VIRTUAL WALKTHROUGH IN A LOST TOWN – THE VIRTUAL ARGOSTOLI

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ABSTRACT
Virtual reconstruction of urban areas, which are lost due to natural or man-provoked disasters, is nowadays feasible through the usage of contemporary three-dimensional technologies and virtual reality. With the aid of topography, architecture, history and archaeology, the once existed urban areas, or even whole cities, can be reconstructed as close as possible to the original. The work presented in this paper is such an attempt. It focuses on the urban area of Argostoli in Kefalonia, Greece, which was completely destroyed by an earthquake during 1953. Using all kinds of information involving the town, a part of the urban area has been reconstructed in three dimensions and a virtual tour is now available.

KEY WORDS
Virtual reconstruction, 3D modelling, virtual reality, virtual walkthrough

1. Introduction

Argostoli has been the capital and administrative centre of the island of Kefalonia, Greece, since 1757. Argostoli developed into one of the busiest ports in Greece, leading to prosperity and growth. It's expansion was rapid. It was the second town in Greece with electricity and street lighting, water mains, museums, tree planted streets, squares, beautiful mansions, institutions, conservatories, theatres, small productive units, and sports life. In this well organized town, cultural and intellectual activity flourished. The bombing of the town by the Germans in 1943 and then the 1953 earthquakes lead to its total destruction. It's recovery essentially starts in the 1980's and, today Argostoli is an entirely different town.

In this paper we present the work carried out in order to revive a significant part of the town of Argostoli, the coastal commercial street that was destroyed during the earthquake. Fortunately, due to the prosperity of the town, several photographs, descriptions and maps are available. A topographic map and several photographs and drawings belonging to times before the catastrophic earthquake [1] were available and proved to be valuable resources for the reconstruction.

2. Virtual Reconstruction of Urban Areas

Virtual reconstruction of urban areas that no longer exist is a very active research field. There are numerous works that deal with the problem of reconstructing an urban area from limited references. In some cases urban areas still exist in some form whereas in other are destroyed, lost or significantly altered.

The field of virtual reconstruction of historical urban areas is really rich with projects. Some of them introduced the idea of combining gathered historical information and different digitization methodologies to provide with an improved final 3D model [2]-[4]. In [5] a versatile open-source-software-based workflow for 3D reconstructions of urban areas is proposed. The authors applied the proposed workflow for the reconstruction of a part of the old town of Kavala (North-Eastern Greece). Forte et al. [6] have also exploited the importance of open source software proposing an approach to real-time Web based 3D landscape reconstruction. A case study of a 3D reconstruction of a part of one of the biggest traditional settlements of Greece, which exhibits mixed traditional Greek, European and Oriental architectural features is presented in [7]. Alshawabkeh et al. [8] discussed the application of terrestrial 3D laser scanning for the 3D reconstruction of Petra in Jordan. Koutsoudis et al. [9] presented a case study of applying terrestrial 3D laser scanning for the digitization of the remnants of a Byzantine castle in the city of Kavala. They produced a Web-accessible 3D model of the castle based on the high density raw data derived from a time-of-flight 3D scanner. Gutierrez et al. [10] worked on the reconstruction of Sinhaya, a X-XIIth century Muslim suburb in the city of Zaragoza. They presented their reconstruction using an interactive 3D Cave immersive virtual reality system.

