3D City Guide

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Abstract.

In recent years we observe that the application of 3D models has been forged ahead at several specialties. The development of new technologies and methods give a possibility to develop complex applications serving the user needs.

The aim of the ongoing 3D City Guide project is to examine the preparation and usability of real 3D models for touristic purposes on mobile devices; on the other hand, the project aims to create a sample system. Based on our experience, we will offer methods for development of tourism information systems for PDA devices. The two-year project is performed by the coordinator, FehervarEPITESZ Ltd. and the partner GEOINFO Nonprofit Ltd. and it will be ended in spring 2011.

In the research phase we collect regional historical data about the chosen sample area in Szekesfehervar inside the historical downtown. In the data collection, it is necessary to browse the archived documents in libraries. As a result, the exploration and collection of the historical and archaeological data will be done. The positions of the buildings and other spatial objects will be determined with surveying methods. For spatial and non-spatial data processing and visualization, a data model and a procedure model will be created, considering the capacity of PDA devices. At the time of the 3D model's production we will analyze the data which are created with laser scanner or modeled from the existing maps. The database will be optimized to be used on PDA devices.

The purpose of the system is to inform and guide the tourists who are visiting the city. The development of the sample system will be based on the results attained during the research activity. Besides proprietary solutions, open standards and open source technologies will be applied in the development.

This paper gives an overview about the progress of the project, the technological background, methodological considerations and the planned functionality of the sample system.

Keywords: 3D modeling, PDA

1 Introduction

The 3D City Guide project is founded by the Hungarian National Office for Research and Technology and performed by the coordinator FehervarEPITESZ Ltd. and the partner GEOINFO Nonprofit Ltd. The project consists both research and development activities. The aim of the project is to examine the preparation and usability of real 3D models for touristic purposes on mobile devices; on the other hand the project aims to create a sample system. Based on our research, we will offer methods for development of tourism information systems which work on PDA devices. The two-year project consists of two one-year phases. It will be ended on 30.04.2011.

1.1 Objectives

The project name 3D City Guide is a popular name in recent years. Checking it on the Internet, it can be seen that there were started several projects with similar names. Generally in these projects, the aim was the development of some kind of navigation solution.

Our project has some special objectives which distinguish it from the other projects. These are the followings:

- the sample system will work only on PDA devices
- we will collect heterogeneous data including historical, archeological and tourism-related data from the sample area
- the primarily spatial data collection will be the laser scanning
- we will use a standard to build the data model and manage the 3D model in the sample system
- the research tasks will produce 3D data optimization methods and data integration procedure.

In order to achieve these objectives, we will perform the tasks described in the next section.

1.2 Tasks of the first phase

Technology review and selection
In order to modeling the city in 3D and developing the sample system, it is necessary to define the technology background which includes the software and hardware platform, the developing tools, data storage and data visualization technologies. The result of this task the selection of the technology what will be applied in the system development.

Methodology research for model optimization
The application of the different surveying methods will produce different detailed spatial data sets. The spatial data representation on PDA devices depends on the capacity of devices therefore the analysis of the data optimization possibilities is a planned activity in the project. As the result of the activity, we wish to provide methods for the data optimization.

Historical, archeological and tourism-related data collection
Szekesfehervar is one of the oldest settlements in Hungary. The chosen sample area is located in the historical downtown so it has a good potential to serve various historical, archeological and tourism-related data. The attribute data of the sample system are the results of this data collection activity.

Data modeling
The data model is the basis of the sample system. The complex model will consist of geometry, image, audio and text data. In this activity we determine the proper data structure and proper data content of the tourism information system. The outcome of this activity is a logical data model.

Procedure for data integration
The logical data model defines the data structure which will be used by the sample system. A logical model did not serve any information about how we should fill up the database. In order to find a solution to this problem a procedure will be produced. It will determine the interfaces of the database and the steps of data integration.

Survey and data processing
The primary method of surveying will be the laser scanning. It is planned to perform laser scanning outside of the buildings and inside as well. Besides the laser scanning, using the existing maps and the plans of buildings (especially plans of objects which didn’t survive the centuries) wire frame models will be created.

1.3 Tasks of the second phase

Data optimization
Using the results of methodology research, the data optimization will be performed. At the end of the optimization, a PDA-usable content will be produced.

System development
The 3D City Guide tourism information system will be built on the produced database. The results of researches will be appeared in the functionality and visual appearance of the system.

