GEO-VISUALIZATION TOOLS IN CULTURAL HERITAGE MANAGEMENT

Elias Grammatikogiannis
School of Rural and Surveying Engineering, National Technical University of Athens,
9, Iroon Polytechniou str., 15773 Athens, Greece
Tel: +30-210-772-2756, Fax: +30-210-772-2750
E-mail: egrammis@survey.ntua.gr

Efstratios Stylianidis
School of Urban-Regional Planning & Development Engineering, Aristotle University of Thessaloniki,
University Campus, 54124 Thessaloniki, Greece
Tel: +30-2310-991445, Fax: +30-2310-1438,
E-mail: sstyl@auth.gr

Maria Giaoutzi
School of Rural and Surveying Engineering, National Technical University of Athens,
9, Iroon Polytechniou str., 15773 Athens, Greece
Tel: +30-210-772-2749, Fax: +30-210-772-2750,
E-mail: giaoutsi@mail.ntua.gr
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ABSTRACT

During the recent decades there has been a period of rapid transition in most of the world's cities. In such a context the traditional city centres -where most of the cultural heritage of the world countries is found- are threatened by a number of developments such as population congestion, infrastructure expansion, atmospheric pollution etc.

As a result, great interest has been exhibited by decision makers in effective preservation/conservation policies which alleviate the pressures caused by the above negative developments.

Monuments constitute an integral part of the historical and cultural identity of a country, region or city. Apart from their potential role as tourist resources they are also the everyday 'habitat' of local societies marked by their own indigenous values. As a result, there has been recently a shift in focusing on policy support tools which incorporate both the qualitative and quantitative aspects of monument conservation. These tools are dedicated to ensure that future generations will enjoy the cultural goods; the same qualities in their access to monuments as at present. [1].

Towards this end there is need for tools and methods, in support of the decision making process, enabling the efficient Management of our Cultural Heritage.

1. INTRODUCTION

The paper focuses on the development of a Geo-visualization system that supports decision makers. The system provides structured information on the potential attributes of the monument under preservation/conservation, so that aesthetic, financial, social and historical aspects to be included in the decision process.

Apart from the value added for planning purposes, the system will enable the

visualization of the monument's technical characteristics that is rather useful in a decision support/making environment. The system, as a web-based application, has enormous potential contribution since all information is accessible to the broader decision making community but also to potentially interested stakeholders wherever issues at stake arise between the decision makers and the broader community.

More precisely, in the first part of the paper the state-of-the-art of the existing Geo-visualization tools is presented (e.g. web-based GIS, the Virtual Reality Modelling Language (VRML) and the Google Earth software), while the second part elaborates the role of Geo-visualization tools in the decision making process.

The third part, in turn, describes the methodological framework of the proposed system incorporating the steps of the: a) topographic surveying of the monument under study for the 3D reconstruction of the monument's basic geometry, b) image acquisition for texture modelling using photogrammetric techniques and finally c) the implementation of a 3D web-based representation. The integration of such a tool in the planning process is strengthening both the participatory and negotiation potential of the decision making process.

In the fourth part a case study is presented, using the monument of "Aerides" in the Plaka area. The application could be used for multiple purposes in the decision making process namely as a representation tool but also as a technical support tool identifying damages of the monument throughout the years and increasing awareness on the matter.

Finally, the paper is concluded with some prospective remarks on the use of such policy support tools in the broader context of conservation planning.

2. GEO-VISUALIZATION TOOLS

In this section, the concept of Geo-visualization is discussed and several Geo-visualization tools are described.

2.1. Geo-visualization concept

A wide range of definitions appeared in the literature regarding the concept of Geo-visualization. Certain differences appear among these definitions, depending on the specific use of Geo-visualization. A representative definition of the Geo-visualization concept introduced by Van den Brink et al. [2]: '*Geo-visualizations are two-dimensional or three-dimensional visual representations of data that have a geographic reference. Geo-visualizations can be used to exchange spatial information in spatial planning processes.*'

Based on the above definition several Geo-visualization tools have been built. These are described in the following section.

