OBJECT MODELLING AND VISUALIZATION IN ARCHITECTURE

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ABSTRACT:

A complete documentation of an architectural object covers both the geometric aspect and the pictorial one. While the pictorial information of the object is often delivered in the form of conventional photographs, the geometric modelling can usually be performed by photogrammetry. Using surface modelling techniques and digital photogrammetric tools (e.g. digital orthoprojection) the geometric and the pictorial modelling can be integrated in a complete system. Triangulated irregular networks are most suitable to describe object surfaces. With the help of raster computer graphics, surface models can be visualized in different ways. Experiences with modelling and visualization of architectural objects are presented. Examples demonstrate the applicability of the proposed procedures.

Keywords: surface modelling, visualization, triangulated irregular network, architectural object, architectural photogrammetry, architecture information system.

1. INTRODUCTION

To document an architectural object, line maps obtained by e.g. photogrammetric stereo plotting are usually used. Since they constitute a part of the geometric aspect of the object only, certain information concerning e.g. the appearance of the object should be added. Therefore, conventional photographs are simply the carrier of issues like paintings, mosaics, tiles, marble incrustations and other decoration elements. In many cases, however, line maps seem not to be sufficient for representing the whole geometric issue of an architectural object. On the other hand, documenting an object digitally is promised by computer technologies nowdays and delievers a broader flexibility than the analogue documentation mentioned above. For instance, an architectural object can geometrically represented by one or more digital surface models (DSMs) instead of line maps. DSMs can then be visualized by means of raster computer graphics pictorially. For a better understanding of the object, digital ortho images can be generated (Mayr/Stephani, 1988) and displayed in different ways (Stephani/Tang, 1990), both based on available DSMs.

This paper presents some experiences with modelling and visualization of architectural objects. A system is proposed for achieving a complete documentation of architectural objects using modern computing techniques. Practical examples are given.

2. AN INTEGRATED SYSTEM

As illustrated in Figure 1, a complete documentation of an architectural object can be achieved in an integrated system, consisting of photogrammetric recording, data acquisition, data preparation, object modelling, visualization, data management and analysis.

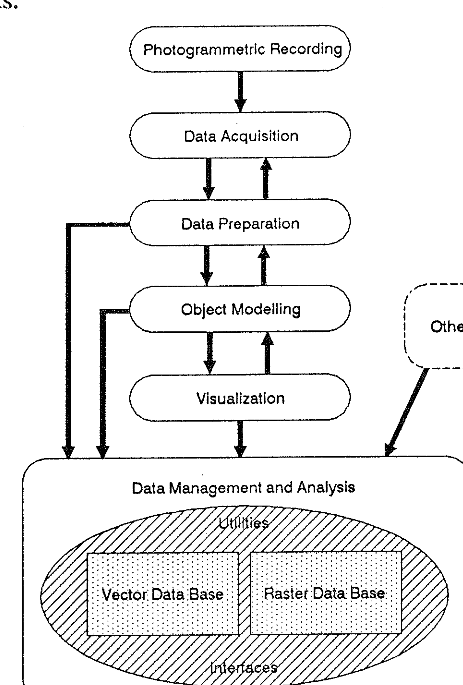

Fig. 1: An integrated system for architecture documentations.

Photogrammetric Recording

In order to gain a desired result, objects should firstly be recorded either by metric or semi-metric cameras. In this case, photos can be scanned and stored digitally in a further step. On the other hand, digital CCD cameras are available today and may be used for this task, too. In addition, certain control information has to be acquired for the purpose of photogrammetric image orientation and restitution.

Data Acquisition

Distinct points and structure lines of the object are collected from stereo models using e.g. an analytical plotter, constituting primary data for surface modelling. Depending on the properties of the architecture concerned, various strategies can be applied to the data acquisition, e.g. computer-aided grid point measurement, profiling, single point registration, isoline tracing, automated or semi-automated line following. There are two things here to be taken into account. Firstly, adequate strategies should be used for parts of an object which are of different shapes. Secondly, an acquisition approach should be selected in accordance with the surface modelling method being concerned in further processing (Stephani/Tang, 1990). In case of digital images, image matching techniques may fully automate the procedure of point and line extraction.

