BUILDING 3D PHOTO-TEXTURE MODEL INTEGRATED WITH GIS FOR ARCHITECTURAL HERITAGE CONSERVATION

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Commission V, WG II

KEY WORDS: Cultural Heritage, Digital Photogrammetry, Historical Buildings, GIS

ABSTRACT:

Architectural heritage must be conserved by using contemporary approaches. Conserving the historical buildings depend on appropriate measurements and data related to their life history. At this stage, digital photogrammetric techniques and GIS (Geographical Information System) integration would be one of the best solutions. GIS has a capability to integrate and update graphic and non-graphic data according to user inputs. In this paper, 3D model of historical buildings is constituted by using photogrammetric techniques, and added to GIS database to carry out querying, updating and analyzing their properties. As a result, in this study, an example of photogrammetric and GIS integration has been presented to conserve the historical buildings as a simple Architectural Information System (AIS).

1. INTRODUCTION

Architectural heritage preservation makes necessary to produce an initial technical documentation to be able to establish the necessary plans and studies which allow later to develop both suitable approaches and criteria for appropriate buildings interventions. Every time becomes more necessary the application of the most modern methods to carry out some technical documents production. (Hernán-Pérez, 2001).

Documentation of cultural heritage objects is not an end in itself but serves as a tool to make information accessible to those (research experts or any interested persons) who cannot investigate the object itself. Different reasons can be found for the necessity of this information transfer:

- The object is not accessible to interested parties (e.g. rock paintings in caves).
- The object is too large or too complicated to be overlooked and it would be too time consuming to execute an own investigation.
- The object (or just a part of it) is visible only for a short period of time at its original location (as in archaeological excavations or when unearthed during civil engineering projects).
- Persons living far from the object cannot afford to visit it.
- The object is in danger of slow deterioration (environmental factors) or sudden destruction (earthquakes and other natural disasters, war and vandalism).

The last two points must be taken into account in any case, additional ones may exist at the same time (Boehler, W., Heinz, G., 1999).

Contemporary approaches have to be used to carry out the documentation procedure. The result of the documentation has to include not only the graphical knowledge but also some non-graphical information such as objects' history, conservation status and owners.

Nowadays, to solve with success the necessities mentioned, graphic and alphanumeric database is needed, on which all the implied professionals in this topic can lean on and make their performances. In addition to, the elaboration of some architectural surveying, the techniques based on the use of the Digital Photogrammetry and GIS allow us not only to edit some plans with a high degree of graphic precision and metric accuracy, but also to detect all those defects or structural and constructive degenerations that cause the minimum deformations or alterations in the formal state of the building. Also, these technologies highlight on the conventional techniques in being an open system that allows the gradual incorporation of new applications or studies as these they leave applying. As conclusion one can affirm that the digital photogrammetry and the GIS provide a group of advantages and benefits in the architectural tasks impossible to obtain with such an efficiency, velocity and economy by means of other procedures. These advantages and benefits are among others:

· To have a graphic database of quality, on which can work in a coordinated way, all the professionals involved in the cataloguing and preservation tasks.

· To provide a basic instruments for the coordination and pursuit of the works and carried out studies or to develop.

· To facilitate the access, manipulation and bring up to date of all the information.

· To reduce the costs, so much in the obtaining of the data, like in the later tasks to carry out during the documentation process, restoration and preservation.

· To facilitate the exchange of data between diverse organisms and companies whose performances can impact or to influence in the environment of the monument (Hernán-Pérez, 2001).

In our project, forming an AIS is aimed with acquisition data by Digital Photogrammetric techniques and visualizes it in 3D with GIS environments. Different queries on 3D model of object have been done by linking graphical and attribute data. Briefly, our system has two main components; a digital photogrammetric system that we constitute a 3D model of the architectural object and the data base management system that

we performed a relationship between graphic and attribute data of the object.