Also rich with projects is the field of lost urban areas reconstruction. One of the most famous is that of the ancient city of Rome [11]. The urban reconstruction in this case is based on a plaster model of the ancient Rome, which was completed in 1970 after a three-decade collaboration of topographers and modelers. The data acquired from scanning the plaster model were used to rebuild the virtual model of the ancient Rome. In the latest version of the 'Rome Reborn' project the city consists of 32 hand-modeled significant buildings, like the Coliseum, and about 7000 *procedurally* generated building using the techniques described in [12] and [13]. Procedural modeling of buildings is a significant aid in 3D reconstruction of urban environments, because it provides an automatic, realistic and homogenous cityscape for the accommodation of landmark buildings that are modeled manually. In [14] and [15] the virtual reconstruction of ancient Pompeii is presented. The 3D model of ancient Pompeii is generated automatically using procedural modeling, as well as archeological and GIS information from the site. The final result is a 3D model with high level of detail and realism, which gives a good glimpse of how ancient Pompeii might be in total, at that time [16]. A similar project to the one described in this paper is shown in [17]. It is a virtual reconstruction of down town Sao Paolo of 1911, which was created using historical documents from that period, like photographs, card postal, city plans, pretty much everything that was available and could be used from that period. Another similar case of virtual reconstruction using just old photographs is presented in [18]. In this particular work, an old mixed-race area of Cape Town called District Six, was reconstructed from a set of old and uncalibrated photographs.

3. The Case of Argostoli

Argostoli was a town of economic growth and prosperity during the first half of the twentieth century and as of this, it was documented in various ways. Photographs, topographic maps, descriptions, stories and texts can be found that describe the town and its everyday life. Additionally, local people are a very valuable source of information, either by providing information about how they lived through the period of interest, or by conveying the stories of their ancestors.

Our main source of information was [1], which represents a publication that concentrates digitized original documentation material of high significance and historical value, bringing together all available local sources of information. Although the town was already relatively well documented, in several cases there was an uncertainty on the actual relative position of buildings and the form of their facades. In these cases, the help of the locals and of the Corgialenios Library in Argostoli (http://www.corgialenios.gr) was more than welcome.

Figures 1-3 show some examples of the material presented in [1] that was used to produce the virtual reconstruction. Put in chronological order, *Figure 1* shows a painting of the town in 1864 (a little before the union with Greece), *Figure 2* represents a panorama of the town during 1901 and *Figure 3* shows an areal photo of the whole town during the late 1940s.

Figure 1. Argostoli in 1864, a little before the union with Greece

Figure 2. Argostoli in 1901

Our task was to create a web-based interactive virtual walkthrough of an urban area consisting of about 52 buildings, deployed on the coastal road along the harbor of Argostoli. The requirements for web-based interactive functionality, dictated to keep a tight budget in terms of polygon numbers and textures sizes, in order to allow an interactive experience even to users with moderate computer power. The usable data in our disposal for reconstructing the area before the earthquake were limited to a digital copy of a draft 1:2000 topographic map of the town (*Figure 4*) and some scanned old and low quality photographs.

Figure 3. Aerial photo of Argostoli (late 1940s)

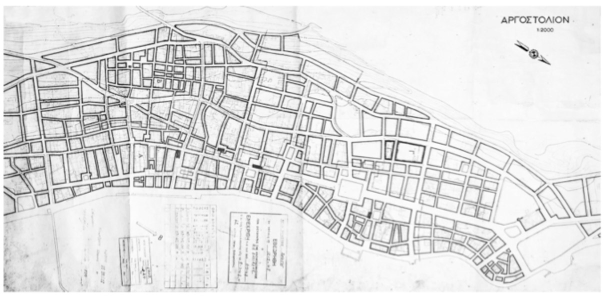

Figure 4. Topographic map of Argostoli in 1948

A number of problems had to be dealt with: firstly, all photos of the area of interest were not of the same period. As of this, small differences can be identified on the same building through time. This gave rise to a need for identifying the period with clearer photos (on the average) that could be more usable for a consistent reconstruction. Additionally, the bad quality of the photographs and their inadequate number rendered photogrammetry inapplicable. Techniques based on vanishing points or lines, like those presented in [19], where also inapplicable due to the high ambiguity of the blurry photographs. Another issue was how to reconstruct the third dimension of the buildings; the only available information was an 8 megapixels digital photograph of the area's topographic map, which was dated back to 1948, providing some information about the length and width of the buildings, but as proportions and not as actual metric units due to the fact that it was a digital copy. Last but not least, there was a limited timeframe for the implementation that forced us to use more radical solutions for the construction of the 3D model of the area.

