THE POTENTIAL OF APPLYING 3-D VISUALISATION METHODS

FOR REPRESENTING DESTROYED SETTLEMENTS

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ABSTRACT

Modern technological advances have enriched the means for electronic representation of 3-D data. Proper data acquisition enables the production of visualisations of the built environment as close to reality as possible. In this paper such an effort is described. The theoretical approach is followed by the description of a specific application concerning the representation of an old traditional settlement, which was destroyed by an earthquake. The data collection and the processing of the 3-D data are described in detail. Finally sample renderings are presented and compared to old amateur photographs available. The results are discussed and assessed for their representation value and usefulness.

KURZFASSUNG

Die modernen technologischen Fortschritte haben zweifellos die Mitteln fur die elektronische Representierung von 3-D Daten bereichert. Geeignete Datenerfassung erleichtet die Produktion von Visualisierungen der gebauten Umwelt so nah der Realitat wie moglich. In diesem Bericht wird ein solcher versuch beschreibt. Nach der theoretischen Einfuhrung folgt die Beschreibung der spezifischen Anwendung, die sich mit der Representierung von einer traditionellen Siedlung, die von einem Erdbeben zerstort wurde, beschaftigt. Die Datenerfassung und die Verarbeitung der 3-D Daten werden ausfuhrlich beschrieben. Die Ergebnisse werden ausgewertet fur ihre Representationswert und Benutzbarkeit.

1 INTRODUCTION

Modern technological advances have enabled researchers to provide three-dimensional representations of space in a number of different ways. Usually, the three-dimensional representations vary in scale, in data sources and in representation media. By examining the scale, it diverges from very large to very small values. In very large scale representations an object (i.e. a building or a part of a building) is presented with all of its details –see for example relevant application in Guerra and Balletti (1999). In large scale representations groups of several objects are presented with high degree of detail -see for example the application of Georgopoulos et al. (1997). Furthermore, in small scale representations a part or even all the earth's surface is presented, and additional media can enrich the representation by adding a virtual character, consisting for example a virtual globe (Riedl, 1999).

Data acquisition to this end may be realised either through accurate mensuration processes or by using other kinds of available pertinent information. Depending on the representation scale the three-dimensional data may be extracted from a wide range of sources consisting of field surveys, vertical or oblique metric or non-metric photographs and existing images, plans or maps, or even from an existing GIS (Schilcher et al., 1999). The nature of photogrammetric techniques, especially for large or very large representations, allows for a rather complete data acquisition, providing both qualitative and quantitative spatial information. A comprehensive survey of the use of photogrammetry in large scale representation can be found in Lammi (1999). Hence, it is considered as a most suitable way for providing the necessary raw data for the three-dimensional visualisation of space in large scale.

The visualisation output, in most of the cases, may combine plans, vertical views or oblique perspective views on plain paper or on a display and even more virtual walk-through or fly-through in the portrayed area on a computer or video device.

The aim of this paper is to describe the methodology for producing the three-dimensional representation of traditional settlements. The major steps to this end are the data processing, the three-dimensional modelling and the adopted visualisation method. All the above are evaluated for their applicability and interoperability.

As an example, the three-dimensional visualisation of a traditional North Aegean settlement, which was destroyed by an earthquake about 30 years ago, is presented. The available data were small scale aerial photography before the natural disaster, old non-metric oblique photographs of the settlement and an up-to-date detailed survey of the terrain. Using these raw data and applying suitable methodology the three-dimensional visualisation in large scale of the area, as it was before the earthquake, was produced. The vector result was then rendered to make the final visualisation product more realistic. Such an effort produces a result, which is considered as invaluable in terms of restoration and revival of a destroyed settlement.