2.2. Geo-visualization Tools

Geo-visualization tools are divided into two main groups, namely the traditional and the computerized Geo-visualization tools. The traditional group comprises methods such as pen and paper, paper maps, photographs and physical models, which are methods that do not apply any kind of technology [3]. These are very simple Geo-visualization methods and their description is beyond the scope of the present paper.

On the other hand, the computerized methods are GIS Mapping, Three Dimensional (3D) Modelling, Virtual Reality (VR) and Urban Simulation, which are computer-based methods. The paper describes a series of computerized Geo-visualization tools, which do not only use technology to represent objects but also use web-based infrastructure, providing thus the possibility to represent objects in a wide range of audience via the World Wide Web.

The computerized Geo-visualization tools that are described below are: a) the web-based GIS, b) the Virtual Reality Modelling Language (VRML) and c) the Google Earth Platform. All these tools have the capability to represent objects via the internet.

2.3. Web Based GIS

A representative definition for GIS was given by Kingston et. al [4]: '*GIS is an advanced computer tool box for the input, storage editing, manipulation, update, integration, analysis, visualization and output of spatial data*'. The web-based GIS platforms provide users the capability to process spatial data via the Internet.

One of the most representative examples of web-based GIS platform is the so-called Virtual Slaithwaite that is a Geo-visualization tool specializing in informing people. This project is held in Slaithwaite Village, located near to the city of Yorkshire in Great Britain. In this platform, a 2 Km^2 is represented in a web-based GIS platform, providing people of Slaithwaite the opportunity to: select different spatial objects (e.g. road, building etc.) and also to express their views on the future development of the certain area or object, e.g. the construction of a new building.

2.4. Virtual Reality Modeling Language (VRML)

Virtual Reality Modelling Language (VRML) is a Geo-visualization tool that reconstructs the urban and rural environment. According to Laurini [5], VRML is:'… *a wide-field presentation of computer-generated, multi-sensory information which tracks a user in real time.'*.

There are several virtual reality application fields, such as Virtual Reality Modelling, Virtual Reality Walkthroughs, Virtual Archaeology and Urban Planning [6]. In each of the above fields, a different use of the virtual environment is presented, aiming at the achievement of different goals. In the paper, the Virtual Reality Modelling is applied, using the VRML in order to represent the 3D real scenes, like roads, buildings etc.

Using the VRML language, a digital environment has been built, providing the user the capability to navigate freely inside the reconstructed model. In this context, the user can explore the reality in a virtual environment. VRML programming language is an Internet based tool that can be used to visualize infrastructure and present it via the Internet to the WWW users.

2.5. Google Earth

The Google Earth gains gradually more attention as a Geo-visualization tool. The Google Earth is a platform that uses a mosaic of satellite images, overlaying additional information such as national boundaries, roads, 3D buildings, places/points of interest etc., on WGS84. This platform can be used in order to

design, visualize and place objects in their geographical position.

Figures 1 and 2 are representing two characteristic examples of Google Earth implementation that shows infrastructures attached to satellite images. More specifically, Figure 1 represents alternative ring road in the protected Natura area of Vistula in Poland [7], while in Figure 2, a wind turbine reconstruction is presented [8].

Figure 1: Alternative ring road in Vistula Area

Figure 2: Wind Turbine representation in the Google Earth platform

3. THE ROLE OF GEO-VISUALIZATION TOOLS IN DECISION SUPPORT/MAKING PROCESS

The role of Geo-visualization tools in the decision support/making process is very important. This role will be discussed in the following, based on the fundamental characteristics of these tools, namely object reconstruction; integrated representation system; and user interaction.

- **Object reconstruction**

The Geo-visualization tools are able to reconstruct the object of interest (e.g. historical monuments, temples, statues etc.) and to place them in their exact geographical position. In this sense, decision makers do not only have a better, more realistic view of the object of interest, based on its geometric and architecture features, but also do have a view of the surrounding environment characteristics.

- **Integrated representation system**

The Geo-visualization tools are perceived as integrated representation systems, mainly due to two specific characteristics:

- The first characteristic relates to their capability to correlate information to the reconstructed object. In this way, Geo-visualization tools users are looking the reconstructed object, reading parallel certain information of the features they examine.

