Creating and Using Virtual Cities

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City modelling is a topic which has been on the agenda for a long time and two main approaches from different angles in this field can be identified. GIS experts have attempted over the years (in collaboration with programmers) to build information systems for cities by means of combining graphical information with related metadata. Architects also started to get involved in this field. However, they were mainly interested in the spatial aspects of a city model and created their own "city models" for different purposes. Today crucial questions concerning the creation itself are resolved, the vision of implementation into daily work becomes more and more important. In other words: "what to do" with the accumulated data. This paper intends to identify the core role of the architect in the field of 3D-city modelling .

Keywords: *Urban Modelling, 3D Modelling, GIS, Virtual Worlds, City Model*

1. Introduction

City modelling has always attracted a sort of "competition" between architects and GIS experts. Many of the early city models were initiated by architects - affiliated to universities - as part of their educational and research oriented activities. A significant number of these were predominantly created as rather crude 3D models and represented bits and pieces of a city. As soon as CAD software packages with the ability to draw in 3D were both available and affordable the number of 3D city models rapidly increased. Architects started to add non-spatial information to their city models and interestingly GIS experts started to feed spatial information to their maps. Nowadays these two approaches are merging and a possible explanation for this process is doubtless the development of interactive internet technologies. Examples of best practice in the context of these technologies clearly show how important it is to visualise and present all data that is available for a city environment in an adequate way. Therefore it seems to be clear that we are evolving from the modelling of city blocks and the drawing of digital maps towards virtual cities (or even virtual worlds). First efforts in this working were initiated by municipalities and clearly showed that important aspects have been disregarded because no professionals with a background in architecture seem to have been involved in these attempts at all. This holds not only true for problems regarding the creation of a city model, but even more so for

problems related to the “what-to-do-question” with a city model.
On top of this, a well-structured database environment is required in order to ensure the consistency of “intelligent” or “information rich” data and to keep a 3D city model sustainable over the passage of time. This, together with the concept of LOD’s (Level Of Detail) is of high importance and this is similarly treated in many of the existing city models.

2. Notes on the creation of 3D city models

First of all it has to be pointed out that the digital modelling process ranges from manual CAD construction to semi–automated or even (nearly) fully automated systems based on photogrammetric data. The technology of Laser Scanning is continually evolving and this method - both aerial and terrestrial - is also used for the creation of city block models or 3D façades. Commercial products such as Cyber-City-Modeller, Imagis or MetropoGIS are available and these allow a user to “get a city into 3D”.
For the Graz city model (see section 3 of this paper) MetropoGIS has been used and this software package was developed by an offspring of the VRVis research centre (http:/www.vrvis.at/). A subset of the methods utilised here are summarised below:

- Block Model Generation
  The project deals with the creation of a photorealistic 3D city model from existing 2 1/2 dimensional GIS data provided by the municipality. The input data consists of roof lines, a 30m grid DEM (Digital Elevation Model including break lines) and registered aerial images for texturing aims.
- Feature Extraction
  A system to extract 3D information from oriented digital façade images using various feature extraction/matching methods. The focus is laid on 2Dfeature extraction from digital images including contour chains, line segments and vanishing points. The extraction of 3D lines is based on line matching over multiple oriented views. The system is designed for the automated extraction of 3D lines from façade images.
- Relative Orientation of Image Pairs
  Vanishing points and points of intersection are used to estimate the relative orientation of image pairs.
- Relative Orientation of Image Sequences
  Image pairs and corresponding points facilitate the calculation of image sequences.
- Semi-automatic Georeferencing of Image Sequences
  A system to augment a 3D city block model with geo-referenced terrestrial images of the façades is implemented. Terrestrial images are shot by a handheld digital consumer camera (short baselines). The relative orientation of the photographs is calculated automatically and aligned to the 3D block model with minimal human input using vanishing points. The resulting city documentation system delivers a fully 3D geographic information data set.
- Line Modelling and Dense Point Matching
  A line matching process is used to gather a set of 3D lines in object space and a dense point matching system which creates a point cloud of a façade.
- Multiresolution Textures
  A method to automatically calculate texture maps for a given three-dimensional object out of a sequence of images is used. This is an interesting aspect for the creation of the textures for a city model. It is frequently difficult or impossible to take photos of a building without elements in the foreground (e.g. persons, vehicles, vegetation).