2. INFORMATION TECHNOLOGIES AND THEIR INTEGRATIONS

The rapid development of information technology at the end of the last century has led to the realization that without the application of modern techniques in archaeology and conservation it is not possible to keep up to date of the demanding documentation processes which are directly connected with an increasingly demanding research methodology and with the documentation itself. As part of many methods of recording of culture heritage were photogrammetry is one of the techniques of data acquisition, which has successfully established itself in conservation and archaeology over the last hundred years. On archaeology the photogrammetric method of documentation is predominantly connected with rescue excavation or recording of standing structures, since this method of documentation is seen as the only one to guarantee the reliability and accuracy of the actual condition. In the past the process of excavation was directly dependent on the execution and speed of the photogrammetric shooting, the stereophotography, development time and the ability of the team. Because of the limitations mentioned above the excavation process often had to adapt itself to the shooting of stereo pairs, the photogrametrist was not always rationally exploited, while a laboratory for the production of photo–sketches was not always available, which slowed the progress of the excavation. Manipulation is fast and very important in the archaeological interpretation of the site. Another important advantage of this method of photogrammetric recording is the speed of data acquisition and instant processing. Documentation of this type in digital form is also essential in the drawing –up of conservation programmers, which in the final phase lead to various presentation decisions, and for the preparation of various models of visualizations, design of modern structure shelters or coverings. The comparison showed that significant differences exist in the accuracy of photographs of the same architectural remains, and above all that we can understand archaeological or architectural drawing as a phase of preliminary interpretation. Preliminary interpretation, if not done together with photogrammetric documentation, is not a true representation of the actual condition, and since the documentation is also created for the future, only a document, which shows the true condition, is credible (Stokin, 2002).

3. PRINCIPLES OF ARCHITECTURAL PHOTOGRAMMETRY

For many purposes detailed plans of existing buildings are required. Especially for the preservation of architectural monuments a great variety of data about the facades and the structures is needed for documentation purposes and for planning of further activities, especially by CAD methods. If the original plans are not available or if the facade has been changed the only way to acquire this data is the survey of the buildings surface. This can be achieved either by direct measurements using scaffolding or indirectly by photogrammetric approaches.

The basic idea of architectural photogrammetry is to reconstruct the imaging geometry, which was effective during the exposure of photographs in order to derive object coordinates. However, the three dimensions of the object are reduced in the photograph to a two-dimensional image space. This is why three-dimensional object coordinates cannot be derived from one image. Photogrammetry therefore combines information from two appropriate images to survey a three-dimensional object.

The photogrammetric approach offers several significant advantages compared to classical surveying methods. Field operations are reduced to the acquisition of photographs and the measurement of a few control points. In this way a tremendous amount of information is permanently stored in the photographic film, surpass sing each construction plan or drawing. Any detail of a building, which is photographed in at least two images, can be subject to photogrammetric restitution. This procedure can be carried out at any time and at any place independently from the object. Modern photogrammetry can effectively provide metric data of high and homogenous quality from existing buildings for CAD purposes (Albert, J., Wiedemann, A., 1995).

4. PHOTOGRAMMETRY AND GIS

The use of new techniques and an interdisciplinary approach offer a wide data base and thus make it possible to make more reliable interpretation of the results, which are an integral part of the conservation project. The integration of photogrammetric and geographic analyses through the employment of computer documentation system permits precise documentation, rapid access to data and elaboration with new methods.

Since the development of the science of photogrammetry, there have been many applications of its techniques and technology in the recording and documentation of monuments and sites of importance. Whilst there may have been a redirection of effort when aerial mapping expanded following the invention of aircraft, there has been a shift again to other measurement applications offered by photogrammetry, especially those in architecture and archaeology. 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 PhotoModeler). In addition systems that use imagery from consumer digital and analogue video systems and sequences of images have almost automated the creation of 3D models (as has the development of 3D laser scanners)(Ogleby, 1999).