These problems, led us to combine the information on single photographs with a number of geometric hypotheses based on structural constrains of the buildings. The main hypothesis was that the building structures exhibit a lot of orthogonal characteristics, as stated also in several other works like [18], [20]-[22]. The facades, the doors and the windows can only be orthogonal; also the same hypothesis holds for the shape of most of the buildings, a fact that was supported by the topographic map of the area as well.

Using the orthogonality hypothesis we managed to approximate the shape of each building with quite accurate proportions, however approximating the actual dimensions of each building was another puzzling issue. The third missing dimension of the buildings, the height, was derived by examining various photographs of buildings with people standing or passing by. By assuming that a man with a top hat had an average height of 180 cm, we approximated the height of the buildings accordingly. We modeled the whole area proportionally, starting from adjacent reference buildings and expanding, using image based measurements by matching visible buildings in photographs with already modeled ones.

In order to cope with the tight deadlines of the project, we followed a manual technique similar to [3] and [5]. The footprint of each building is derived from the rough topographic map of the area and it is then evaluated according to the available photographs depicting the specific building (*Figure 5.1*). Then the next step is to extrude that footprint perpendicular to the ground plane, to the estimated height of the building. As we described in the previous paragraph, the height of each building is derived proportionally by comparing the building against either features of known size or other buildings that have already been modeled and appear in the photographs of common features (*Figure 5.2*). After the extrusion of the footprint we end up with a basic 3D geometric representation of the building. Using the available photographs as a reference, we divide the whole building along its footprints' extrusion path in order to create the individual floors (*Figure 5.4*) and we cap the end of the extruded geometry, either using an inclined roof or a flat terrace. The next step is to create the façades of the building. This is done by further dividing the faces of the basic geometric object, according to the buildings' features that are visible in the photographs, creating in that way placeholders for the windows and doors of the building (*Figure 5.5*). Afterwards, these placeholders are replaced by geometric primitives, from a pre-modeled set of windows and doors (*Figure 5.6*). Finally, additional architectural features like balconies and columns are added, in order to make the building appear similar to that depicted in the available photographs (*Figure 5.7*). In order to give consistency to the 3D reconstruction and create the appropriate atmosphere of that time all the buildings consist of the same architectural elements, selected from a small asset library that we created taking into account building characteristics from a few 'decent' photographs.

Another aspect in the virtual reconstruction of buildings, or, in general, subjects that exist only in very old photographs, is the ambiguity about their original color. From the literature as well as from documentation and preservation work on the buildings of that period, we know that, in some areas, constructors were using more than one color to paint the exteriors.

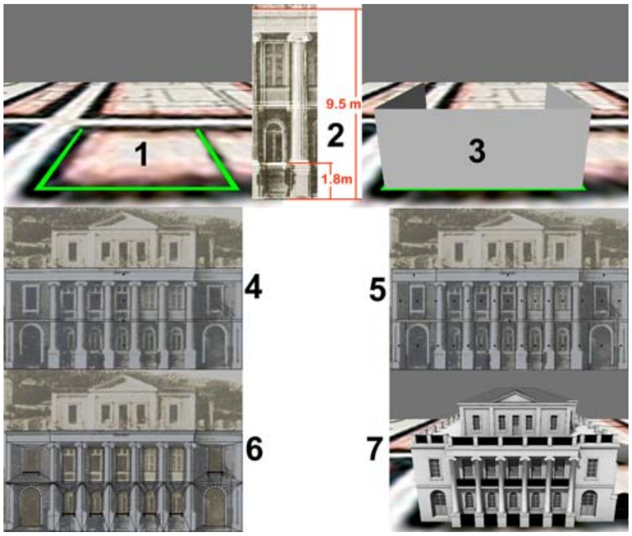

Figure 5. Phases of the virtual reconstruction of buildings

However, due to the lack of information concerning building colors of the specific region and era, we decided to use the characteristic sepia color toning of old photographs to the whole 3D reconstruction. Technically, in order to increase the realism of the reconstruction, we added hard shadows from a bright virtual sun and applied ambient occlusion lighting, as well as some cracks and patches on the wall textures of the buildings. The final model was exported in VRML format so that it could be accessible through the web using typical (freeware or demoware) VRML browser plug-ins. A demo of the 3D reconstruction with reduced texture quality and geometry for faster download and low-computer-power accessibility is available online at http://www.ceti.gr/3d_demo/argostoli/argostoli.wrl. *Figure 6* shows a screenshot during a virtual walkthrough.

