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On the Borderline

Building a 3-D City Model with Students

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This paper describes ongoing experiences with the „digcity" project at Graz University of Technology (Austria). It presents a different approach in creating a 3-D City Model compared to other urban modeling projects. The substantial input made by students defines the basic characteristic of this project. In this contribution the redefinition of the project management is described. An outline of the project itself has been presented already in previous papers and presentations (Dokonal et.al., 2000 and 2001). These papers are updated here and the latest developments in this project are presented.
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1. Introduction

City modeling has been a topic now for quite a long time and over the years a large number of cities or parts of cities have been digitally modeled throughout the world. A recent study of CASA [1] carried out a review of more than 60 3-D city models worldwide and listed approx. 300 cities. Although this is a substantial number, to our knowledge obviously numerous other existing city models are not listed here what is not amazing, as they were never accordingly published. The main reason for the increasing demand for city models is the urgent needs of telecommunication companies for their network of transmitting towers and also the development of internet based city information systems for both citizens and tourists.

Some of the older existing city models have been created several years ago for a rather specific set of tasks. As they are not used any longer for the original requirements and furthermore, the data resource and reliability of the models is unclear, the potential for re-use is rather limited. Such a constellation could easily serve as an explanation, why they are stored somewhere and mainly forgotten; the only way to retrieve their existence is to get in touch with the people who have been involved in the creation. The presentation of the „digcity" project on the occasion of CAAD-conferences leads to contacts with some of these people. Many of them had encountered similar problems as we experienced, although the procedures in creating city models were basically quite different.

According to the CASA study mentioned above there is no standard or predominant method in city modeling. CASA identifies three different approaches: Traditional 3-D CAAD, Photogrammetric Analysis, Surveying and GIS. The significance of the City Model developed at Graz University of Technology is the combination of those three approaches the main focus being on the impact of the model and its creation within the framework of architectural education.

2. The Idea behind „Digcity"

The starting point for the use of spatial models were the first crude 3-D urban models created in the framework of Urban Design Study Courses at the Faculty of Architecture. Over the years the growing skills of the users in combination with sophisticated software and powerful as well as affordable hardware led to a situation that more and more design and urban

projects were modeled and visualized individually at Graz University of Technology. All these computer-based models were created for several purposes and accidentally in different ways. Unfortunately, re-using these models for other projects was not possible and in the course of the time several parts of the city were modeled again and again. This work improved the skills of the students basically in computer modeling, but did not deliver any further benefits or any additional values for the Faculty or the City. At that time even the Municipality of Graz performed a few projects on 3-D visualization of special points of interest within the city limits but with the same limitations to sustainability. However, the increasing demand of the availability of digital data for urban analysis, visualization and design projects led to the idea of the Graz City Model.

Our first intention was to obtain something like a city model to work on from the Municipal Department of Survey. There had been several attempts to create a 3-D-city model automatically or at least „semi-automatically“ based on the available data resources but all attempts have failed so far. Their latest research project seems more promising but there are still a lot of unsolved questions. One of the main problems is concerned with the triangulation of the façades which we tried to avoid in our concept to make the application of textures easier (fig 1).

Another problem of the existing automatic creation of the city model (apart from the error rate) is the fact that it is in a way built “top down“. In this system the eaves define the geometry and therefore the representations of the buildings are bigger than they are in reality. The Department of Survey is cooperating with Graz University of Technology on this topic and is trying to correct this by using data from the cadastral map. However, a final solution has not been developed yet.

3. The Principle Structure of “Digcity”

The set of principles behind the creation of the Graz city model has already been summarized in previous papers (Dokonal et.al., 2000 and 2001). These publications present more in detail the process of creation including setup of data sources, building of