2 DESCRIPTION OF METHODOLOGY

Considering the needs of a large scale representation of a small settlement, it should include, in general at least, the portrayal of the earth's surface and the settlement's buildings. Moreover, the representation should include the appropriate level of physical or technical details, in order to achieve a considerably realistic visualisation output. Thus, the earth's surface should be enriched by portraying existing streams, roads, or other relevant details and the buildings should be presented with their roofs, doors, windows, balconies etc. It is of significant importance to point out that there is no need to represent each individual building exactly as it was before the earthquake at this scale of visualisation. What is really important is the overall image of the settlement, while at the same time its architectural character is represented as accurate as possible. The above concept led to the decision of adopting a visualisation model based on information acquired from existing amateur photographs. The visualising output was based on a 3-D wireframe model of the settlement, which was derived by analysing the elementary construction forms of the buildings, while preserving their architectural character, instead of a more complex model with attached raster images (Nakos and Tzelepis, 1998) derived from the amateur photographs.
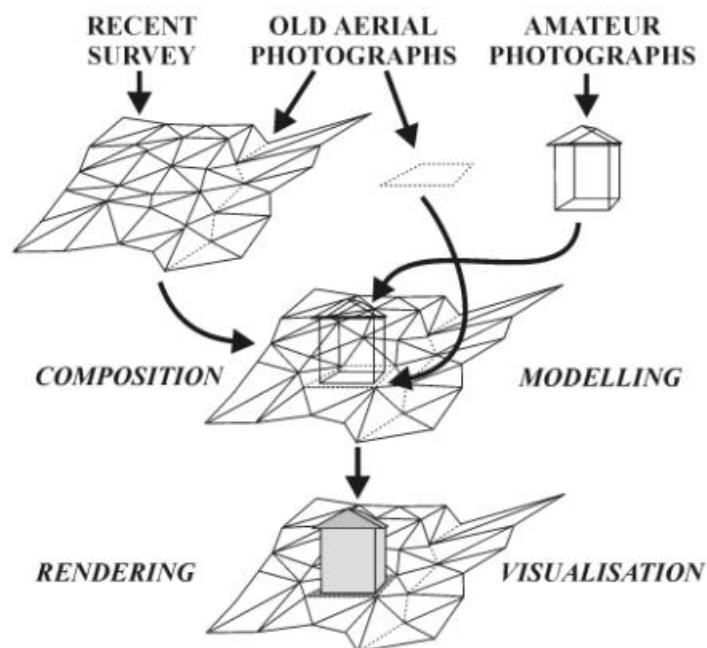

Figure 1. The outline of visualisation methodology

The topography of the area under study can be digitally described by producing a Digital Terrain Model from data derived from recent large scale surveys. The TIN method gives more reliability to large scale representations and the ability to include physical or technical details (i.e. streams, roads etc.) in the model as breaklines. Therefore the TIN method was utilised for the project. Of course, the locational information of the existing details was not present in the recent survey and thus it was necessary to extract it from aerial photographs taken before the earthquake. The shape of

the buildings was derived from old amateur photographs and the models of the buildings was produced as 3-D solids using an appropriate architectural design software package. The locations of the destroyed buildings and the outline of their basement were also determined from old aerial photographs. In order to be able to superimpose the model of the buildings on top of the model of the topography, the TIN model of the topography was modified to include the outlines of the basement as breaklines. Finally, the model of the settlement was composed and was ready to be rendered in order to be visualised from different viewpoints in a CAD environment. The above described methodology is illustrated in Figure 1.

The evolution of existing technological environment for visualising three-dimensional space has three significant advantages both in software and hardware. The first one allows users to model three-dimensional spatial objects in a sophisticated way. The second one integrates data having different structures (vector or raster). The third advantage provides users with tools to perform complicated analytical transformations on spatial data in a very reasonable processing duration. More specifically, existing software platforms are supporting user's perception of the real world as solids, composite solids, surfaces or wireframes and translate them into graphical objects (i.e. polylines, arcs, faces or meshes etc.), having three-dimensional properties. In addition, existing software enriched with sophisticated analytical methods, allows users to perform photogrammteric compilation, geometric transformations, image processing (i.e. resampling, radiometric corrections etc.) and also provides them with powerful editing environments. Furthermore, the core of the existing visualising software is characterised by the depth of the visualisation media such as oblique views or animated movies in appropriate realistic form. These views are created by rendering the three-dimensional graphical objects or by draping images on three-dimensional meshes. Their realistic character is provided through extended libraries of digital motives for "dressing" the three-dimensional objects during rendering and through the simulation of the effect of natural illumination -by creating shades- and various meteorological conditions (i.e. fog, rain, snow etc.), as it is suggested in a relevant study (Nakos and Tzelepis, 1998).

