

3D URBAN MODELLING WITH VRML TECHNOLOGY – COMBINATION OF 2D AND 3D INFORMATION AND INTEGRATION TO MOBILE CLIENTS

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A 3D representation of a city embedded in an internet environment is not a new technology. It is already used in many projects which present tourist information. But 3D modelling assumes a lot of manual operations and these are still not fully operational to handle, even if there exist special software (e.g. CyberCity) nowadays, that support the generation of 3D scenes. The emphasis of this paper is to present a method for improving the automation of generating 3D VRML scenes by using simple and adapted procedures which are implemented in a GIS environment. Our goal was to create a backdrop which is easily modifiable and replaceable. Especially within a city we find areas (e.g. shop windows), whose appearance changes continuously. Their representations can be replaced by simple worksteps in the 3D workflow. A 3D environment is based on a pool of different data e.g. cadastral maps, floor plans, and aerial images, which should have a minimum resolution of 50 cm, to guarantee the recognition of all important items. The cadastral maps should be controlled by using current aerial images to eliminate errors. More complex buildings are assembled from several simplified building sections. Subsequently, an automated modelling takes place after adding a few parameters (building height, roof form, etc.). For a realistic natural representation, the texturizing was assisted by using digital photographs of the building facade. The whole VRML scene is modular. Each wall was generated as an individual VRML file, turned and shifted into the suitable position. Every single wall can be addressed individually and this facilitates the adjustment of the textures enormously. In this way small changes of the buildings could be easily maintained without generating the whole VRML scene again. Finally, the modular city file was loaded into a main file with optional additives such as trees, viewpoints etc. This additional information could also be generated likewise automatically. For orientation purposes a general map was integrated, in which the position and line of sight of the user is indicated by an arrow. In addition we linked the introduced VRML technology with a powerful WebGIS application. Within this application the user can navigate through a dynamic map, take a look for attributes or search for certain objects. The 2D internetmap system is realized with Open Source software (UMN MapServer, Apache WebServer, PostgreSQL/PostGIS). One innovative feature is the possibility to switch between 2D and 3D visualization (individually). Furthermore it was tested how mobile clients could be used. With an Ultra Mobile PC (UMPC) a 2D navigation based on Open Source software was realized.

KURZFASSUNG:

3D-Stadtdarstellungen im Internet sind keine neue Technologie. In verschiedenen Applikationen findet eine solche Form der Darstellung ihren Einsatz. 3D Modellierungen beinhalten für eine Darstellung eine Vielzahl von händischen, zeitintensiven Operationen. Mit dem nachfolgend dargestellten Projekt soll eine Methode zur verbesserten Automatisierung von 3D-VRML-Szenen präsentiert werden. Das Ziel war es, eine Anwendung zu entwickeln, welche in einfachen und modularen Schritten verändert werden kann. Die 3D-Anwendung basiert auf unterschiedlichen Datengrundlagen (ALK-Daten, Luftbilder etc.). Um Fehler in der Darstellung von Gebäuden gering zu halten wurden die Katasterkarten mit den Luftbildern verglichen. Komplexe Gebäude wurden in ihrer Darstellung vereinfacht. Um Gebäude so realistisch wie möglich darzustellen wurden für deren Texturen digitale Photos verwandt. Die gesamte VRML-Szene wird modular aufgebaut. Einzelne Wände bestehen aus einzelnen VRML-Dateien, welche auf Basis der ALK-Daten in die korrekte Position gebracht werden. Veränderungen an Objekten können individuell an den einzelnen Objekten vorgenommen werden. Es ist nicht notwendig, dass die gesamte VRML-Szene umgestaltet werden muss. Innerhalb einer WebGIS-Anwendung (Gebäudeinformationssystem) wurden 3D-Szenen an eine 2D Internetkarte angelagert. Das 2D-System basiert auf Open Source (UMN MapServer, Apache WebServer, PostgreSQL/PostGIS). Es wird dadurch möglich, aus verschiedenen Blickwinkeln einen Eindruck von der universitären Gebäudelandschaft zu erlangen. Der User kann zwischen der 2D- und 3D-Anwendung wechseln und sich zudem textliche Informationen zu einzelnen Gebäuden präsentieren lassen. Attribute von einzelnen Gebäuden (z.B. Raumebelegung, Ausstattung etc.) können über ein Content Management System verwaltet werden. Zudem wurde getestet, wie 2D bzw. 3D Anwendungen in mobile Endgeräte integriert werden können. Unter Nutzung eines UMPCs konnte eine GPS-gestützte Navigation in einer 2D-Anwendung, basierend auf Open Source Software, umgesetzt werden.