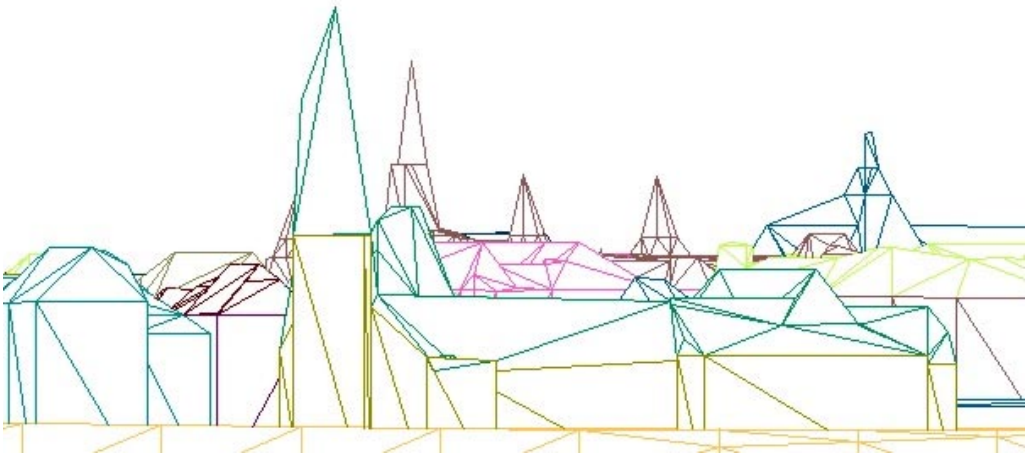

Figure 1. Automatically created city model from the Department of Survey with triangulated façades projected from the eaves.

the CAD models, concept of the levels of detail (LoD's) and the data management system. The 3-D city model is based on models of individual buildings within the city. An AutoCAD-drawing is produced for every building by using 3-D polylines. After conversion into 3-D faces, there is still a possibility of changing the model of every individual building. The main data source for this model is the photogrammetrical evaluation of aerial pictures supplied by the Department of Survey and a site analysis taken by the students. The governing data principles are to be defined unambiguously and are to allow for tracing back in order to grant usefulness. As data gathering done by different individuals delivers patchwork the pertaining defined guidelines are to be carefully observed. Any information to be added to the 3-D city model is for this reason recorded on a data sheet. Building data are entered into the database at varying LoD's (level of detail), depending on availability of basic data. The necessary information for the different LoD's are stored in individual files and linked to the basic model if required.

A detailed documentation sheet on every individual building is kept up-to-date clearly stating data source, any mistakes regarding basic data, data corrections, etc. This documentation represents an essential component of the data records. So far the data storage is kept simple by means of a clearly defined naming convention for the set of files necessary for a building; a script files them accordingly into a directory system. For more details please refer to the website [2].

4. Experiences and Examples

An important characteristic behind the specific procedure for the creation of the Graz 3-D city model is the potential contribution by a large number of students. The first intention was that through bundling and coordinating all efforts in city modeling a perspective for collecting and assembling all the entire parts of the city modeled in the framework of different study courses could be established. This idea has partially failed - mainly because of the rather liberal study conditions in Austria. Therefore substantial work on the project is now being performed in the framework of workshop courses focusing on collaborative modeling. This means that we have fewer students than expected to work on the city model but get better results. Also the problem of "dropouts" decreased and we can react quicker during a workshop.

We already referred to the adapted concept, which is based on a workshop course of collaborative modeling, where groups of three to four students are working on all aspects of an area to be modeled digitally, i.e. not only the construction of the basic geometry of the building but also making digital photos of the façades and rectifying them to use as textures. One of the main problems was that a lot of students did not understand the importance of the rules explained in the How2Do-webpage. Everyone who works with a CAD system does things slightly different and not all of the students understood the consequences of ignoring the rules. In the beginning we had students who disconnected their building from the overall coordinate system by using copy and paste commands, surely not a suitable procedure in the framework of a city model. We tried to add all necessary information about possible problems during the construction of the 3-D building models into our website but we had to realize that it is also important to keep the help file simple and "handy" to use - otherwise nobody uses it. It turned out that it is inevitable to check every step and help the students during their work to prevent them from arriving at dead ends.

The other major problem still arising is the varying quality of the documentation sheets. Some students fail to understand the importance of the documentation for this project although repeatedly explained. Therefore we still wind up with quite "mixed quality" of documentations (fig 2).

Furthermore, the complex roof structure of the mediaeval city of Graz sometimes proves difficult to understand for the students in its spatial complexity. In some cases the understanding of the geometry of a roof fails and so does the following digital