Verification and validation
The created city model will be verified from an architectural point of view.
The sample system will be validated from a tourism point of view.

1.4 The present state of the project

In this early stage of the project, the technology selection was finished. The data modeling and the thematic data collection have a final, common activity to harmonize data according to the model and/or correct the model based on thematic data. The methodology research has been started focusing on point cloud optimization.
In the next chapters, the planned functionality of the sample system, the technology background and a part of the methodology research are presented.

2 Planned functionality of the sample system

The sample system will be implemented on a PDA device which has a GPS receiver. The main functions of the system are to guide tourists between places of interests and provide 3D visualization.
It is planned to add a text-based and a voice-based guiding function to the system. Using the guiding function a tourist will get thematic information about objects in audio, text and image. The information will be available in Hungarian, English, German and French.
The time dimension is an important planned feature of the system because an object might have one or many historical attribute data and historical spatial data.
The 3D model will consist of three main object types:

- City objects (eg. buildings, statues, city furniture, etc.)
- Objects inside buildings (e.g. a building most interesting parts, paintings, statues, etc.)
- Historical object which cannot be seen (e.g. demolished castle wall or buildings)

The capacity of the PDA device and the result of the model optimization will determine the exact 3D capability of the sample system.

3 Technology background

In this chapter, the technology review and selection task is presented.
In order to choose technologies for 3D modeling and sample system development, the following requirements were defined:

- the mobile devices should have a built in GPS receiver
- the mobile device should have at least 3.5" size display
- the primary way of input is the touch screen
- the sample system should work on more device types.

In order to analyze technologies, the next aspects were considered:

- the types of mobile devices
- the capacity of mobile devices
- the mobile operating systems
- the development platform
- the possibilities to store and display data
- the hardware and software compatibility
- the development environment
- the available, open source libraries for development
- the applicable data collection methods
- the similar and working solutions
- the development standards and trends.

These aspects are related and determine each other on several ways.
Based on the aspects and requirements, we analyzed:

- the available mobile devices on the market

- the mobile operating systems
- the development platforms, frameworks and IDEs
- the related OGC standards
- the APIs for 3D graphical representation.

Finally, the selected device was a Mio P560 PDA with built-in GPS, 3.5" display and 2 GB RAM. Windows Mobile 6.0 classic operating system with installed .NET CF 2.0 works on it.

3.1 Development platform and tools

The selected platform was the .NET Compact Framework (.NET CF) which is a Microsoft .NET framework for Windows CE and Windows Mobile operating systems. The .NET framework provides libraries and a virtual machine for application development such as the Java platform. The development of .NET framework was based on a Microsoft implementation of Sun Java platform. For a .NET development several programming languages are available however Microsoft primarily offers technology for C# and VB.NET programming languages. Nevertheless, an open source alternative is available, the SharpDevelop IDE. [Microsoft][IC#SharpCode]
For mobile application development, there are several commercial software development products available on the market. One of these is the Basic4ppc IDE developed by Anywhere Software. This development environment contains the Basic4ppc programming language which based on the .NET CF framework. The Basic4ppc was chosen for the project because of its built in libraries and the available open source additional modules which are published and maintained by an active user group.[Anywhere Software]
For the sample system development it is necessary to create some custom libraries which are not provided by Basic4ppc nor its user group. For this purpose it is intended to use the SharpDevelop IDE.

3.2 Data storage and representation

For structuring and modeling the collected spatial and non-spatial data the KML and CityGML markup languages provide standard solutions.
CityGML is an open information model for storing 3D city models. It is implemented as an application schema for the Open Geospatial Consortium (OGC) standard Geography Markup Language 3 (GML 3). On 20.08.2008, the CityGML 1.0.0 was approved as an official OGC standard. This model manages the geometry and thematic attributes of 3D objects. Its geometry model represents the geometry and topology of 3D city models; its thematic model represents the semantic information of objects. This semantic approach makes possible to determine relationships between objects and to use the same model for different applications by the semantic-driven representation. [Kolbe][OGC]
KML is another OGC standard for representing geographic data. It is not based on GML and has no capability to store semantic attributes.
In this project the CityGML was chosen to store the 3D city model.
In the sample system for visualizing 3D data it is needed to use a graphical application programming interface (API). For this purpose there is a Microsoft development tool, the Direct3D which is a part of DirectX API. Direct3D can be used on Windows platforms including .NET CF.