1. INTRODUCTION

3D representation of a city in the internet is a quite common technology. There are different ways to present objects in 3D, for example with CityXML. Generally many manual operations are necessary to develop a 3D scene and it's a difficult process to produce these scenes automatically.

The benefit 3D gives is a more or less realistic impression about a special area of a city (or even the whole city). In that way a city marketing can be build up and tourism can be supported.

With this paper a method for improving the automation of generating 3D VRML scenes shall be presented.

Furthermore we want to show how 2D and 3D presentations can be combined and integrated in a mobile client.

2. MAIN GOALS OF THE PROJECT

- Illustrating the reality in an adequate way. The facades of the houses are visualised by digital photographs. The cadastral map is used for the correct positioning of the buildings.
- The results should be presented in the internet; that's why a standard modelling language (in this case VRML (Virtual Reality Modeling Language)) is used.
- 3D-objects should be created as automatically as possible. To keep the workflow simple the cadastral data have to be simplified and should have just a very few parameters (e.g. roof form and roof direction).
- The constructed VRML-Scene is modular. Each wall is an individual file and can be addressed individually. In that way there is no need to change the whole VRML-Scene if one wants to change a building (Michel, Bockmühl 2006a).
- Combination of 2D and 3D applications.
- Integration of 2D and 3D applications in different mobile clients (PDA, Ultra Mobile PC).

3. PREPARATION

The first step is to simplify the ground layout for each building. Every building should consist of 4 vertices. That makes it as easy as possible to fit the textures to the object. That simplification can be done only semi-automatically because this procedure is quite complex.

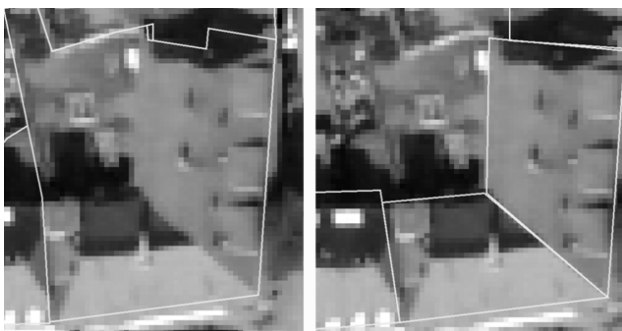


Fig.1: Cadastral map layer over aerial image before and after simplification (Michel, Bockmühl 2006b)

As Fig.1 shows, to construct the housing-simplification an aerial image is added. This should have a minimum resolution of 50 cm, to guarantee the recognition of all important items. In a further work-step the parameters of the building have to be

added. Form and direction of the roof can be extracted from an aerial image or from direct observation by the user. The heights from ground to roof and from ground to top can be got by an stereo-image as well.

3.1 Texture examination

Two types of textures are differentiated.

- **Background texture**
Each wall has a background texture which covers the main area. Small images are used that are tiled continuously in the whole wall area. The pictures are supposed to be quadratic and the pixel count should be to the power of two. The textures should have a homogenous appearance.
- **Object texture**
Special objects should be displayed with a special texture. An object can be used for different object areas and objects can be changed in a simple way, what is important for areas that change their appearance continuously.

The use of two types of textures is quite important. By taking a picture for the background texture often disturbing objects (cars, trees etc.) are in that pictures. By overlaying the picture with an object texture disturbing effects can be deleted.

The digital photographs should be made parallel to the object, so that no rectification is needed. This is not always possible especially in narrow streets. In these situations, the result is a tilted photo with perspective distortion (Fig. 2).