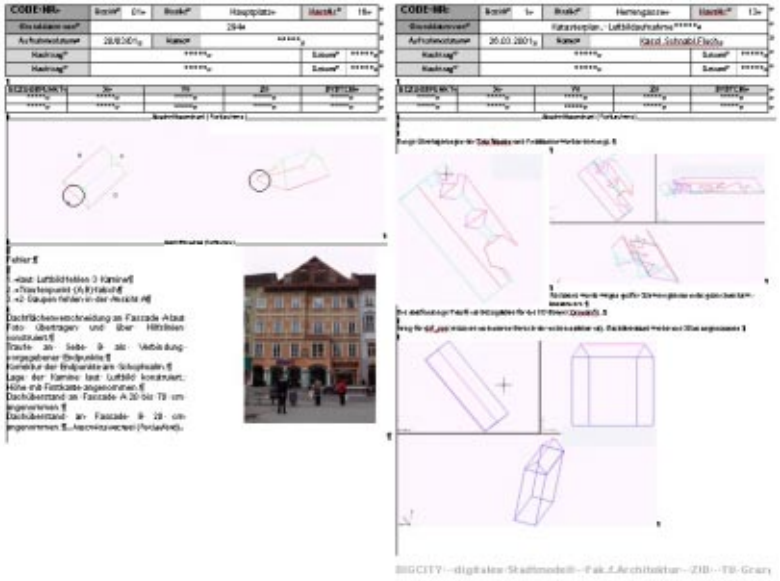

Figure .2 Example of a "good" resp. "bad" documentation sheet explaining the construction.

Figure 3. Example of a basic data set.

construction from the available data. These students need quite a long time to create a proper geometry. Our decision producing the surfaces with 3-D polylines (to prevent triangulation) causes more difficulties for the students regarding plausibility-checking of the model by using the CAD system and often checking geometries by means of the Modeler is required (fig 3).

The fact that the basic data were obtained by the Municipal Department of Survey led to a substantial error quote significantly contributing to such problems of understanding. It was already discussed with the Municipality that one reason for this relatively high error quote is the fact that at the beginning of the photogrammetrical evaluation of aerial pictures many individuals were involved and the procedure was not professionally established. The problem now is that there are quite often “correct points” but unfortunately combined with wrong attributes or allocations. For example, a measured point is correct in height but actually belongs to an adjacent building thus the line drawn in the photogrammetrical evaluation is non-existing in reality. This fact causes a lot of confusion to students and slows down the creation-speed enormously. However, the work on this model acquaints them with the spatial complexity of building and roof structures. Therefore we are tempted to continue to work with the students who participated in a workshop course and learned how to handle the job. This would really help in increasing the speed of the creation of the model itself. And we are to bear in mind that this project is not only focusing on the model itself but also on the learning effects during the creation (fig 4).

We are still trying to eliminate tedious work involved with the creation of the model such as checking and turning the plane normals. This task has been performed “automatically” by means of a

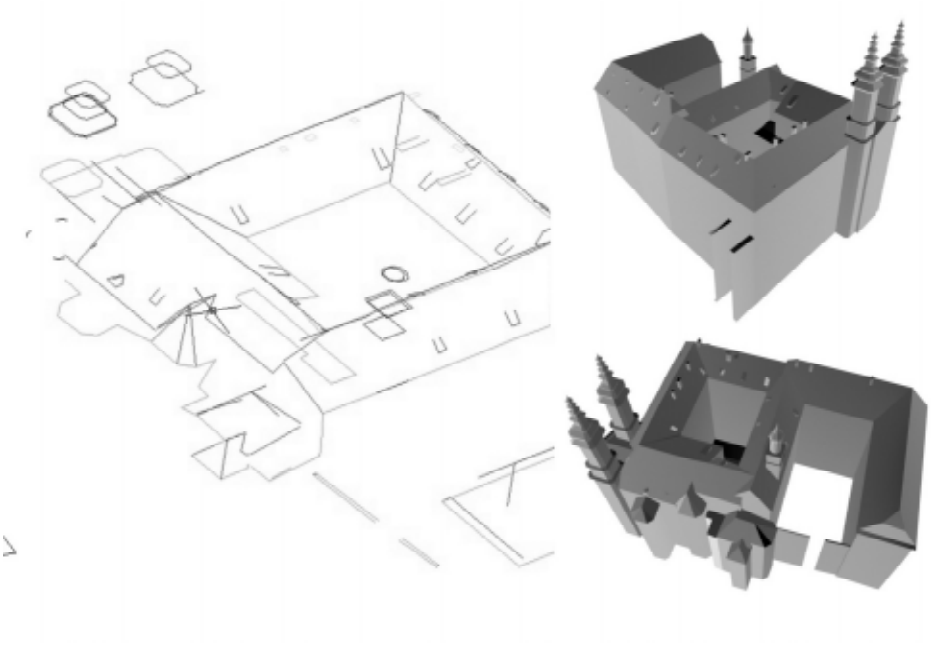

Figure 4. Basic data (left) and model of building(right - without textures).