- The second important attribute of the Geo-visualization tools is that they can integrate huge amount of information, i.e. 3D reconstructed objects. For example, it would be realistic, just in one platform, to incorporate all historical monuments of Athens with their specific characteristics, providing thus an ideal tool for heritage management purposes.

- **User interaction**

Geo-visualization tools play an important role in the decision making process based on their potential user interaction and the publicity via the WWW. These attributes form the basis for the provision of information to the public in respect to changes in the reconstructed objects (e.g. rehabilitation works on monuments), validating in this way the decision making process.

4. METHODOLOGICAL FRAMEWORK

This section describes the methodological framework that is necessary for the 3D object reconstruction and its representation on a web-based platform. This framework is consisting of three main stages, namely: a) topographic surveying of the object of interest, b) image acquisition and c) development of the 3D web-based representation platform.

4.1. Topographic Surveying

In this stage, fundamental topographic techniques are used, in order to build the basic object geometry under a georeference framework.

The step of topographic surveying is composed of two steps: a) the use of a GPS system and b) the use of a Total Station.

- **Use of GPS System**

In the first step of the topographic surveying stage, two reference points near the measuring object are established. Using the GPS system, the coordinates of the reference points in EGSA ’87 system (national datum) are defined.

- **Use of Total Station**

In this step, the basic geometrical/architectural features (e.g. edges, curves, height of the object etc.) are measured. The products of this step are ground plans and facades of the measuring object that enclose the necessary information for the object reconstruction. All measurements are also held under EGSA ’87.

4.2. Image acquisition

The second stage of object reconstruction refers to image acquisition. The images will be draped into object’s basic geometry in order to create the textured model.

4.3. 3D Web-based representation

At the final stage, the images and its 3D rough model are integrated in a 3D web-based representation.

The selected representation platform should fulfill two basic requirements.

Firstly, the platform should drape the images on the object. Secondly, the whole representation system should be able to incorporate in a web site without using complex procedures.

5. THE CASE STUDY OF AERIDES

The system described in the previous sections was implemented in the historical monument of Aerides, in the Plaka area, Athens. A short description of the historical and the architectural characteristics of the monument is given. Then, is the presentation of the reconstruction phase which consists of: a) Topographic surveying; b) Image acquisition; and c) 3D web-based representation.

5.1. Short Description of the Monument

The Aerides monument, also called Tower of the Winds or Horologion, was built by Andronicus of Cyrrhus. The Tower of Winds is located on the Roman agora, at the historical centre of Athens. The monument has an octagonal structure of 3.4 m side length and 12 m height. In each side of the monument a marble wind statue is illustrated; in the North side the wind of Boreas, Kaikias in North-East, Apeliotis in East, Eurus in South-East, Notus in South, Lips in South-West, Zephyrus in West and Skiron North-West. Figure 3 is presenting the North East side of Aerides.

Figure 3: *North East side of the monument of Aerides*

Table 1 presents the most important architectural characteristics of the

monument, such as the winds' representations mentioned previously.

Table 1: *Architectonic Features of the Monument*

Wind	Statue	Wind	Statue
Boreas (N)		Notus (S)	
Skiron (NW)		Eurus (SE)	
Zephyrus (W)		Apeliotis (E)	
Lips (SW)		Kaikias (NE)	

5.2. Monument Reconstruction

Figure 4 is presenting the ground plan of the monument as an output of a quick topographic surveying. The red lines represent the wall of the monument while the green one the steps. Only representative points were captured during surveying campaign in order to describe the general outline/geometry of the monument.

The Tower of Winds is North oriented, which was expected since the monument was the astronomic centre in the ancient years and was confirmed by current GPS measurements.