Figure 6. Screenshot of a virtual walkthrough

4. Conclusion

Virtual digital reconstruction of lost urban areas is nowadays feasible through the usage of contemporary 3D imaging technologies and virtual reality. Existing documents about the area of interest can be used in order to extract topographic, architectural and historical-archaeological information in order to construct a description of the area. The work presented in this paper is such a case. The urban area of Argostoli in Kefalonia, Greece, which was completely destroyed by an earthquake during 1953, was the target of the reconstruction. Using all available information the urban area has been reconstructed in 3D and a virtual tour is now available.

The reconstruction work had to face a number of issues and hypotheses had to be adopted. A drawback is the lack of color, which could not be coped with due to the limited resources and timeframe in this project. A more thorough analysis of the available resources is scheduled for future work regarding this aspect and a more realistic and expanded version of the reconstruction is underway.

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References

[1] Cephalonia of old, The island before the earthquakes of 1953, from the Corgialenios Museum photo Archives, Volume 1, ARGOSTOLI, THE CORGIALENIOS FOUNDATION, 2004, ISBN 960-90220-6-5

[2] Beraldin, J.-A., Picard M., El-Hakim, S., Godin, S. F., G. Valzano, V. Bandiera, A., 2005. Combining 3D Technologies for Cultural Heritage Interpretation and Entertainment. In: The International Society For Optical Engineering, 2005, Vol. 5665, pp. 108-118.

[3] El-Hakim, S., Beraldin, J.-A., Picard, M., 2002. Detailed 3D Reconstruction of Monuments Using Multiple Techniques. In : The ISPRT Commission V, Symposium 2002, September, Corfu, Greece

[4] Tsirliganis, N., Pavlidis, G. Koutsoudis, A., Papadopoulou, D., Tsompanopoulos, A., Stavroglou, K., Politou, E., Chamzas, C., 2001. Integrated Documentation of Cultural Heritage Through 3D Imaging and Multimedia Database. In: VAST2001: Virtual Reality, Archaeology, and Cultural Heritage, November 28-30, Glyfada, Athens, Greece.

[5] A. Koutsoudis, F. Arnaoutoglou, G. Pavlidis, D. Tsiafakis, C. Chamzas, A Versatile Workflow for 3D Reconstructions and Modelling of Cultural Heritage Sites Based on Open Source Software, In procs of VSMM 2008, 20-25 October, Limassol, Cyprus.

[6] Forte, M., Pescarin, S., Calori, L., Camporesi, C., Guidazzoli, A., Imboden, S., Open Heritage: An Open Source Approach to 3D Real-Time and Web Based Landscape Reconstruction. In : VSMM 2005, 11th International Conference On Virtual Systems And Multimedia, Budape.

