CAA Greece

Computer Applications & Quantitative Methods in Archaeology

1st CAA-GR Conference
Institute of Mediterranean Studies
Rethymno, 6-8 March 2014

USING WEBGL TO DESIGN AN INTERACTIVE 3D PLATFORM FOR THE MAIN MONUMENTS OF CRETE

P. PARTHENIOS[1], K. MANIA[2], S. YIANNOUDES[1], A. OIKONOMOU[1], F. MALLOUCHOU[1], L. RAGIA[1], N. PATSAVOS[3], A. CHRISTAKI[1], P. KOTSARINIS[2] M. DIMITRIOU[2]

[1] School of Architectural Engineering, Technical University of Crete (TUC)
parthenios@gmail.com
[2] School of Electronic and Computer Engineering, Technical University of Crete (TUC)
[3] Department of Architecture, University of Thessaly

Abstract

Conceptualization of information allows improved visualization and manipulation of large amounts of data. Especially in digitization of cultural heritage and when aiming at presenting more than one monuments, abstraction of information becomes the key solution. Our proposed application aims to present the main archaeological monuments of Crete through a conceptual 3D model and their evolution through time. The technical implementation is based on WebGL allowing the user to navigate among the main monuments and approach them gradually and interactively through different levels of detail. Furthermore, the ability to switch between the seven historical periods offers a comparative study of their evolution in time. Conceptualization and abstraction of information through varied levels of detail allows the application to be available to anyone on the web, being computationally light and easy to use.

Keywords: Cultural heritage; conceptual modeling; visualization; abstraction; 3D

1. Introduction

Our goal is to design an online platform open to the public for the promotion of the cultural heritage of Crete, through a simple, user-friendly intuitive environment. Our prime challenge has been how to manage such a large amount of information over the internet, in a transparent, light and simple way for the end user, in addition to offering the ability to compare the monuments' and cultural regions form and structure, during the main historical periods in Crete's history. The idea is simple: instead of presenting information to its full extend available up front, we break it into nodes, levels of abstraction, called "Levels of Detail", providing the minimum information needed at each given time. Information is stored on each object, each monument, along with its different Levels of Detail consisting of Crete; Prefecture; Region; Complex; Monument.

Crete is the largest island of Greece, famous for its rich cultural history dating back to the Middle Paleolithic age, 128,000 BC. Standing out as the most emblematic phase of the island's multi-layered contribution to global and national history, is, undoubtedly the era of the Minoan civilization (2,700-1,420 BC). Still, a large number of monuments have been documented throughout the different historical periods, the most important of which are the following seven: Minoan; Classical & Hellenistic; Roman; Byzantine; Venetian; Ottoman; Modern.

Crete being one of the places where most of the cultures which have developed in the Mediterranean have interfered, it is crucial to provide the public with the possibility to produce personal multiple cultural representations and interpretations of the island's polyvalent cultural, historical and geographical scape. It is not intended to promote a strictly architecture-based limited image of Crete's past, but a dynamic understanding of its hybrid cultural identity. In that sense, the points of reference are not strictly based on a 'high culture' agenda; apart from traces of an 'official' historical past, such as the Minoan Palaces and the Byzantine Monasteries of the island, local networks of vernacular settlements and places invested with local myths, legends and events are also to be included. In that sense, addressing history of architecture as part of culture and not just as a catalogue of important buildings per se, it is aimed to unfold the ways in which architecture has been developing in Crete as a witness of the inherent cultural dynamics of change and adaptivity as well as tradition and continuity. Sites symbolizing the unity of local culture as well as contested places indexing the dialectics of local and regional conflicts form an equal part of our localized references. This is the way to turn all this information into something engaging with the interests of the contemporary cultural traveler.

2. Concept of the Cultural Platform

The targeted users for this application are mainly tourists with a varied degree of general interest in history, architecture and archeology. This application helps them plan their visits to monuments and provides them with extra information about how these historical sites have evolved through time. It is a helpful and useful tool that can be easily used by a basic internet user.

Most 3D reconstructions of cultural monuments have focused on the photorealistic depiction of these monuments (Ragia et al. 2014). The schematic visualization of monuments adopted in this paper, presents the monument with only its essential features without descriptive details (Sifniotis et al. 2006). In this way, the user is provided with the necessary information in order to perceive a complete picture of the monument.

Herein, the challenge is to present a well structured as well as open in its possible readings array of diagrammatic information operating more as the matrix for direct as well as less straightforward meanings on behalf of the user. The sheer concept of the diagram stands at the core of the platform’s innovative concept. Knowledge acquisition and interactivity are not necessarily supported and enhanced by an already 'stable' and closed in its interpretation pseudo-realistic render. On the contrary, the diagram, in its abstraction as well as open-ended character functions as an initiator of possibilities and potentialities. Added to that, this is indeed the best way to optimize the available storage and processing technologies with the bulk of 3D information so that the cultural platform provided operates effectively on the Internet.

The 3D diagrammatic visualization depicts the monument without falling short of information, eliminating unnecessary details that can be acknowledged in the near future once the user visits the monument. Therefore, accurate textures for each monument have been avoided and replaced with generic, abstract, textures –which in addition allow for radical shrinkage of the model’s total size. After all, the platform does not seek to replace physical reality and the need to engage with it. What is being sought after is no more than an enlarged synergy between the physical and the virtual for the sake of the visitor.

The grouping of monuments is initially based on their geographic location. Each pin represents a monument or a group of monuments that are geographically close. The user, depending on the monument s/he wants to visit, focuses on a region (pin), in which s/he is informed about that monument or about neighboring monuments for which s/he was not informed. The user may observe the 3D visualization of the monument in a specific time period, as well as its evolution in time, up to the contemporary period. In this way, s/he is informed about the form of the monument in earlier historical periods as well as about its potential proximity to other important monuments of the same period or other.