3   TECHNICAL DETAILS OF APPLICATION

As mentioned above, the aim of this application was to try and represent a destroyed traditional settlement. This application was based on the research carried out within a diploma thesis (Anastassopoulou and Kappatou, 1998) at the Department of Rural and Surveying Engineering of National Technical University of Athens. The small village of Agios Efstratios, the only settlement on a small island of the North Aegean, has stood there for centuries. Built according to the traditional Asia Minor architecture the approximately 500 stone houses covered a hill, thus forming a remarkable sight. On top of the hill a byzantine castle served as the only refuge of the population against the pirates of the past. In February of 1968 a terrible earthquake destroyed most of the houses and the population was forced to abandon the settlement, as the military government decided to build a "temporary" and ugly village on the lowlands around the small port. This village serves the lodging needs of the population up to the present day.

Today the local community wishes to revive the traditional settlement and this application aims at its three-dimensional visualisation, in order to support this task. For this purpose, several data were sought. Aerial photographs before the earthquake, amateur photographs of the village for the period 1940-1970 and a recent survey of the area, carried out in 1995, were the main data sources.

Firstly the Digital Terrain Model of the area was produced using the recent survey of scale 1:1000, assuming that over the years the terrain has had minor or no changes at all. The plots available contained contour lines of 1m interval and numerous dense spot heights. These plots were scanned with a A0 size drum scanner and the contour lines and the elevations were digitised. Subsequently, the vector plots were geocoded in a CAD environment with the help of several registration points. In order to produce a handy DTM the vector information was then processed with the help of a suitable software in the same environment. Breaklines were added where necessary, in order to achieve the optimum representation of the terrain, especially in the case of strong terrain undulations. The processing with QuickSurf yielded a DTM with 3D faces, ready for further processing and rendering.

Secondly the 1:30000 aerial photographs of the year 1960, taken prior to the earthquake, were the only source available, in order to extract the urban web of the settlement, as well as the exact position of most of the buildings. This was considered necessary in order to represent as well as possible the destroyed settlement. The stereopair was relatively oriented and levelled using the elevations of the coastline. The result of this action was the planimetry of the old settlement and the outlines of the old buildings. This product was subsequently suitably scaled with the help of the digitised 1:1000 plot.

Using information from the aerial stereopair and from the amateur photographs the 3-D reconstruction of some typical houses was determined. This process was realised using AutoCAD and a specialised software for geometric 3-D