3.3 Considerations

At the end of Chapter 3 in this section, some development considerations are described.
The development tools will be used on desktop computers. The test versions and the final version of the system will be deployed to the mobile device.
One of the advantages of CityGML is that it serves a conceptual framework to manage spatial data and semantic data together. Using this standard and extending it with special historical, tourism-related data definitions we will provide a data model. This data model, the data integration procedure and the result of the optimization activity will make it possible to use any CityGML data set in the sample system.
A CityGML document is a text based document. The storage of data in text format requires more storage spaces than the storage of data in binary format. On mobile devices to manage a large document may cause performance problems. If it necessary because of performance reasons we will use one kind of implementation of the CityGML language on the mobile device, for example a binary

representation of it. Using a binary representation of the CityGML markup language does not have any effect on the mentioned advantage.

4 Point cloud optimization for city-modeling

After the technology topic, in this chapter the problem of 3D model optimization is described.
The compilation of city models is not an easy task, it depends on the level of detail. The CityGML standard distinguishes four level of details: LOD1, LOD2,LOD3 and LOD4 (Fig.1), [Kolbe-Nagel-Stadler 2009].

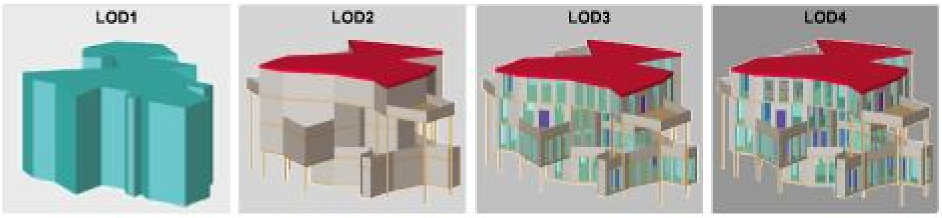

Fig. 1. Figure Level of details in the CityGML

The aerial laser scanning (LIDAR) is capable to serve data for LOD1-3. The terrestrial laser scanning is mainly used for modeling LOD2-4. It means that there is an overlap between these two data capture methods. Although the LIDAR is most efficient in the roof modeling and the terrestrial laser scanning is more useful at façade modeling.
The common point in both methods is that a point cloud is generated as a first step and this point cloud should be optimized for modeling. If we decide not to optimize the point cloud than we can generate models which are very close to the reality, but these models have too much details which is suitable only for engineering measurements and high precise architecture modeling. The easiest way to create a high detailed 3D model is to generate a TIN model, but this TIN model is handled with difficulty at a certain extent, since the number of points is extremely high, it can even reach the number of pixels on the photo covering the scene. In this case the other fast method is to generate disks around the points. The orientation of the disk is determined by the normal vectors perpendicular to the disks. The diameter of the disks is determined by the distance between the neighboring points. By this method the model is rasterized and textured by the photo very easily and the resulting model is very attractive since the generalization is very low and the model is highly similar to the real building (Fig. 2), [Böhm 2009].

Fig. 2. 3D visualization by point splatting

Usually this accurate model is not demanded at city-modeling. Therefore the optimization of the point cloud and a generalized model-building is more practical and most desirable.
There are two main tasks at the optimization: filtering and generalization. The filtering is necessary to delete the unwanted objects from the scene, e.g. cars, plants, people, electric poles and wires and so on. The one way for filtering is to make groups from points. The groups are generated by several techniques. The three main techniques are: grouping of points based on colors, plains and number of laser returning signals (Fig. 3.). Usually the plants have more returning signals (echo), since the laser penetrates the plant and is reflecting more than once until it reaches the ground. The buildings are hard enough to reflect the laser only once, except the windows, chimneys and sharp edges. The other effective way of grouping is generating plain surfaces from the points. Usually some small portion of

points is chosen first (e.g. 5 points) to detect whether they are in common plain. These plains are playing the role of seeds and based on these seeds the neighboring points are attached to the plain. This technique is very similar to the remote sensing method of pixel growing [Vosselman 2009].

Fig. 3. Segmentation of objects by colors and plains

To find the seed plains can be time consuming, the RANSAC method optimizes this procedure [Schnabel-Wahl-Klein 2007].
After filtering the point cloud the next task is to generate the 3D models of buildings. The modeling is divided into three parts: modeling of roofs, modeling of walls, texturing of models.
The modeling of roofs is mainly made by two methods. The first method is based on graph matching. First the plain detection is made as it is described above and than by edge detection a graph is generated and this graph is matched with a library of roof models and the most similar is chosen based on the form of the graph, the number of nodes and the type of edge intersections (Fig4.), [Vosselman 2009].