Photogrammetry is a technique whereby information about the position, size and shape can be attained. Photogrammetric products refer almost exclusively to the object space (maps, surfaces (DEM's), orthophotos, points, profiles). Photogrammetry is an important contribution to many disciplines. The most widespread use of the photogrammetric technique being for the representation of the facades or elevations of building and structures. There are many uses of the technique, including 3D city models for building repair and conservation. The 3D reconstruction of houses and other man-made objects is currently undergoing active research, and is an issue of high importance to many users of GIS, including urban planners, architects, telecommunication and environmental

engineers for historical development, topography, vegetation, land use pattern, transportation network etc. (Duran, 2002).

The GIS is a relatively new technology that joins the computer science advantages with the modern systems of capture of data, so that it allows the integration and the treatment of all type of information of a computer team, in a simple way on the part of any user that requires to work with this information. A GIS include software and hardware tools, and a group of procedures elaborated to facilitate capture, edition, administration, manipulation, analysis, modeling, representation and exit of spatial referenced and semantic data, to solve any type of planning, administration, storage, and so on information concerning problem (Hernán-Pérez, 2001).

With the advent of geographic information systems, a powerful method is available to store graphical and descriptive data with all their links. Digital photogrammetry and the GIS provide a group of advantages and benefits in the architectural tasks impossible to obtain with such an efficiency, velocity and economy by means of other procedures.

5. CASE STUDY

5.1. Photogrammetric Documentation of Opera House

In this contribution, Opera House in Hannover (Germany) was choosed as a historical building (Fig. 1) and, eighteen photos that surround this building, which were taken by one of the Institute of Photogrammetry and GeoInformation's staff in Hannover, were used. The images were taken with Olympus E10 digital camera with 2240×1680 geometric resolution and 9 mm focal length. This camera produces RAW, TIFF and JPEG images, normal and automatic exposition, 4× zoom and black and white control. The camera has been calibrated, so it's principle distance, radial and tangential distortion is known (Wiggenhagen, 2002). In addition to these images, an image map that shows cadastral situation of the building in tiff format was used as a base platform.

Figure 1. The image of Opera House

Photo Modeler software by EOS Systems Inc. was used for photogrammetric evaluation. The Canadian PhotoModeler Software Package is well known as a low cost 3D-measurement tool for architectural and archeological applications. It is a Windows based software that allows measurements and transforms photographs into 3D models. The image coordinates of corresponding points and control points were measured manually and the images were oriented automatically. After the facades of building was identified as a surface patches, the wireframe and photo-texture model were built up using the oriented images (Fig. 2 and Fig. 3).

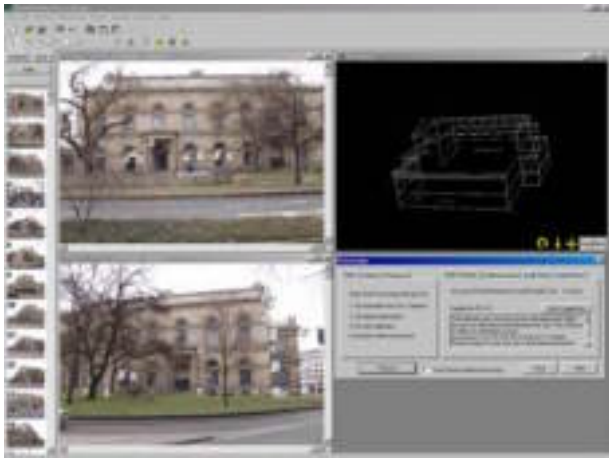

Figure 2. Wireframe Model of Building in Photo Modeler

Afterwards, created 3D model of building was transferred to 3D DXF file to visualize and to relate with its attribute data in GIS.