reconstruction, the AutoIDEA, which operates within AutoCAD. Several typical house forms were determined from the amateur photographs (Figure 2 -left) and these were constructed as 3 -D orthogonal solids, including their roofs as sloped planes (Figure 2-right). A typical landmark of the old settlement were the numerous windmills, situated on top of the hill. For their representation a cylindrical solid with conic roof was also constructed. This process yielded the three dimensional representation of the buildings, ready to be included in the final 3-D scene for rendering.
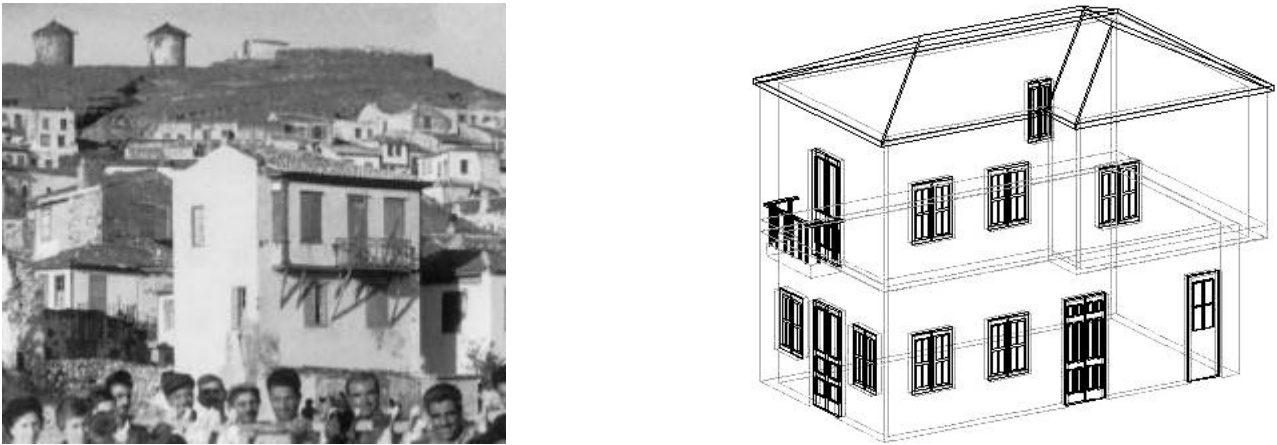

Figure 2. An old amateur photograph of a typical house (left) and a 3-D wireframe model of a house (right)

The next step was to merge all previously described data. As they were all compatible, i.e. vector representations in AutoCAD environment, this was quite a straightforward task. At first the planimetry was merged with the DTM, while the digitised roads served as breaklines. Subsequently the outlines of the buildings were introduced. With their help the bases of the houses were "cut" into the DTM, also as breaklines. In this process the windmill bases were specially treated, as they were of a different shape.

The 3-D wireframe was then completed by the addition of the solids, representing the man made constructions, i.e. the houses, the windmills and the bigger buildings of the old settlement at their appropriate positions. The result of this operation was a 3-D wireframe model of the settlement, as close as possible to the pre-earthquake reality. This wireframe was then draped with suitable rendering attributes, in order to produce the final 3-D visualisation.

4   PRESENTATION OF VISUALISATION

The data collected and processed as described above formed the basis of the final visualisation. As already mentioned there are numerous means of representing and visualising 3-D data. The choice of the right one each time depends on the scope of the final visualisation.
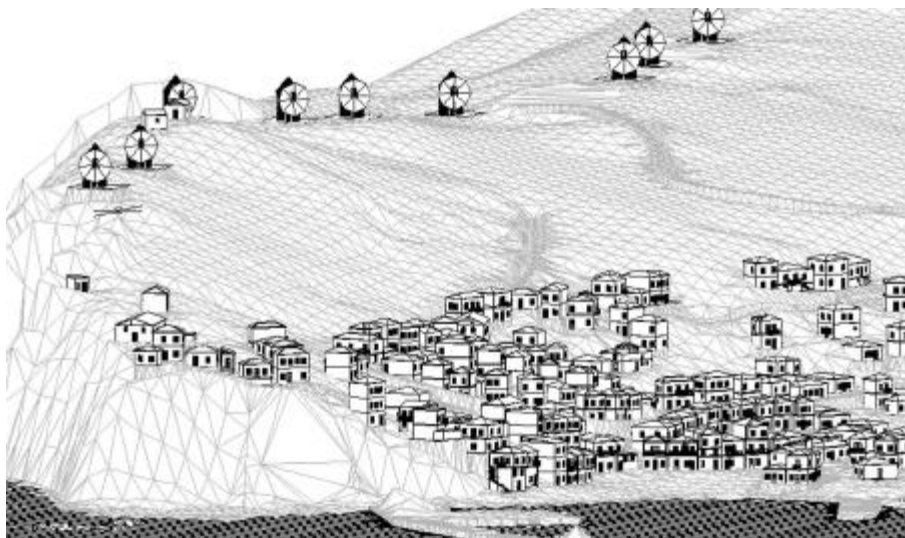