Data Preparation

Two tasks should be fulfilled in this procedure. First, measurement errors in primary data should be detected and eliminated. This can be done as well during the data acquisition using feasibility control utilities on the analytical plotter, as during the procedures of object modelling and visualization, which will be described in the following. Hence, a chained data flow is formed among these four procedures (cf. Fig. 1). Second, acquired data should accordingly be reformated and prepared for object modelling.

Object Modelling

In general, an object can be described by one or more DSMs (2.5D) or solid models (3D). For a detailed documentation of architectures, DSMs are preferred. Surface modelling can be acomplished either by gridding or triangulating primary data (Stephani/Tang, 1990). In contrast to some other applications, lines which represent the main structure of the architecture should completely be preserved in the resulting DSM. Therefore, triangulated irregular networks (TINs) are most suitable for surface description of architectural objects (Tang, 1989). The construction of a TIN of points and lines can be carried out either by a vectorial constrained Delaunay triangulation (e.g. de Floriani/Puppo, 1988) or using the raster-based algorithm, which allows for a simple consideration of constraint edges and, as a matter of fact, improves the computational complexion to a great extent (Tang, 1989, 1991, 1992).

Visualization

A DSM is an orderred set of data, which can be visualized in different ways by means of computer graphics. Visualization can be realized either by vector or by raster utilities. In the latter case, the pictorial aspect emphasizes the properties of the architecture being represented by the DSM geometrically (e.g. Stephani/Tang, 1990). The pictorial information may be carried either by digital images or by computer-generated ones. Digital images (e.g. ortho images) reflect the natural appearance of the architecture, while pictures generated from the DSM give a realistic display of the model (e.g. shaded images) on the one hand and deliever a measure of the model (e.g. elevation layers, slopes and aspects) on the other hand. Combinations of different types of images may even enhance the realism of the display (Tang, 1991).

Data Management and Analysis

In order to meet requirements from different users, an architecture information system should be established (e.g. Rinaudo, 1988). It should consist of at least a vector data base for primary data storage and a raster one for storage of images and DSMs. First of all, an efficient data base management should be available. Utilities for vector and raster processing should be included. In addition, appropriate user interfaces should be designed for purposes of analysis.

3. EXAMPLES

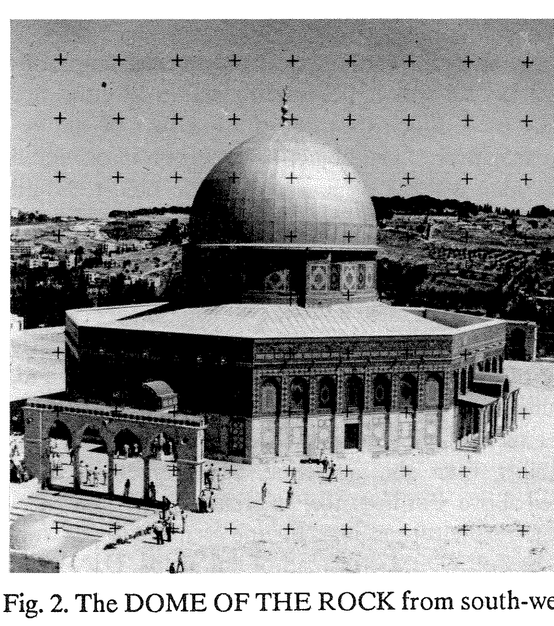

Fig. 2. The DOME OF THE ROCK from south-west.