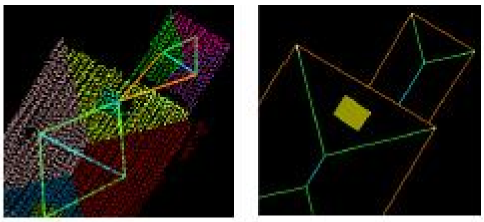

Fig. 4. Modeling of roofs by graphs

The second approach is where only the plains are generated based on normal vectors picked to the scanned points. Using these normal vectors the direction of the roofs can be determined and it is an essential characteristic for the roof models. At is method a preliminary condition is to know the outline figure of the building on the ground (footprint). This footprint can be generated from images or from cadastral maps. When the footprint is generated from images it is a good approach if the footprint is divided into perpendicular cells and these cells are joined together later at the roof modeling (Fig. 5), [Kada 2009].

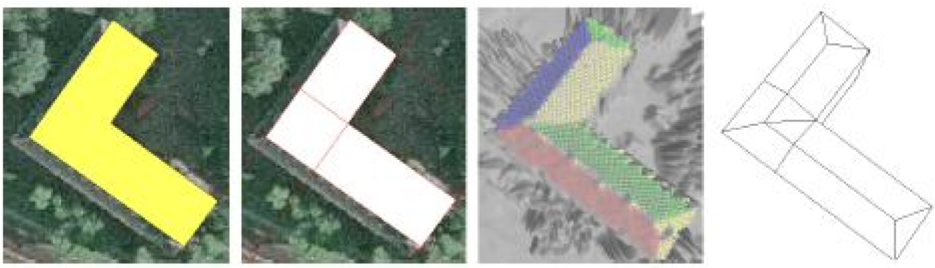

Fig. 5. Footprint detection

As a result we can generate 3D models of the roofs. This modeling can be automatic, but not fully. The complex roofs should be made manually.

The next step is to generate the walls, which is easier comparing to the roof modeling, since it needs only two datasets: the footprints and the height of walls. The footprint is generated from images or from cadastral maps as it is described above and the height of walls is acquired from the point cloud using the roofs and the footprints as masks. The resulting model is a 3D city model, only the façade details are missing (Fig 6.), [Vosselman 2009].

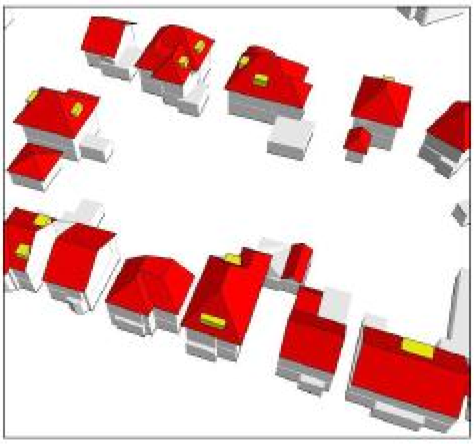

Fig. 6. Generated 3D city model

The façade information can be derived from the terrestrial laser scanning [Döllner 2009]. The door and window frames are very nicely distinguished on the facade, since they have rectangular forms. The last step is to make texture on the model surface. It is compiled from aerial images (normal and oblique images) and from terrestrial images of facades. If one façade is photographed from different views and in different time, than the occlusion objects can be eliminated from the images (Fig. 7.), [Böhm 2009].

Fig. 7. Elimination of occlusion objects

5 Outcomes

In this paper some aspects of the ongoing 3D City Guide project were presented. In Chapter 1 the project objectives and activities were described. In Chapter 2 the planned functionality of the sample system was presented. Information about the technology background was given in Chapter 3. Finally in Chapter 4, the point cloud optimization problem was negotiated.

In this paper, the results and steps of data collection and data modeling tasks were not presented because they have not been finished. The project team will work on the laser scanning, data processing and data integration tasks in the next months.

The expecting outcomes of the project will have the followings:

- methods and procedures to the development of tourism information systems which works on mobile devices with 3D city data
- the 3D City Guide system which serves as a sample solution to similar developments in the future.

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