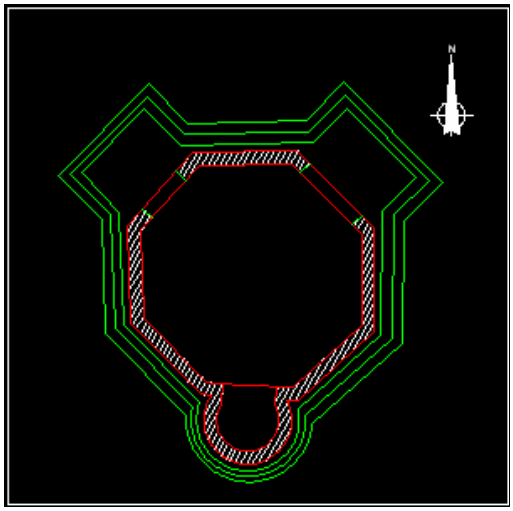
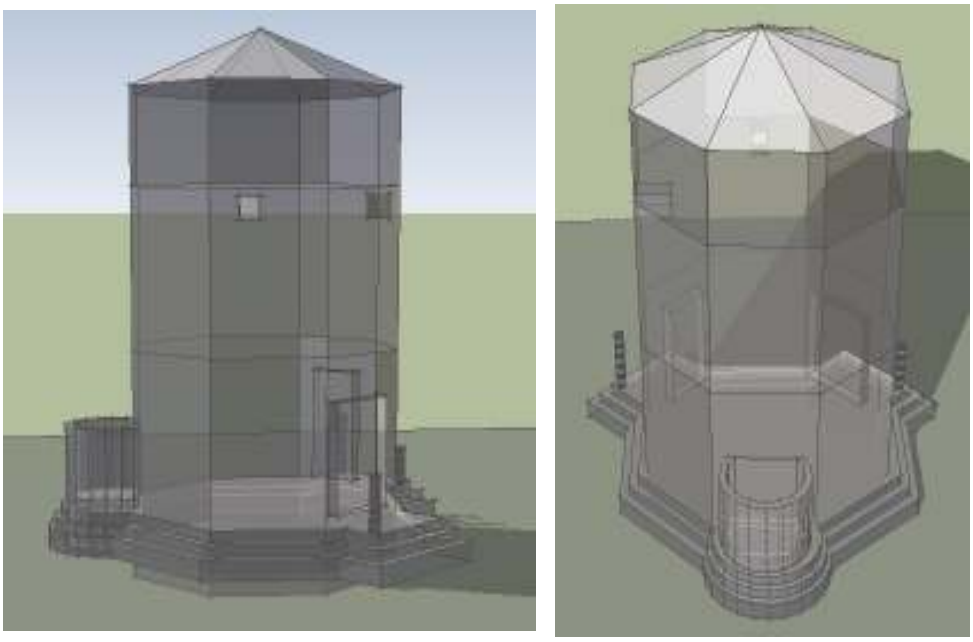


Figure 4: Ground plan of the Monument

The next procedure concerns the 3D reconstruction of Aerides. For this purpose the Google SketchUp [9] software was used. The output of this process is showed in Figure 5.



East side of Aerides *South side of Aerides*

Figure 5: Geometry of the reconstructed monument

Using the Google SketchUp software, the images are draped to the geometry model so as to create the textured model, as illustrated in Figure 6.

North side of Aerides *East side of Aerides*

Figure 6: 3D reconstruction and textured model

Then, the monument is transformed to its absolute geographical position. For this purpose, Google Earth software was used, and the output of this process is given in Figure 7.