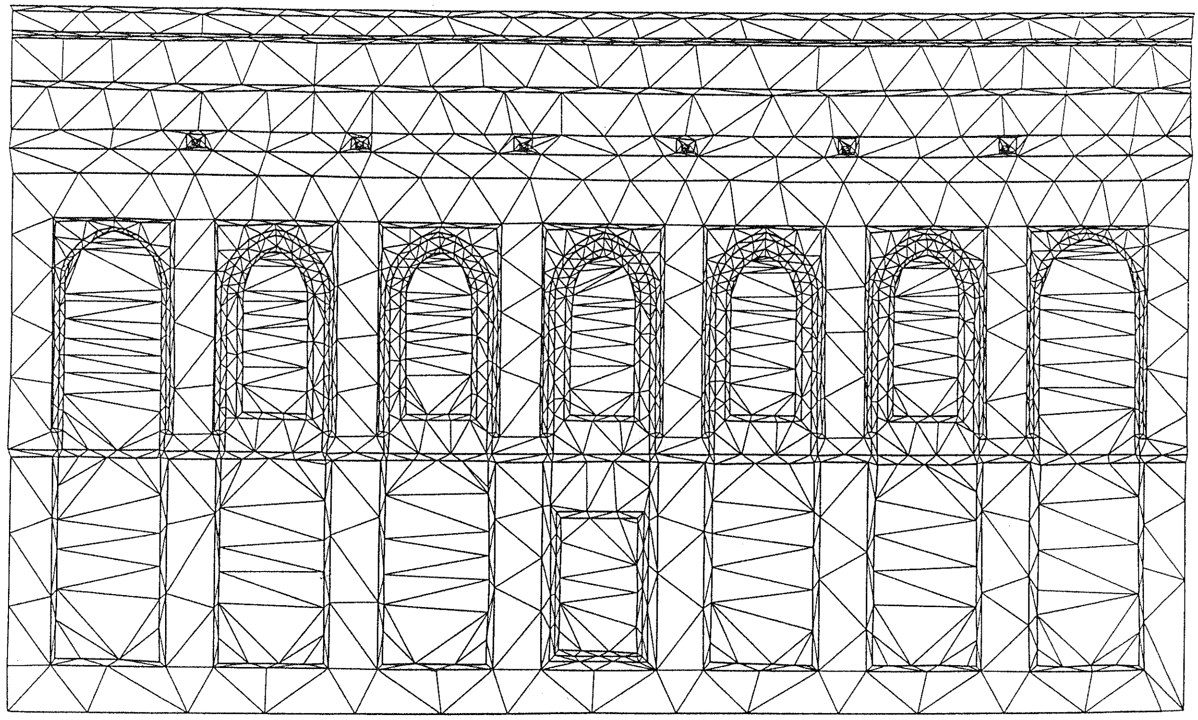

Fig. 3. A TIN of one of the 8 facades of the dome.

Based on the system conception described above, two typical examples selected from the materials of the DOME OF THE ROCK, Jerusalem, were processed. The Dome built by Caliph Abd el-Malik in 691 was recorded using both a metric and a semi-metric camera in 1985 and 1986, respectively (Hell et al., 1988). The aim of this work was the documentation of the architecture for studies of the art history and for the preservation work. Figure 2 shows the dome from south-west.

The first example deals with one of the 8 facades which are 12 m high and some 20 m long and form a regular octogonal prism. For data acquisition, only structure lines of the facade were acquired from stereo models on an analytical plotter, since the facade consists of planes. A TIN (cf. Fig. 3) was then constructed using the raster-based triangulation (Tang, 1991, 1992). To be visualized using raster graphics, the TIN was converted into a dense raster DSM by planar

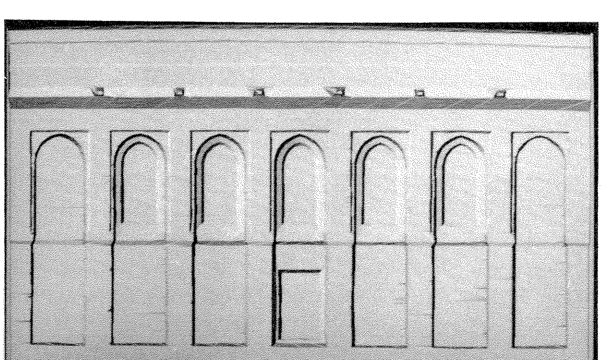

Fig. 4. A shaded image.

interpolation of triangular facets. Based on the raster DSM, a shaded image was first generated (cf. Fig. 4) and then used as coverage information for the generation of a raster perspective image (cf. Fig. 5).