3. Notes on the use of 3D city models

Having created the model and (hopefully) established routines related to the maintenance, a user might want to reconsider the initial vision on usage.

What benefit does for example a planner, architect, politician or "normal" citizen gain from the created city model? In theory, all these potential users of city models could benefit from a model tailored to their specific demands. Nevertheless it must be regarded as a difficult task to provide with the right representation for the right kind of users of all the data stored inside a city model.

The level of realism and the level of interaction can be regarded as core topic in this context A photorealistic textured city model is frequently not the ultimate answer to all questions. The work of Anthony Radford (et.al.) from 1997 dealing with " Issues of Abstraction, Accuracy and Realism in Large Scale Computer Models" is still relevant. For example there is much more to the realistic simulation of the character of a city than correct geometries and appealingly textured façades. This includes aspects of street surface textures, city "furniture", vegetation, etc. To model the whole city with a level of detail in such a way would be an incredibly ambitious and costly task. And to what avail? To have it ready just in case one of your interactive users might want to explore a special part of the city? Whilst this might be important to ensure further funding, (in case the decision makers intend to walk through the computer model, as is rumoured from the Helsinki model), it might be more efficient to let these persons interact with panoramic views of points of interest. It is remarkable to see that even in the work of CASA for Digital London panoramic images are an important factor in presenting "real" situations (http://www.casa.ucl.ac.uk/woodberry/virtual.htm).

The question of the "right amount of interaction" must be regarded to be crucial and still worth further research. Using the right tool or "front-end" to access the data derived from city models is also an important factor. Is interaction an aim in itself or sometimes even a burden? This should be addressed as well.

4. Graz: 3D model commissioned by the City of Graz

Geodata was commissioned in 2003 to setup the 3D city model for the City of Graz by means of using the MetropoGIS-systems and related routines developed by VRVis (http://www.vrvis.at/). Although the municipality of Graz invested substantial financial means for the creation of this model the results as they stand today are far from satisfying. The outcome can be experienced by means of VRML

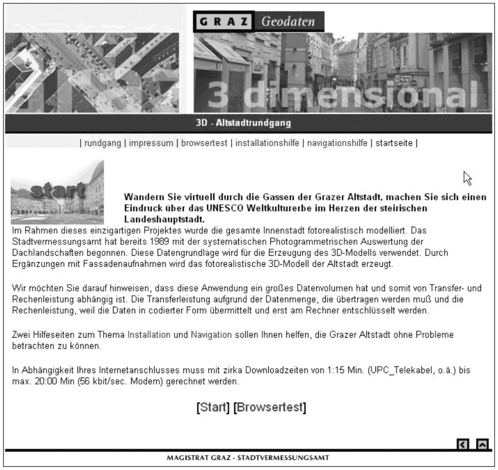

Figure 1
Digital London: CASA Woodberry project.

Figure 2
Graz: "hidden" portal into the 3D – City walk.

models, which are downloadable from the website of the City of Graz (http://3d.graz.at/). It is highly questionable to what extent the bold advertising opener has been fulfilled yet: “Stroll virtually through the lanes of the city of Graz and get an impression of the Unesco World Heritage in the heart of the capital of Styria”.

It has to be noted that the historical town of Graz is listed as a Unesco World Heritage site and this is in particular related to the unique roofscape. The roofscape is not adequately represented in the automated model version. Furthermore, it is obvious that the current state of the VRML model is not able to give any additional information that a videoclip, panoramic image or other means of presentation could not do. Even an architectural sketch would deliver a much better representation.

Opening the crude VRML models (which includes photorealistic textures) to public access can only be explained with certain pressures of “having to show results” and does not really explore and transport the idea of a city model as elaborated in this paper.

Figure 3
Graz: Screenshot from the VRML model vs. the “real world”.