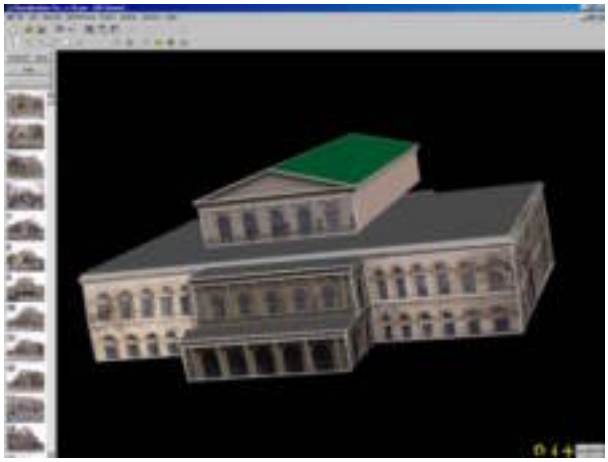

Figure 3. Photo-texture Model of Building Created by Photo Modeler

5.2. Visualization and Querying of the 3D Model in GIS

The 3D DXF file created in PhotoModeler is converted to SHP file format in ArcView. Base map with control points is imported to ArcView program. A georeferencing has to be done to make association between base map and 3D model to see them together in 3D scene. With the help of the TFW (world file for tiff image) file belongs to ArcView, base map is registered and transformed into same coordinate system with 3D model.

One of the main objectives of this study was visualizing the photo texture in GIS environment. However, only the texture parts of the building can be seen in 3D in ArcView. For this reason photo texture could not be used in a structure representation aim. It is also possible to make miscellaneous queries over joined layers (Fig. 4).

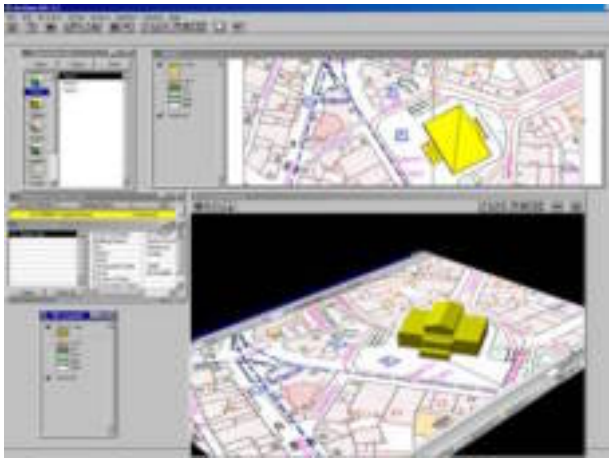

Figure 4. Visualization of 3D Model in Arcview

5.3. The Graphic and Attribute Databases Integration

We use two different kinds of databases: first one, which includes in text information, is attribute data and the second one, which has geometrical information, is graphical data. The first database is handled with Arcview 3.2, which is a GIS software by ESRI, and the second database is generated from the photogrametric digital system (PhotoModeler). Both databases are linked and managed together by the GIS software ArcView 3.2, creating the AIS.

To make a relationship between graphic and attribute data, database knowledge or an attribute data belong to the related object is needed. For attribute data that should be in the AIS, a content design has been done and filled in MS Excel in DBF (Data Base Format) file format. The following table shows the integration of the graphic and attribute data (Table 1). In this project, although only 3D texture model has been generated as graphical data, all the components of the attribute data have been used. It can be added the other parts of the graphical data. Besides, in any time the users can update all data.

Attribute Data		**Graphic Data**
Archive Number		Plan
City Name		Orthophoto
District		Photography
Street		Profile
Building Name	⟺	Sketch
Construction Date		Video
Owner		Animation
Previous Works		3D Photo-texture Model
Conservation Status		Other graphical data
Materials		
Special Notes		

Table 1. Attribute and graphic data

6. CONCLUSION

In this study, design and application of an architectural information system has been realized in a simple sense. The basic components of the system are digital photogrammetry and GIS. An integration between the 3D model of object generated from photogrammetric techniques and attribute data concerning the same model of object has been provided. With this integration, the data will be continually updated, analyzed and queried. Aspect of the documentation, registration and observation of historical objects, two techniques used is nicely proportioned. The results of the study confirm that the management and observation of the historical buildings with proposed AIS was done very easily and effectively.

7. FUTURE LINES

The project designed for AIS as a proto-type will be extended on the basis of city or country. As mentioned above, one of our first objectives was to visualize of the 3D photo texture in GIS, but it was not provided completely. Afterwards, we will focus on solving this problem and add the project other additional information.

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