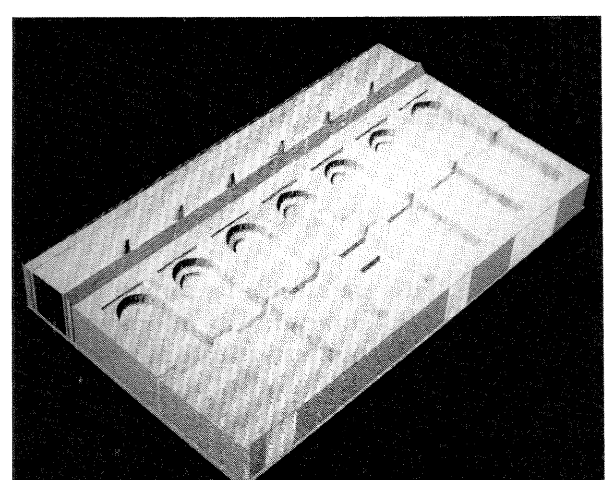

Fig. 5. A perspective image coverred by shading.

The second example handles a part of the cylinder on the central rotunda. The outer cylinder has a diameter of more than 24 meters and is coverred by tiles. Primary data were also captured on an analytical plotter. In accordance with the specific shape and in order to keep the data amount minimum, a special strategy was applied for data acquisition as well as for surface modelling. Actually, the cylinder is approximated by narrow rectangular planes, the tiles. Hence, primary data were accordingly acquired. As mentioned above, a TIN was at first constructed. In order to obtain a smoothed DSM, the TIN was then converted into a suitably dense grid of points. In a further step, the points were used as reference data for surface approximation by the finite element method (Ebner et al., 1988). Finally, the filtered gridded DSM was converted into a dense raster DSM by bilinear interpolation, from which raster products were generated. Figure 6 shows an image of elevation layers of the part of the cylinder and Figure 7 is a perspective view correspondingly.

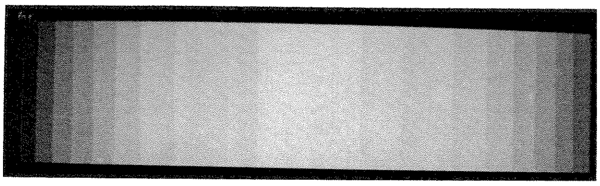

Fig. 6. Elevation layers image.

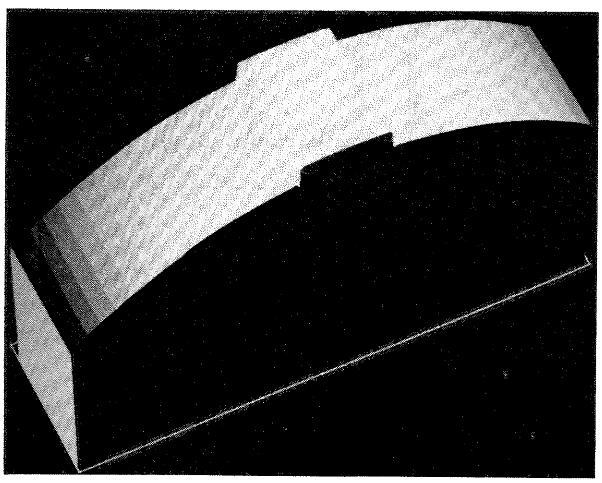

Fig. 7. A perspective image coverred by elevation layers.

4. CONCLUSIONS

In most cases, TINs are suitable for surface description in architecture. However, TIN filtering by grid approximation is also necessary in case of smooth objects. Computer-generated images not only provide opportunities for better understanging of the architecture but also make it possible to detect measuring errors in the data acquisition sensitively (cf. Fig. 4). An architecture information system will certainly contribute to documentations in architecture a great deal.

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