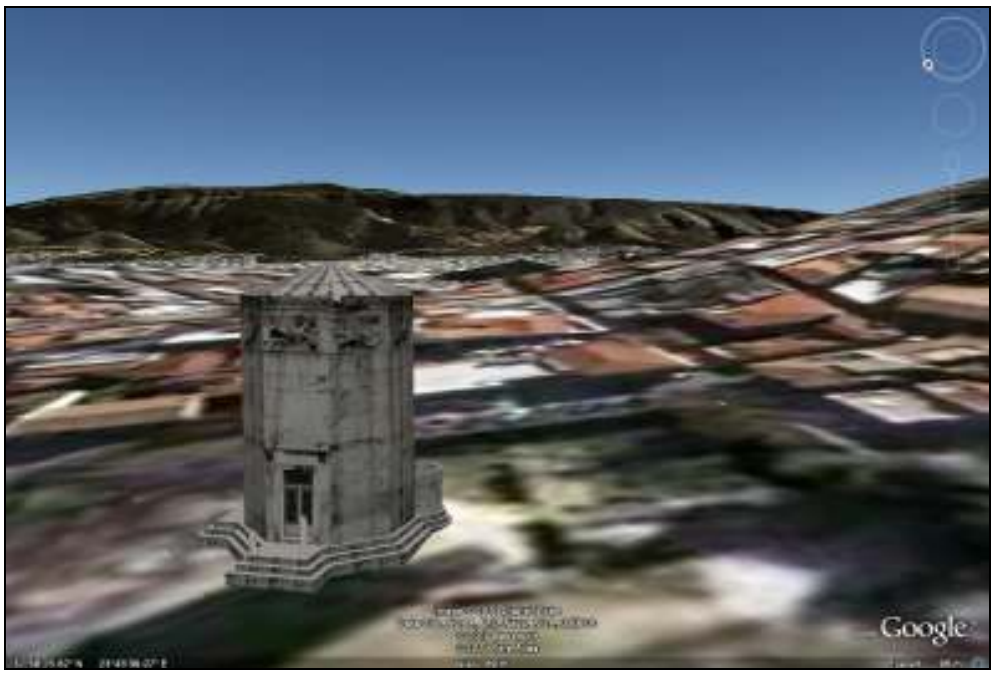


Figure 7: The monuments of Aerides placed in Google Earth

Finally, we have the release of the Aerides model in the Internet. For this purpose, a web site is developed that embeds the 3D Google Earth representation. In this platform, the users can explore the specific architectural features of the monument, measure various geometrical features (e.g. distances) and read important historical and other useful information for the monument.

