Visualization in ViSuCity, a tool for sustainable city planning

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Abstract

This paper gives an overview of several aspects of visualization for city planning as they were used in the project ViSuCity. The overall objective of ViSuCity is to develop an effective web-based, interactive visualization demonstrator, ViSuCity, to support sustainable city planning in terms of information sharing, analysis, development, presentation and communication of ideas and proposals throughout the city planning processes. In this paper, we discuss and show some results regarding LOD, scalability, streaming, and examples of visualization of roads, etc that are important for city planning.

Categories and Subject Descriptors (according to ACM CCS): I.3.8 [Computer Graphics]: Applications—

***Keywords**: visualization, computer graphics, LOD, urban planning, city planning, streaming, scalability*

1. Introduction

ViSuCity, a Visual Sustainable City Planning Tool, is a project that was jointly funded by the Knowledge Foundation, Swedish Foundation for Strategic Research, Vinnova, etc. in 2008 through its first call for Visualization Demonstrators (Heavy). The project consortium has many partners from academia (KTH Geoinformatics, Urban Planning and Computer science and communication), industry (Sightline, Sweco, Digpro, Blom) and community (Stockholm City Planning Administration, Stockholm County's Regional Planning & Transport Office and the Swedish Road Administration).

The overall objective of this research was to develop an effective web-based, interactive visualization demonstrator, ViSuCity, to support sustainable city planning in terms of information sharing, analysis, development, presentation and communication of ideas and proposals throughout the city planning processes. Parameters relevant for an integrated sustainable city planning, such as transportation system, infrastructure, energy, water and waste management, green structure, etc will be integrated to enhance the quality of both the planning process and the planning results. A short overview of the project can also be found in [ViS].

2. Research questions in the project ViSuCity

The research and development of the ViSuCity project was focused on the following eight research issues:

- How can a visualization framework be used to enhance the quality of both the planning process and the planning result including parameters relevant for an integrated sustainable city planning, such as transportation system, technical infrastructure, energy supply and efficiency, water and waste management, green structure, etc.?
- How can we efficiently generate 3D models of the present & past (if possible) built environment using remotely sensed data and existing 2D data?
- How can GIS and BIM be integrated in the most efficient manner for planning?
- How can we refine spatial, object and web database technologies for effectively retrieving & managing 3D data & other spatial data related to sustainable planning?
- What is the most efficient way to present large volume of planning data to planners, decision-makers and public via internet?
- How can we implement easy-to-use tools such as multi-criteria evaluation (MCE) for analysis of sustainable planning alternatives? How to effectively visualize results of

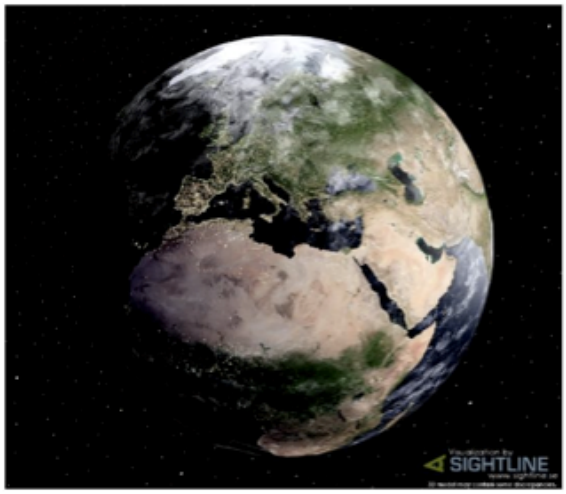

Figure 1: *The image is streamed and when coming closer more details are being presented.*

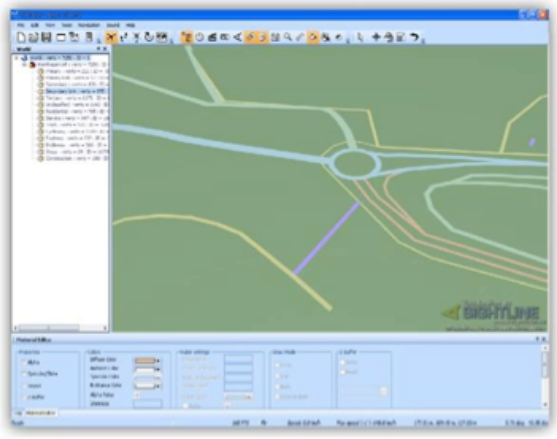

Figure 2: *Roads are being connected using different algorithms and techniques, here set up with the editor in the Neo4 system in ViSuCity.*

MCE and various sustainability indicators at different scales to support sustainable planning?