[7] Koutsoudis, A., Arnaoutoglou, F., Chamzas, C., 2007, On 3D Reconstruction of the Old City of Xanthi. A Minimum Budget Approach To Virtual Touring Based On Photogrammetry, Journal Of Cultural Heritage, Elsevier, Vol. 8, No 1.
[8] Alshawabkeh, Y., 2005. Using Terrestrial Laser Scanning For The 3D Reconstruction of Petra – Jordan. Photogrammetric Week ’05, Wichmann, pp. 39-48.
[9] A. Koutsoudis, F. Arnaoutoglou, G. Pavlidis, V. Tsioukas, C. Chamzas, Creating Internet Friendly 3D Tours Using 3D Range Scanner Data, In procs of the 3D Colour Laser Scanning Conference, UCL, 27-28 March, London,UK
[10] Diego Gutierrez, Francisco J. Seron, Juan A. Magallon, Emilio J. Sobreviela, Pedro Latorre, Archaeological and cultural heritage: bringing life to an unearthed Muslim suburb in an immersive environment, Journal of Cultural Heritage, Vol. 5, 2004, pp.63-74
[11] Gabriele Guidi; Bernard Frischer; Monica De Simone; Andrea Cioci; Alessandro Spinetti; Luca Carosso; Laura L. Micoli; Michele Russo; Tommaso Grasso, “Virtualizing Ancient Rome : 3D acquisition and modeling of a large plaster-of-Paris model of imperial Rome”, Proc. of SPIE Vol. 5665, Videometrics VIII, J.-Angelo Beraldin, Sabry F. El-Hakim, Armin Gruen, James S. Walton, Editors, 56650D, Jan., 17, 2005.
[12] Pascal Müller , Gang Zeng , Peter Wonka , Luc Van Gool, “Image-based procedural modeling of facades”, ACM Transactions on Graphics (TOG), v.26 n.3, July 2007.
[13] Yoav I. H. Parish , Pascal Müller, “Procedural modeling of cities”, Proceedings of the 28th annual conference on Computer graphics and interactive techniques, pp. 301-308, August 2001.
[14] Pascal Müller , Peter Wonka , Simon Haegler , Andreas Ulmer , Luc Van Gool, “Procedural modeling of buildings”, ACM Transactions on Graphics (TOG), v.25 n.3, July 2006.
[15] “Procedural Pompeii”, Online at http://www.procedural.com/cityengine/showcases/procedural-pompeii.html, latest visit Jul 13, 2009.
[16] Jacobson, J. & Vadnal, J. (2005). “The Virtual Pompeii Project”. In G. Richards (Ed.), Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2005, pp. 1644-1649, Chesapeake, VA: AACE.
[17] Marcelo Zuffo, Marcio Cabral, Leonardo Nomura, Mario Nagamura,Fernanda Andrade, Silvia Ghirotti, Olavo Belloc, “X3D Experiences on Historical Architectural Digital Reconstruction: A Case Study of Sao Paulo city in1911”, IEEE VIRTUAL REALITY 2007 - WORKSHOP 1: THE FUTURE STANDARDS FOR IMMERSIVE VR.
[18] de Kadt, C., Gain, J., and Marais, P. 2009. Revisiting district six: a case study of digital heritage reconstruction from archival photographs. In Proceedings of the 6th international Conference on Computer Graphics, Virtual Reality, Visualisation and interaction in Africa (Pretoria, South Africa, February 04 - 06, 2009). S. N. Spencer, Ed. AFRIGRAPH '09. ACM, New York, NY, 13-21.
[19] Sinha, S. N., Steedly, D., Szeliski, R., Agrawala, M., and Pollefeys, M. 2008. Interactive 3D architectural modeling from unordered photo collections. In ACM SIGGRAPH Asia 2008 Papers (Singapore, December 10 - 13, 2008). J. C. Hart, Ed. SIGGRAPH Asia '08. ACM, New York, NY, 1-10.
[20] Li, Z., Liu, J., and Tang, X. 2006. Shape from regularities for interactive 3D reconstruction of piecewise planar objects from single images. In Proceedings of the 14th Annual ACM international Conference on Multimedia (Santa Barbara, CA, USA, October 23 - 27, 2006). MULTIMEDIA '06. ACM, New York, NY, 85-88.
[21] Debevec, P. E., Taylor, C. J., and Malik, J. 1996. Modeling and rendering architecture from photographs: a hybrid geometry- and image-based approach. In Proceedings of the 23rd Annual Conference on Computer Graphics and interactive Techniques SIGGRAPH '96. ACM, New York, NY, 11-20.
[22] S. F. El-hakim, “A flexible approach to 3D reconstruction from single images”, SIG-GRAPH ’01 Sketches and Applications