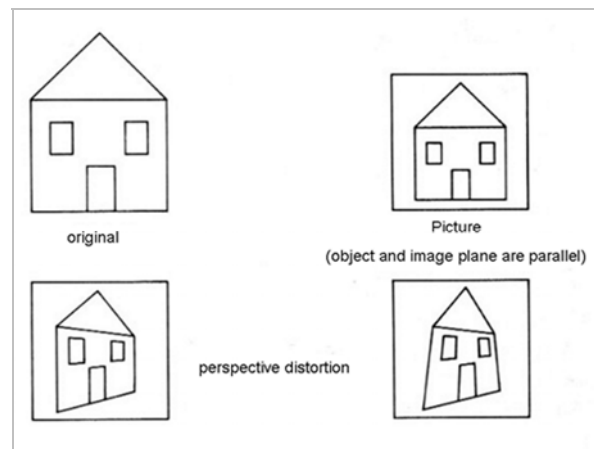


Fig. 2: Perspective distortion (modified and translated) (Weinmann 1988)

For that a linear rectification has to be used. In that way the distorted picture is transformed in an image parallel to the object. By using the rectification the proportional distance is conserved, what is adequate for modelling the appearance of the buildings.

To measure the positions two factors are needed (height and width) that convert the measured pixel (value to centimetre, value for creating the VRML-object). "These factors have to be calculated by dividing the distance of the building through the distance of the pixel measurement. The two factors are necessary in order to get the proportional distance between the objects. Because of the inexact measurement of the building heights, some small differences can appear. Each object is rectangular and so two pairs of coordinates are needed and these

have to be saved as attributes of the wall-line. With this information, the generation of the VRML building can be done automatically” (Michel, Bockmühl 2006b).

3.2 Texture adjustment

The arrangement of the object textures has to be done manually. At first the object areas have the same size like the objects in reality. So the textures can put above them without distortions. Each wall is generated as an individual VRML file so the controlling of the texture adjustment is easy.

3.3 Building scene

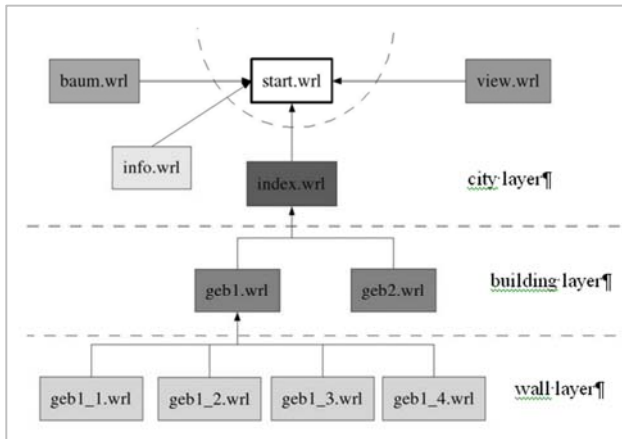


Fig. 3: Modular building scene (Michel, Bockmühl 2006b)

Each wall has an own file (geb1_1.wrl, geb1_2.wrl etc.). The walls are shifted in an appropriate position. That happens in the geb1.wrl-file (e.g.) that contains the whole building. In the city layer, each building is shifted into the suitable position and is included in a separate file (index.wrl).

The modular 3d-city is loaded in a mainfile, in which additional objects (trees for example) can be loaded.

Because of its complexity not all aspects of the reality can be demonstrated. It is necessary to simplify the reality (for example roof types).

3.4 Including in HTML



The VRML-scenes can be loaded into HTML-files.

Fig. 4: 3D-VRML-Scene (altered from Michel, Bockmühl 2006b)

JavaScript can be used to assure the interaction between the user. The user can navigate in the system and can get an overview of cities or their buildings.

4. COMBINATION OF 2D AND 3D DATA

At the Institute for Geoinformatics and Remote Sensing (IGF) a system will be developed that will be able to present the buildings of the university in 2D and 3D. The architecture is based on Open Source software (UMN MapServer, Apache WebServer, Postgre-SQL/PostGIS).

Typical users of that system are students, employees of the university, visitors or internetusers which want to get an impression or an overview of the buildings that belong to the university.

In this application a virtual scenery is presented to the user. In a html-iframe the user can see a building in 3D and a 2D internetmap (fig.5). In the map locations of the buildings are displayed. Certain buildings can be chosen over viewpoints or a html-selection-list.



