DOCUMENTATION AND ANALYSIS OF CULTURAL HERITAGE BY PHOTOGRAMETRIC METHODS AND GIS: A CASE STUDY

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ABSTRACT:

Turkey is one of the rare countries with a rich cultural heritage. We have been left with a historic heritage covering the centuries from pre-historic to modern times, which have left the marks of their civilizations on the lands of Anatolia. Therefore these riches should be preserved and left to the next generations with the care such treasures deserve. We have to be aware of the responsibility of leaving these treasures to the next generations as well as displaying them to the tourists. The saving methods of these treasures are supported by modern technology. Using these methods enables us to increase the efficiency and impact of the saving process. Using the advanced technologies in the disciplines other than architecture and by cooperation among the different fields, the future of cultural heritage can be guaranteed in order to save the historical objects and areas. It is necessary to organize the plans and works covering the necessary technical documents of the objects and lands to preserve these objects and lands. With the help of these documents, it will be possible to reach the desired information for the works carried on these objects and lands. The information system generated by the use of digital photogrammetry and Geographical Information System together will enable any person interested in saving the cultural heritage to reach the necessary data. As mentioned above, integration of photogrammetry and GIS leads to the efficient use of data, analysis and presentation opportunities, which are very important for saving the cultural heritage. The aim of this study is to use this technology for the photogrammetric documentation of the cultural heritage and to enable the use of the documentation by using GIS.

1. INTRODUCTION

Architecture is a substantial part of our cultural heritage. But whereas other elements of our cultural heritage may be protected by putting them behind a glass in a museum, architectural monuments are widely used and endangered by long term influences like traffic or air pollution or destructive events causing heavy damage like earthquakes, fire or war etc. But by all means when monuments are seriously damaged, or completely destroyed, the amount and quality of any surviving documentation becomes highly important.

Therefore it is necessary to document the actual state of the architectural monuments in a manner, which opens the opportunity to detect continuous damage by change detection techniques and to restore the monument in case of heavy damage. Before starting to acquire new data on the monument already existing data sources have to be obtained, e.g. existing plans of previous restorations, ancient pictures or documentation's of architectural research projects**.**

The 3D reconstruction of buildings has been an active research topic in Computer Vision as well as in Digital Photogrammetry in recent years. Three-dimensional building models are increasingly necessary for urban planning, tourism, etc. (Suveg and Vosselman, 2000).

Three-dimensional photo-models help us to understand spatial objects, even if they are not accessible for us. Using photo-models from existing objects can make it easier for us to understand complex spatial structures. With the help of methods coming from virtual reality we can link additional information in the form of text or sound sequences to our photo-models. An architect, for example, can generate an interactive three-dimensional information system based on a photo-model, which describes and visualizes an important building (Dorffner and Forkert, 1998).

Visualization efforts in Photogrammetry do not have a long history. In the beginning of 90's the first photogrammetric attempts were mainly focused on the use of CAD software and the generic visualization tools they had to offer. Most of the research efforts at that time were concentrated to automating the data acquisition and processing through Digital Photogrammetry concepts, thus little attention was paid on how to add value to the data.

2. TEXTURE MAPPING AND VISUALIZATION

A three-dimensional photo-model is an object model where the texture information is taken from photographs or other optically working recording systems. It consists of two parts. One part is the three-dimensional object model in which the shape of the object surface is stored. Adjoining surface patches approximates the object itself. The second part is the photo-texture, which is transformed to the patches (Dorffner and Forkert, 1998)**.**

To visualize the derived model the photogrammetric data are converted to VRML Virtual Reality Modeling Language). VRML is a format for 3D data with features like hierarchical transformations, light sources, viewpoints, geometry, animation, fog, mate-rial properties and texture mapping (Carey and Bell, 1997). VRML is an open format that has become popular because of its suitability for publishing 3D data on the World Wide Web. For this reason there is a lot of software available that can handle VRML. This software allows a user-friendly interactive examination and visualization of the data. The conversion to VRML is fully automatic and consists of two

parts: geometry conversion and texture mapping. In the geometric part the object coordinates and the topology information are converted. (Heuvel, 1998)