- How can we promote participations from different stakeholders and the public by giving users the ability, e.g., to a) easily discern, enlarge, turn and enlarge/diminish certain aspects within integrated structures, b) redline or edit certain features in a planning scenario?
- How can interdisciplinary collaboration among experts and other stakeholders within and between the private and public sector be strengthened by new visualization tools in order to enhance the quality of the planning process and the quality of planning proposals with regard to sustainable urban development? Is the demonstrator effective and easy to use? How can the usability successively be followed up and analyzed in the chosen case studies?

3. Methodology and implementation

The research questions in this project have been treated with different methodologies as it is a very interdisciplinary project. It would not be possible to go into detail on methodology for all the research questions and implementation issues in the project. We will in this short paper focus on a few questions, mainly with relations to visualization. Available tools were investigated in order to see how they could be used for the purpose of the project. Examples of tools and techniques investigated were OpenStreetMap, CityEngine, Generative Modeling Language (GML), Level of detail and streaming. The techniques were studied together with the software system Neo4. More details on the project can be found in [ViS10].

4. Visualization details

Here we will highlight a few of the visualization techniques that have been used and investigated in the project.

Streaming: On a computer, the user can interactively display a city plan, in ViSuCity, in less graphical complexity and have a shorter visibility distance of the city plan in full detail. When the user moves about in the 3D city plan details starts to show up as the user comes closer. These details loaded in a data stream either from the local hard drive or streamed over the internet directly in relation to how the user is acting. As the performance of computers grows, the visibility distance can be greater and greater meaning that more data in full quality can be presented at the same time, thus the visibility distance is one parameter that ViSuCity can control to adopt to the capability of the computer. This presents the two fundamental benefits with interactive real-time streaming of 3D content, one is downloading content and presenting on demand of the users actions in navigation the city plan, and in the other end the data to be streamed, the amount is determined by how much the computer is capable to present. In a master thesis project streaming is used to show various levels of details [Tho10], as illustrated in a global view in Figure 1.

Scalability: In the project data about rendering quality has been collected and can be used to adjust the quality according to the computer and the need of the user, who can set the quality in a dialogue (set to High, Medium or Low).

Road visualization: to connect roads in crossings turned out to be a non trivial problem and different options and algorithms were investigated in order to achieve a good visual result also when angles between roads meet in angles close to 180 degrees [Bar10]. An example of road connections is shown in Figure 2.

Figure 3: *Two 3D models in different level of details from Blom's production environment used in the project.*

LOD: level of detail is a common technique for adjusting the presentation in a balance between quality and computational speed. This technique has been used in ViSuCity. An example can be found in Figure 3.

Compression: The need for compression is a key feature for many graphics applications both for hardware oriented systems and for software systems that need extensive storage for the data in urban planning. Wavelet based point compression has been investigated in the ViSuCity project [WQ09], see Figure 4.

5. Visualization in context of ViSuCity

The ViSuCity project includes many research questions as described above. In this paper we focus on a few of the questions that are related to visualization and graphics although it is hard to extract visualization issues without taking other aspects into consideration. The purpose of visualization in ViSuCity is to help the user to take the decisions needed for the city planning process. It is also important to realize the very complex process for city planning including many different users such as politicians, experts, citizens, representing different spatial and/or planning levels from the national

Figure 4: *Automatic grouping of a LiDAR point cloud into objects with distinct height differences. These objects are then classified into terrain, buildings and trees.*

and regional scale to the detailed scale including city district level, block level, building level, apartment level and equipment level. Included are also different aspects such as planning of landscape, public space, transportation, waste, water, energy, social and economic aspects. An overview of the process used can be found in Figure 5. For many of the stages in the figure appropriate visualizations are needed.

It can also be important to use tools for visualization together with tools for evaluation. The Figure 6 is intended to illustrate this fact.

6. Some examples of results

A final report from the project is given in [ViS10]. Examples of reports and papers from the project are given in [Alm10, Bar10, MB11, Mao10, Ols09, Par10, Poo09, Ran, She, Tho10, WQ09].