Fig. 5: 3D and 2D combined (Michel et al. 2007)

It is possible to enter the buildings virtually to have an overview about the chattels. Basically every object in the virtual world can be linked with the database.

Every room has special attributes like area, illumination, telephone mainlines, WLAN-access, etc. These attributes are available in the information system.

Via a content management system (cms) the attributes of the objects can be altered easily (Michel et al., 2007).

The cms is based on an extensive structure of PHP-scripts and is Open Source software as well.

5. MOBILE INFORMATIONS

The system is successfully tested on a PDA by using the WLAN-internet connection of the university. Certain informations of rooms or chattels can be collected easily by this way. The update of these data is done by the server automatically. A disadvantage is that only certain “PDA-software” can be used.

Currently it is tested how mobile clients can be used to integrate the applications. An UMPC (Ultra Mobile PC) is used (ASUS

R2H). This UMPC has a distinct better performance than conventional PDA and a larger display. It has integrated WLAN, a GPS-receiver, 768 MB RAM and its processor has a performance of 900 MHz. The hard disk contains 60 GB.

On that mobile system typical desktop applications are running. In addition Apache WebServer, PHP, Mozilla Firefox and the gps-program "u-center" are installed.

With a programmed PHP script the GPS coordinates are retrieved from the NMEA-string of a logfile and changed into a German coordinate system (Gauss Krüger) (fig.6).

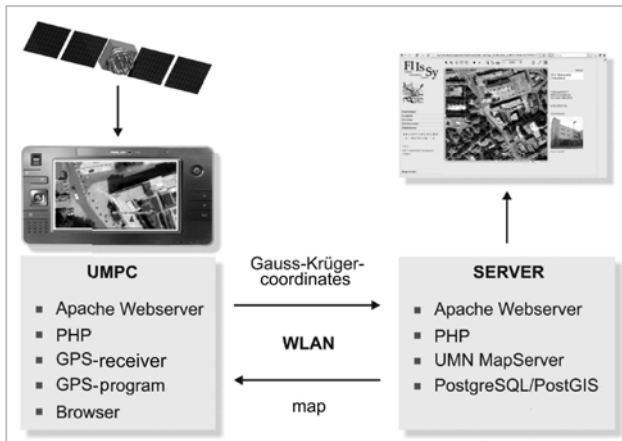


Fig. 6: Navigation via an UMPC (altered from Michel et al. 2007)

Via a WLAN-connection the coordinates are sent to a server and stored in a PostgreSQL/PostGIS-database. Due to JavaScript the application is started every 30 seconds again and only new arriving data are written in the database.

At the server site the UMN MapServer gets access to these data and presents them in a map layer. In the 2D system the user can see where he is located (Michel et al. 2007).

A next step should be to test how a combination of 2D and 3D systems is working together in that mobile client.

5. CONCLUSION

The developed method simplifies the generation of a 3D representation of a city. Single objects can be modified by using separate work-steps without generating the whole VRML scene again.

The 3D representation of the buildings as the main component of the system can be completed with many additives to get a more realistic overview. These additives can be point information like trees or viewpoints.

It has to be shown that there are many options to complete the 3D-environment with dynamic elements like animation. The number of these elements influences the time of work. Furthermore, the loading time is enhanced with increasing degree of reality. (Michel, Bockmühl 2006b).

The 3D representation can be integrated in different systems, e.g. in combination with 2D visualization, so that people get an overview of a city from different dimensions.

Via the 2D information system a user can navigate in the typical way. He can get a quick overview of the area and is able to zoom in and out.

The use of mobile clients like PDA or UMPC offers even the opportunity to navigate in nearly real time through the 2D scene.

6. REFERENCES

- Michel, U., Bockmühl, T., 2006a. 3D-Modellierung leicht gemacht. *GeoBIT* 3, pp. 13-15
- Michel, U., Bockmühl, T., 2006b. GIS and Remote Sensing for 3D Urban Modelling by means of VRML Technology. Proceedings, SPIE Conference, Stockholm, Sweden, Vol. 6366
- Michel, U., Behncke, K., Plass, C., 2007. Virtuell über den ganzen Campus. *GIS BUSINESS*. 5, pp. 20-23
- Weinmann, G., 1988. *Architektur-Photogrammetrie*. Wichmann Verlag, Karlsruhe