3. PHOTOGRAMMETRY AND CULTURAL HERITAGE

Developments in the sciences of photogrammetry and image processing over the past decade or so have seen an increase in the automation of the data collection process, ranging from high precision industrial applications through to simple solutions for non-traditional users (for example, *3D Builder* and *Photo Modeler*). In addition, systems that use imagery from consumer digital and analogue video systems and sequences of images have almost automated the creation of three-dimensional (3D) models (as has the development of 3D laser scanners (Ogleby, 1999).

4. CASE STUDY

In this study the monastery of Christ Pantepoptes (Eski Imaret-i Atik Cami) in Fatih was selected to sample building for the case study (Figure. 1) Fatih is situated at the slopes of the fourth hill in the Historic Peninsula in Istanbul. The district starts at the shores of the Golden Horn-Haliç, and extends up the slopes along the Atatürk Boulevard. Retaining walls reaching up to 15 meters are to be found at some spots along the Atatürk Boulevard, as well as dykes and terraces dating from the Byzantine period. These structures present an interesting view in the direction of Galata, Golden Horn, and the Historic Peninsula. (Gülersoy et all, 2001).

The monastery of Christ Pantepoptes is known to have been either founded or renovated by Anna Dalassena, mother of Alexius I Comnenus (1081-1118). Built on the summit of the City's fourth hill, above the underground cisterns, it commands a magnificent view of the Golden Horn and the Bosphorus. The location explains the name Pantepoptes, i.e. the All-Seeing. The church is of the cross-inscribed type with four columns supporting a dome. Its ground plan is that of a three-aisled church with two narthexes. Though in a state of neglect, the elegantly proportioned building has retained the fine decorative brick work of the exterior, the shallow niches, the arches framing single or triple windows, the arcade of the gallery on the west side, the meander and rosette friezes, as well as sections of the cornices carved with palmettes.

Figure 1. The sample building

4.1 Photogrammetric Documentation

Detailed geometric information of the sample building was derived from architectural photogrammetry and geodetic measurements. (El Din, 2000). The images were taken with

Rollei D7 metric camera. The images were not taken normal case. The control points (approx. 35) were realized by using geodetic techniques. The control points were measured using Pentax total station.

In this step the image coordinates and lines were measured manually each image. The process of tie point measurement has to be done interactively and therefore is very time consuming. Together line measurement the object topology was specified and thereby the coplanarity of the lines bordering a face. This topological information must be stored alongside the point identifiers and coordinates in the data set. In our study we used the low-cost program Photo Modeler by Eos Systems Inc. for point measurement and definition of topology (Eos Systems Inc., 1997). The photogrammetric evaluation was done partly. Afterwards creating 3D model can be transferred to DXF format and then merged in AutoCAD. Fig.2 shows an example of photogrammetric evaluation and 3D wire frame model of the monastery model of Christ Pantepoptes (Duran and Toz, 2002).
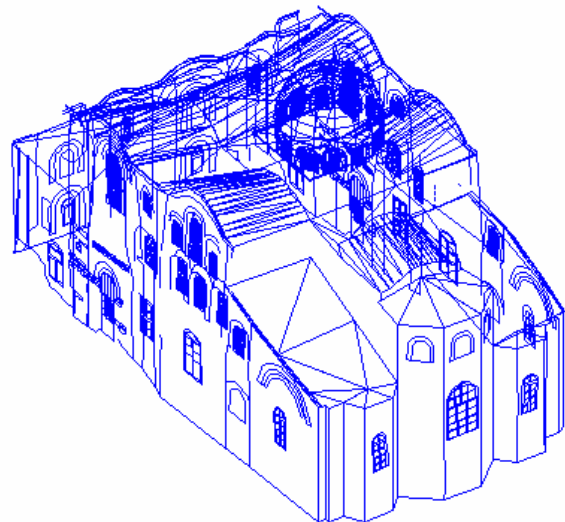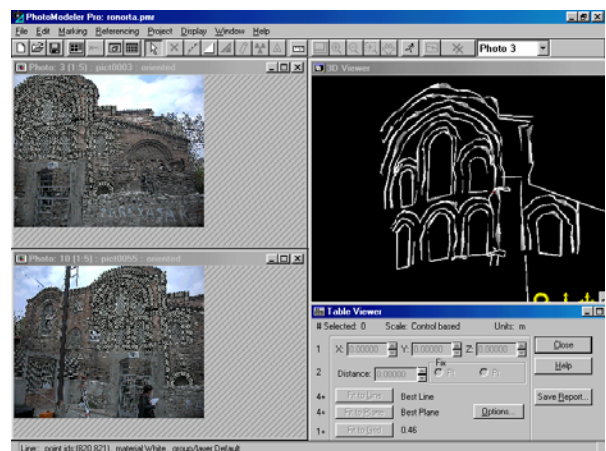