Figure 3. The 3-D wireframe model of the settlement

In the present case the scope of the visualisation was to arm the local authorities with a tool in hand in order to enable them achieve two goals. The first one was to persuade the local community to accept the proposed action of reviving the abandoned settlement, as the population presents mainly a sentimental resentment towards their destroyed houses. The second goal was to persuade state authorities to consider the problem and ensure the necessary funds for the whole operation. Hence a visualisation was needed, among others, which would show that the means for a reconstruction were indeed available and that such an effort would be worthwhile both for the local population as well as for the welfare of the island.

Figure 4. The visualisation output from a similar viewpoint of Figure 5

Therefore this work aimed at a general visualisation of the old settlement at a relatively small scale with minimum detail, but enough to achieve its aim. It was considered appropriate to use the relatively simple rendering possibilities offered by AutoCAD in order to serve these goals. Hence the 3-D data in the wireframe form (Figure 3) were rendered appropriately in order to produce the desired result (Figure 4). The comparison of an old amateur photograph (Figure 5), taken before the earthquake (Ministry of the Aegean, 1999), with the result of this study leaves no doubts whatsoever about the power of the rendering process.

Figure 5. An amateur's photograph, taken before the earthquake, portraying the old settlement
(Ministry of the Aegean, 1999)

5   CONCLUSIONS

This project has shed light to several issues concerning the 3-D visualisation process. As far as the data sources are concerned it has been established that both vector and raster raw data may be exploited to serve the needs of such an application. Non-metric old amateur photographs have proven invaluable, because they convey rich qualitative information about the reality to be represented. This becomes even more significant for those cases that the object does not exist any more. Modern software packages enable the integration of data from radically different data sources. Digital photogrammetric techniques play an important role to visualisation applications by minimising the processing times and by allowing the representation of non existing objects but captured on old resources. Finally, such outputs as the produced visualisation can be used as strong promoting media for the reconstruction efforts in cases of destroyed settlements or other similar projects.

REFERENCES

Anastassopoulou A., Kappatou G., 1998. Photogrammetric representation and visualisation of the destroyed settlement of the Agios Efstratios Island. Diploma Thesis. Faculty of Rural and Surveying Engineering, National Technical University of Athens, Greece, (In Greek)

Georgopoulos A., Nakos B., Mastoris D., Skarlatos D., 1997. Three dimensional visualization of built environment using digital orthophotography. Photogrammetric Record, 15(90), pp. 913-921.

Guerra F., Balletti C., 1999. 3D reconstruction for the representation of the church of S. Marino: solid modelling, mapping, CAD, Photogrammetry. In: International Archives of Photogrammetry and Remote Sensing, Thessaloniki, Greece, Vol. XXXIII, Part 5W11, pp. 210-214.

Lammi, J., 1999. A Method for Three-Dimensional Modelling of Buildings from Digital Aerial Imagery. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series, No. 117.

Ministry of the Aegean, 1999. Ai-Stratis. Photographic Traces (1940-1970). ISBN 960-7859-22-7, p. 217. (In Greek)

Nakos B., Tzelepis N., 1998. A 3-D Realistic Representation of Urban Space. Proceedings of 5th National Cartographic Conference, Thessaloniki, Greece. (In Greek)

Riedl, A., 1999. Virtual Globes – A New Era for Globes? Proceedings of 19th International Cartographic Conference, Ottawa, Canada, Vol. 1, pp. 649-656.

Schielcher, M., Guo Z., Klaus M., Roschlaub R., 1999. Aufbau von 3D-Stadtmodellen auf der Basis von 2D-GIS. Photogrammtrie Fernerkundung Geoinformation, Heft 3, pp. 157-170.