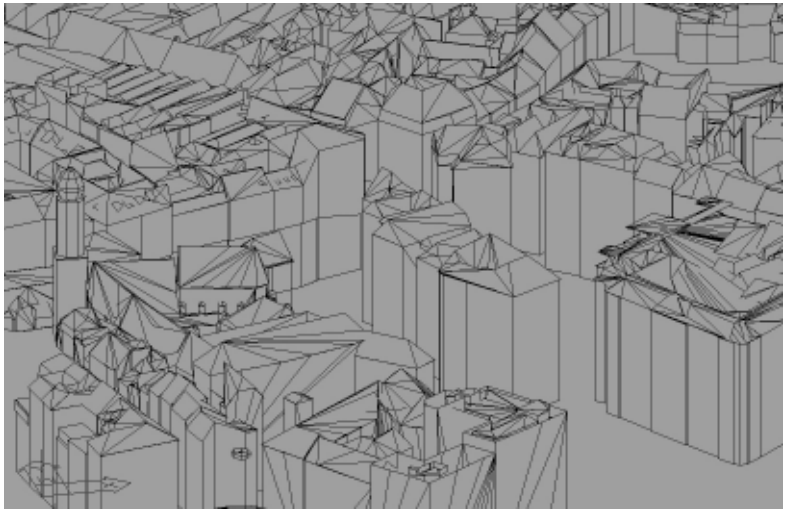

Figure .5 Partial model of the city center with extended heights.

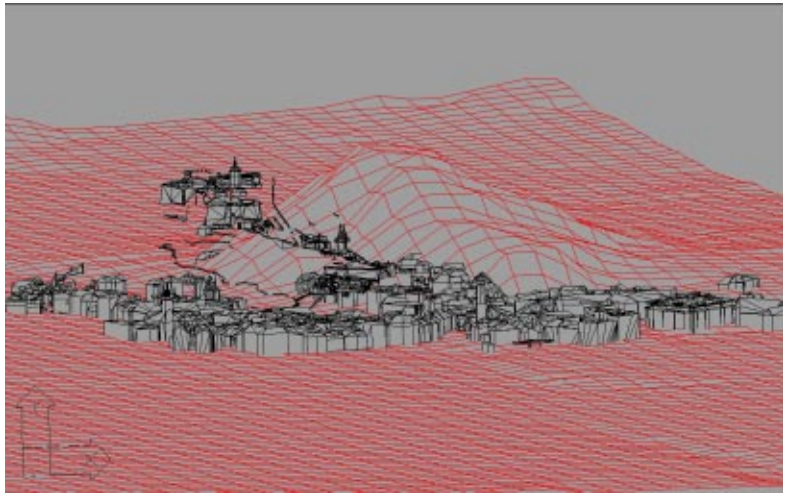

Figure 6. Partial model with a representation of the terrain.

modeler software (Maya) using a plugin. Another problem area is the removing of multiple points on the same coordinates of a polyline now being checked with the help of a lisp routine in AutoCad. The question of the optimum moment for switching between CAD software (which gives better control for the construction) and the Modeling software (which gives better control of the surfaces) during the creation of the model is still a topic under discussion.

Due to the above problems we were not able to

use all the geometry the students produced since the beginning of the project. At the time of writing the Graz 3-D City Model consists of approx. 320 reliable buildings and the efforts are now being directed towards the closing of the “white spots” in the inner city. The project will be continued within a workshop structure which is still “under contruction” to get the best results, both for the 3-D City Model itself and the instructive as well as educational effects for the students involved (figs 5 & 6).

5. Conclusion

Trying to establish a city model on the principles described in this contribution is doubtlessly working “on the borderline”. In order to speed up the process of the model creation there is a strong temptation to work with professionals or at least more experienced students. It would be much easier and quicker to reach the point were the results of a model with a high degree of completeness can be visualized and a focus can be laid on future uses of the accumulated data. However, from its very intention “digcity” has been established as an educational project, a central principle to be kept in mind, whereas the level of necessary support of student input is under adjustment. A main goal behind the creation of this 3-D city model is to create improved resources for architectural education - both on levels of urban design and on those of (architectural) project design.

Notes

[1] Center for Advanced Spatial Analysis at UCL London: http://www.casa.ucl.ac.uk/3dcities which contains a brief summary of their research on 3D-city models and a listing of more than 60 different models.

[2] http://www.digcity.tu-graz.ac.at contains a more detailed description concerning the guidelines and working procedure. A careful explanation of techniques is furthermore presented here.

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