Figure 2. Examples of the photogrammetric evaluation and 3D wire frame model of the monastery model of Christ Pantepoptes

4.1 Rendering and Animation

After digital data were merged for 3D modeling in AutoCAD, it was saved as .dxf file. This file was imported into Max. After editing photos of the monastery of Christ Pantepoptes (Eski Imaret-i Atik Cami) in Adobe Photoshop, they were stacked on surfaces of building by using mapping technique in material editor of 3D StudioMAX. Stacking photos on surface of the

monastery made the building seem realistic (Ozaslan and Seker, 2001).

After creating 3D model and stacking photos on the building, the last step was rendering (Fig. 3). Rendering a scene or scenes (animation) by using 3D StudioMAX is possible. It is possible to export the project into file formats jpg, bmp, eps, tif or into video formats mov, avi, by using 3D StudioMAX's render editor. In this project lots of scenes were rendered into bmp format and a short animation in avi format was created as an example.

Figure 3. 3D textured model of the monastery of Christ Pantepoptes (Eski Imaret-i Atik Cami) in 3D Studio MAX.

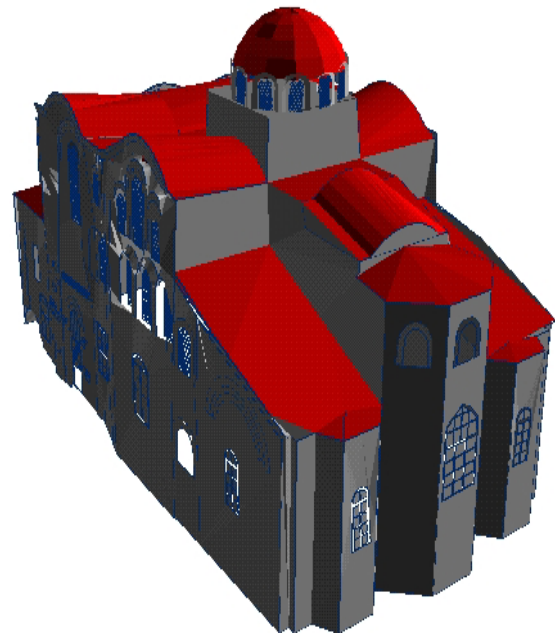Figure 4. 3D textured model of the monastery of Christ Pantepoptes (Eski Imaret-i Atik Cami) in AutoCAD.

Figure 5. 3D model of the monastery of Christ Pantepoptes (Eski Imaret-i Atik Cami) in ArcView.

In this project 3D textured model was also created in AutoCAD and in Arc View environment (Fig. 4 and Fig. 5).