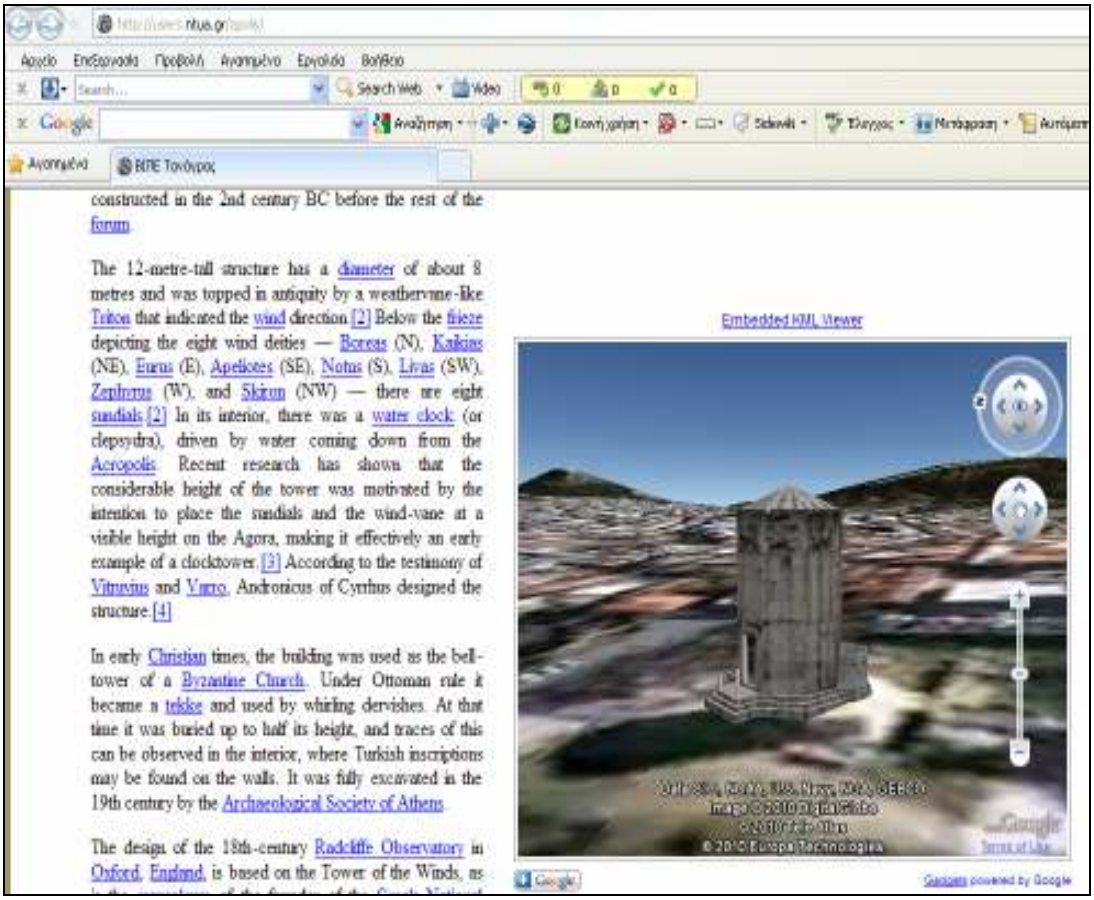


Figure 9: Google Earth monument representation embedded in the web

6. RESULTS

The methodological framework described in section 4, was applied in the historical monument of Aerides. The main objective of this process was the reconstruction of the monument and the presentation of the monument depiction via the internet in the broad public. The monument of Aerides was represented using the Google Earth platform and was embedded in a web site.

The output of this process is a web site that embeds the reconstructed monument of Aerides and gives the opportunity in the web site visitors to navigate themselves freely inside the virtual environment of Google Earth platform. As a result, an *interactive* representation system has been built that allows users to explore the geometric and special architectural features of the monument in their physical size.

The proposed web-based Geo-visualization platform includes another important element which is the parallel presentation of 3-d monument's view with useful information of the monument in a textual form. In that sense, the 3-D monument's reconstruction can be accompanied by historical information, information relevant with rehabilitation works etc.

7. CONCLUSIONS

The proposed representation system can be used to cover many aspects of monuments rehabilitation, preserving the cultural heritage and providing an appropriate management tool. Some of the Geo-visualization system applications

are the following.

Firstly, the web based Geo-visualization system can be used from decision making centres as a planning tool in which the monuments that need rehabilitation appear together in a common Geo-visualization platform. In this sense the system could be a useful tool for the monuments management by decision making centres.

Secondly, the representation system can be applied as an information tool for the broad public, informing the people for the rehabilitation works in the monuments appeared in the Geo-visualization platform. In this way, information relevant to erection works or rehabilitation techniques used for the preservation of the monuments could be provided by the proposed platform.

Finally, within the representation system capabilities is the use of the proposed system for educational purposes, increasing tpeoples' awareness for the preservation of the monuments. The fascinating, virtual environment can attract easily people to explore the reconstructed monuments and diffuse significant information, enabling this way people to understand the monuments preservation necessity.

REFERENCES

[1] McKercher B., Du Cros H. (2002). Cultural tourism: the partnership between tourism and cultural heritage management. The Haworth Hospitality Press, p.43.

[2] Van den Brink A., Van Lammeren R., van de Velde R., Dane S., (2007), Geo-Visualisation for Participatory Spatial Planning in Europe, PSPE Project, p.26.

[3] Al-Kodmany K. (2001), Visualization Tools and Methods for Participatory Planning and Design. Journal of Urban Technology, Volume 8, Number 2, pages 1-37.

[4] Kingston R., Carver S., Evans A., Turton I., (1998), Virtual Decision Making in Spatial Planning: Web-Based Geographical Information System for Public Participation in Environmental Decision Making, Proceedings of the Workshop of the International Association for Public Participation, SPICE '98, Tempe Arizona, October 3-7.

[5] Laurini R., (2001), Information Systems for Urban Planning. A Hypermedia Co-Operative Approach, Published by Taylor & Francis, London and New York.

[6] Kruijff E. (1998), Moving Sketches, Designing and Communicating Preliminary Design Ideas, Graduation Thesis, Utrecht University, The Netherlands.

[7] Andrzejewska M., Baranowski M., Kowalska A., Matuskiewicz J., Roo-Zieli-Dska E., Rusztecka M., Solon J., (2007), Development of a Geo-Discussion Panel as a Tool for Public Participation in Poland, PSPE Project.

[8] Grammatikogiannis Elias (2007), Evaluation of Alternative Sites for Wind Park Location: A Methodological Approach, Diploma Thesis, Dept. of Geography and Regional Planning, School of Rural and Surveying Engineering, National Technical University of Athens, Athens (in Greek).

[9] http://sketchup.google.com/download/index2.html