a wish list of supporting features, the implementation of software tools can be started parallel to constructing the data basis and data integration. Three categories of tools are in our focus:

- Tools for exploration and analysis,
- Tools for editing and configuration, and
- Visualization techniques.

The development of land management supporting features will be based on an iterative and incremental software development model. This ensures that shortly after the project start an initial system is available, which can be incrementally refined. In this way, feedback and proposals can early be integrated and risks in the software development process are reduced. The following sub sections outline these categories.

Tools for Exploration & Analysis

This work package encompasses the development of techniques for the analysis of site respectively land plot properties. It includes basic techniques to assess and visualize land management related parameters such as economic situation, environmental qualities, urban planning parameters, or other domain specific parameters. The 'traffic situation indicator' terrain would be such an application.

Another example represents a tool that processes development plans, generating principal 3D building models based on planning parameters. Thus, the abstract information of 2D development plans can be transformed into a 3D scenario. This approach supports people without planning background and helps them visualize and understand development plans and their implications.

Editing & Configuration

This work package addresses one major drawback of many existing (geo-)virtual environments. In general, most virtual environments are based on static models. Although the technical progress during the recent years led to impressive and detailed virtual 3D city models, which can be viewed and navigated in real-time, interactive editing or other interactive features are often limited or not available at all. Through the use of object-based programming techniques it is possible to assign geometric and visual properties to the 3D objects, which can be edited in real time (cp. Buchholz et al 2006, Döllner et al. 2005). To stick to the earlier mentioned example such parameter might be the site occupancy index describing the maximum area that can be occupied when constructing a building. By defining this parameter in the data model and adding an interface that enables users to interactively redefining it, the system can be used to process scenarios where the site occupancy is utilized to different degrees.

Visualization Techniques

We also focus on visualization techniques, combining insights and methods from cartography, planning and geovisualization. To follow the previous example, imagine the system would be configured to calculate abstract 3D building models from development plans and configuration parameter. How should this information be visualized appropriate? If the same visualization techniques used for the existing buildings in the city model would be applied, recognition of the uncertainty of this information, the scenario character, would be neglected. A possible solution may be to use colours for thematic visualization, which is an accepted method in 2D cartography. But would that support an intuitive recognition of the information, or would be other solutions, such as the use of transparency or non-photorealistic rendering techniques more appropriate? Which approach is best suitable for the visual communication of specific information, can only be assessed by user feedback and evaluation. Thus the incremental software developing approach and the close cooperation with potential future users is important for the outcome of the project, as it ensures early feedback.

Information Systems

The case studies will result in four prototypic information systems, each designed to address specific management tasks. These information systems will be based on official virtual 3D city models, basic geoinformation and thematic geoinformation. To ensure the utilization of the information systems as well as to transfer them to users outside the administration in case of public participation, information products will be built from the source systems. Therefore, the relevant information has to be identified, extracted from the database and converted into products, which can be provided to users via DVD products or web services. To ensure the usability of the resulting products it is necessary to define interaction and navigation settings as well as to assure the proper use by digital rights management. Furthermore, a feedback option has to be implemented to allow for collecting statements, critics, and proposals from the users.

Summary

Because of the spatial background of land management it seems obvious that geovirtual environments provide a high potential as media for the presentation of information related to urban land management. Existing applications, e.g., the virtual 3D city models used at the Buisness

Location Center Berlin and at the urban development department of Berlin (cp. Figure 1), already show that they can be utilized for planning and management tasks. Still these applications are very limited with respect to geo-processing and interactivity.

The outlined research project aims at uncovering potentials of 3D city models for land management by developing and providing domain specific functions for land management and decision support. It will provide working examples and prototypic information systems based on the case studies. It will be built upon state-of-the art geovisualization techniques, existing 3D city models and best practice examples for land management. It therefore combines recent findings in IT system engineering, computer graphics, urban and environmental planning, and geoinformation science. Through the close cooperation with local and regional authorities as well as through the planned software development strategy, a domain-specific and problem oriented approach is ensured.

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Fig. 1 Official 3D city model of Berlin with thematic coloured buildings (Source: Senatsverwaltung für Wirtschaft, Technologie und Frauen 2006)

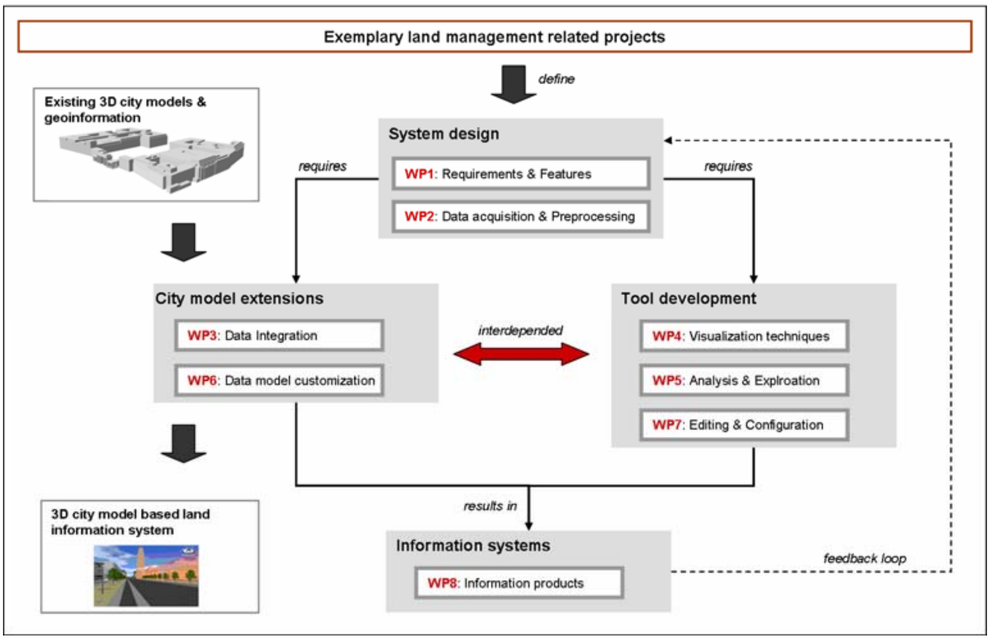

Fig. 2 Overview on the research project and the main work packages (WP).