One result of the project was a demonstrator. The demonstrator's key features and capabilities are summarized as follows:

- Flexible tools to efficiently import existing 3D models and deploy available GIS and other data to generate a 3D model of the actual and current situation that relies on open standards for data exchange (IFC, GML, CityGML).
- Able to easily import and manipulate alternative volume studies and detailed studies created by architects and engineers in this interactive 3D environment. - Able to import and visualize traffic and transportation, technical infrastructure, environmental parameters other than buildings and adopt it to the visualization.
- Multi-criteria evaluation tools (see Figure 7) to analyze certain aspects of urban planning alternatives with regard to sustainability for example accessibility to public transportation, energy, water and waste flows, microclimatic

	Urban Development Process			
Development achievements	**Programming**	**Projection**	**Implementation**	**Administration**
Examples where visualisation supports development of suggestions and solutions	Comparison between system alternatives for integrated water, sewage and waste management	Further development of chosen system alternative	Support for implementation – follow the building and construction process	Visualisation supporting the follow-up of the district's performance
Examples where visualisation supports evaluation and follow-up	Visualised multi criteria analysis linked to system alternatives	Follow-up model with indicators and target levels – hierarchical construction from object to region	Follow-up model with gap analysis target – performance during implementation	Follow-up model with gap analysis target – performance during administration stage
Programme development	Interconnecting base model for all input elements and multi criteria analysis	Base model with illustration possibilities, showing target levels and simulated measurements	Base model illustrating the implementation and showing the construction process and preliminary performance in different construction stages	Base model showing performance in for example three levels (not fulfilled, fulfilled, highly fulfilled

Figure 5: *Different stages in the urban development process in ViSuCity.*

conditions, air pollution and noise etc by innovatively visualize information in 3D,4D and 5D. This will facilitate the weighing of criteria as well as the evaluation of alternatives of these criteria as important part of the MCE procedure.

- Tools to aid decision support, alternative studies, redlining, commenting, analysis of consequences, etc.
- Possibilities to analyze effects and consequences of physical plans with regard to all these aspects combined.
- Able to adapt to the different stages of the planning process, for local computer work and web-based presentation.
- Able to deploy the city plan project as an interactive 3D presentation to be experienced on the web in an easy to use platform.

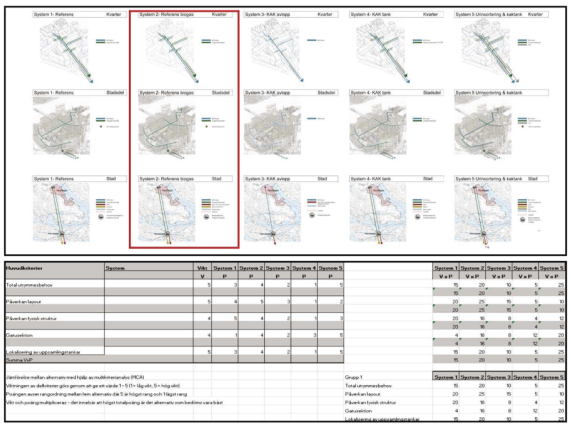

Figure 6: *Different alternatives are visualized and the table gives evaluation criteria.*

An example from the prototype of ViSuCity can be found in Figure 7.

7. Discussion and conclusions

The need for visualization is obvious in a project for city planning. There are several different aspects that have been met and investigated in ViSuCity. They include:

- pure visualization problems and techniques
- integration with evaluation criteria
- modeling and data collection to be used for visualization
- user oriented adjustments when designing the interface of the system
- sustainable aspects of the system

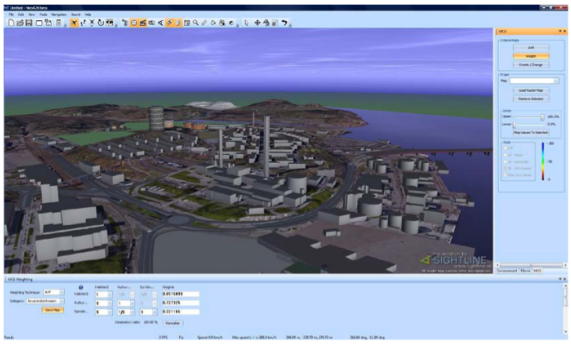

Figure 7: *Multi-Criteria Evaluation in ViSuCity.*

Visualization is a key issue in a city planning tool like ViSuCity and it is important to keep up with the fast evolution of the techniques both from a hardware point of view and from a software and algorithmic point of view. In spite of this it is clear that the integration with other aspects in the system is also a complicated problem. Many challenges remain to be solved and treated when designing and building tools for sustainable city planning. They include such things as to make the visualizations more accessible for non experts.

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