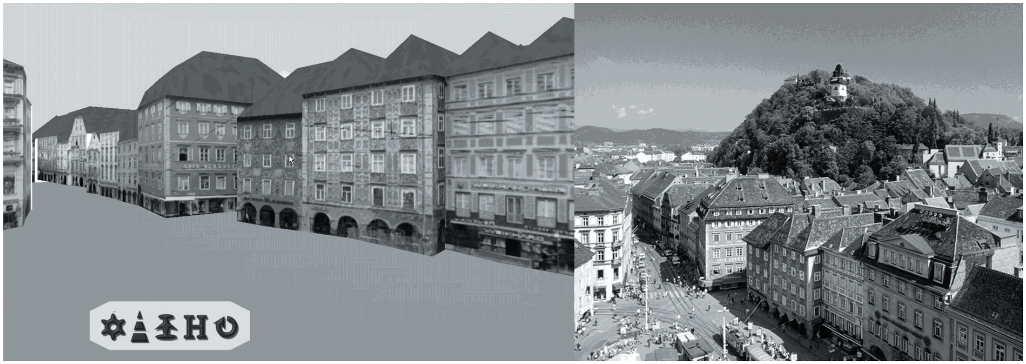

Figure 4
Graz: Main square (Hauptplatz) - screenshot vs. reality.

5. Current state of the "DIGCITY" project

The "DIGCITY" project at Graz University of Technology has already been presented in the context of conference papers and presentations (Dokonal et.al., 2000-2002) and elaborated in detail the concept of creating a sustainable city model in the context of a university with the help of students. Due to different circumstances, the full range of original ideas could not be realised yet. For example, the best available data sets (in terms of accuracy) could not be utilised. In fact the project team was a bit ahead of the state of the currently available technology. This meant the writing of routines to manually create city blocks out of the existing basic photogrammetric data. Nevertheless, in working with these datasets, the relative high number of mistakes in the basic data set was obvious. How could these be resolved properly in the course of automated creation? Therefore, it seemed to be likely that manual input was unavoidable in order to realise refinements – at least in the historical part of the city with its complex roof structures. The authors find the current state of the "DIGCITY" project rather depressing, although there are signs of hope for the future.

At eCAADe 20 is was stated that "The next step in the project is depending on the development of the VRVis city model for the municipality - we will try to use the automatic generated model and refine it with detailed models from our database" (Dokonal et al, 2002). It has to be noted, that an ongoing exchange of ideas takes place with the company and many of the principle ideas set out proved to be useful during discussions. Geodata used the Graz city model as their pilot project for the system and were happy to discuss problems and potential improvements. They have now been commissioned for the Vienna city model and this seems to be very promising. Subsequent joint efforts to improve the Graz model were planned, but these are delayed for several different reasons. Finally, we believe that "bringing back the architects" into the process and evaluating different types of representation of the accumulated data must be regarded as a valuable contribution.

6. Conclusion

It should not be surprising that architects who have been a decisive factor in creating the real world should also play an important role in creating the virtual world when their expertise relating to all kinds of spatial representation is taken into account. When it comes to aspects of visualisation of buildings and cities, architects can call upon on an extended tradition – much longer than the relatively short history of computers. On the other hand when it comes to planning matters, inevitably the spatial aspects have to be included. This is also a core field for architects and therefore a role within the process of city modelling could be expected. Nonetheless, it has also became evident that the digital modelling of complex cities is a complex task that cannot be realised manually within a reasonable timescale by architects alone. The improvement in the automated modelling methods such as Laser Scanning and Feature Extraction gives a vision that in the future a user can "buy your city model from the shelf". If these technologies are more widely spread they will become available at reasonable prices. The speed of these methods will also make it possible to maintain them with a reasonable amount of effort. Finally, the role of the architects involved in this process will shift from being part of the creation of a city model towards finding the right interfaces for the right users for the cities dataset. There is a rich body of research in this area needed and architects will have to take over a major role in this respect.

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Please use the Cumincad database (http://cumincad.scix.net) with the keyword: 3D Modeling

For information on the Digcity Project use (http://www.digcity.tu-graz.ac.at)

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