4.2 GIS

GIS is an important tool for urban planning. GIS includes software and hardware tools, and a group of procedures elaborated to facilitate the capture, edition, administration, manipulation, analysis, modelling, representation and the exit of spatial referenced and semantic data, to solve any type of planning, administration, storage, and further information concerning the problem. GIS technology greatly facilitates the inventory, evaluation, preservation, and documentation of archaeological sites and historical structures. As heritage conservation becomes more holistic and historic sites are steadily becoming integrated with the surrounding landscapes, GIS has been recognized as a critical component in the development of virtual historic collections and archives.

The package we use here is *Arc View* which is amongst the most popular and flexible GIS software. We have two kinds of databases: the one who has the graphical and geometrical data and the one who has the alphanumeric data related to the graphical data. The first one will be generated from the photogrametric digital system or from other graphical external files (like digitized plans, amateur photographs etc.). The second one will be handled with the DBMS ACCESS. Both databases will be linked and managed together by the GIS software Arc View 3.2, creating the information system.

Objects are being built by linking spatial data (point, lines or polygons that are defined by geometry and topology) with non-graphic information in GIS. Coverage, also called as layer, is the basic unit of storage in Arc/Info. In this study Arc/Info has been used for the establishment of topology of the coverage. Then the coverage has been imported to Arc View software. This software has been produced as a vector based GIS but also it has limited use of raster base data as well. In addition to

several querying and analysis advantage, the result of these attributes.

Also some of non-topographic information for feature (attributes) such quarter name, street name, door number, building functionality, basement, medium floor, roof, total floor, building condition, registration, building name, construction date, financer, architecture etc. were stored in the database table. Afterwards digital terrain model (DTM) of study area was being produced and captured with orthophoto in Arc View software. 3D city modelling allows a person to interactively fly and walk-through a given urban space. This technology has already been applied to several cities worldwide; however, it has usually been implemented for limited sections of the city only. For these reasons 3D city model of study area was being produced and linked photographs and .avi files in this project (Fig. 6).
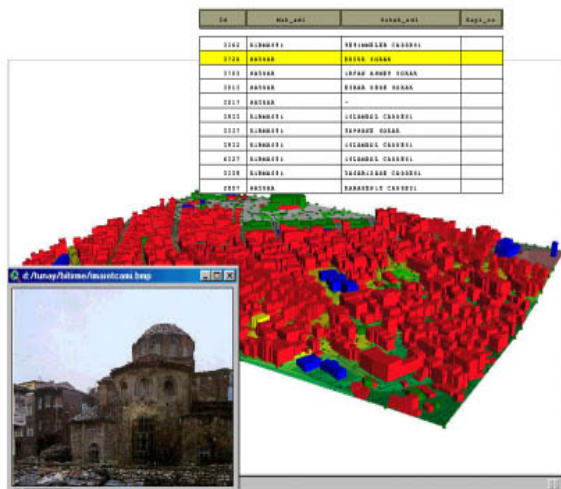

Figure 6. 3D city model of study area and linked photograph

5. CONCLUSION

The increasing use of close-range photogrammetry techniques for recording historical buildings and objects worldwide motivates the development of new tools for data acquisition and 3D modelling.

3D photo-models are best suited to give a clear and detailed impression of existing situations. For the generation of 3D photo-models digital images are needed.

The texture applied to the three-dimensional object model is, as far as available, taken from the photographs. If three-dimensional photo-models are stored in VRML-format, it is possible to visualize and animate them on the Internet. These models can be used easily for generating an information system.

Therefore, 3D photo-models show up to be a new product in the area of planning and documentation.

It is useful to create 3D models both for planning, projects and also for presentation and visualization. In this study both photogrammetric and geodetic measurements were used together to create 3D model. It was seen that 3D Studio MAX is quite professional for creating 3D models and also for creating animations by using these models. So it is very complex to use MAX and it takes a long time learning to use it functionally.

An Architectural Information System with the modules and special archives provides the possibility for the comprehensive documentation of architectural cultural heritage. The pictures can be used for the documentation of pending and actual damages on buildings and sculptures. The information system will help the public to form a view on the development process of their urban environment. The awareness for the importance of the cultural heritage will be raised.

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