At this stage, the monuments that are being presented are the following:

- Kydonia (Chania): Minoan period
- Aptera (Chania): Hellenistic, Roman, Venetian, Ottoman and Modern period
- Yali Camisi (Chania): Ottoman and Modern period
- Venizelos’ Residence (Chania): Modern period
- Agora (Chania): Modern period
- Arkadi Monastery (Rethymno): Byzantine, Venetian period
- Etia Villa (Lassithi): Venetian period.

The classification of monuments is based on their geographic location. Crete is divided into four areas (corresponding to the administrative sub-peripheries/ ‘prefectures’) while and each one is subdivided into a concrete number of municipalities. Each monument is geographically located in a single municipal unit. Each pin represents a monument or a group of monuments that belong to the same municipal unit and are geographically close.

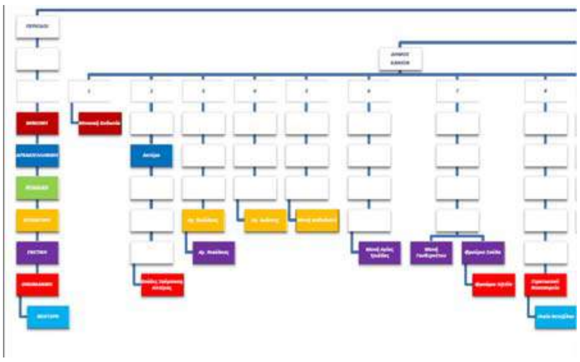

Figure 1 Clustering of monuments

There are five (5) levels of detail as follows:

1. Crete, divided into four prefectures (Figure 3)
2. The Prefecture: in this level each prefecture is depicted along with the pins of the monuments. The orange color represents the pins in the time period selected from the horizontal axis of historical periods, while pins in red transparent color represent monuments from earlier historical periods, which

have not suffered any change or addition in the running historical period (Figure 4).
3. The Region: a part of the municipal unit appears with the monuments of each historical period while the monuments of earlier periods, are depicted with transparency (Figure 5).
4. The Complex: this level presents the cluster of monuments along with the monuments separately, depending on the historical period that we select from the horizontal (Figure 6).
5. The Monument in more detail (Figure 7).

It is essential to also note that, independently from each monument and its specific characteristics, what prevails is a common `language' of representation that runs through the application. In particular, in the level of the Region, the monument that we are each time interested in is presented on a part of the map of the respective municipal unit, along with neighboring monuments, thus allowing the user to grasp its context both in terms of the other monuments in proximity and of the surrounding urban fabric. The diagrammatic view allows the user to 'supplement' with his own eyes what is visually there based on historical information and the visitor's own interests and past experience.

3. Technology

3.1 WebGL

The technology utilized for the implementation of the cultural platform presented in this paper is WebGL. WebGL is a cross-platform, royalty-free web standard for a low-level 3D graphics API based on OpenGL ES 2.0, exposed through the HTML5 Canvas element as Document Object Model interfaces. WebGL is a shader-based API using GLSL (OpenGL Shading Language). GLSL is a high-level shading language based on the syntax of the C programming language employing constructs that are semantically similar to those of the underlying OpenGL ES 2.0 API, adapted for JavaScript. Notably, WebGL brings plugin-free 3D to the web, implemented directed into the browser. Today, WebGL runs in desktop and non-IOS web-browsers such as Mozilla Firefox, Google Chrome, Safari, Opera and the latest version of Internet Explorer. WebGL was selected as the main 3D programming framework for our application mainly because applications are loaded directly to the browser without the need of a plug-in.

Three.js is a cross-browser JavaScript library used to create and display animated 3D computer graphics on a Web browser. Three.js scripts may be used in conjunction with the HTML5 canvas element at a higher-level than WebGL. The advantages of using the Three.js framework instead of native (or raw) WebGL is that the Three.js library has a lot of constructors ready for use and long WebGL code could be replaced by a few lines of code when Three.js is employed. Moreover, the Three.js platform provides model loaders necessary for the display of the 3D models of the monuments.

3.2 3D Models

The 3D models of the monuments are developed in Google Sketchup and exported as Collada files (.dae) as required by the Three.js platform. It is important that the 3D models consist of a small number of polygons as they are being downloaded by users through the Internet in real time. For this reason, the 3D models are modeled in an abstract form without, though, losing the appropriate mesh detail that makes them recognizable and unique. It is also significant that the system is scalable to accommodate a growing number of monuments as well as different parts of Greece or any other country; therefore, intelligent data manipulation so as to reassure easy and fast on-line access is paramount.

3.3 Implementation

We have developed an application for 3D interactive presentation of cultural monuments of Crete (Figures 2-7). The platform implemented in WebGL visualizes each cultural monument in five spatial levels of detail representing initially Crete as a whole, then by prefecture, region, complex of monuments and finally focusing on the actual monument. Simultaneously, each level of detail is visualized in seven 7 different time periods, e.g. Minoan, Hellenistic, Roman, Byzantine, Venetian, Ottoman, Modern. For the first time, the user is able to virtually visit Crete across regions and time. The user interface consists of two bars, one vertical and one horizontal representing the level of detail and the time periods respectively (Figure 2). The user could click on the desired level of detail and historical period in order to view in 3D the appropriate representation by simple interaction with the mouse. They could also navigate inside the 3D models by performing simple mouse events interactively. The canvas of the application is as large as the browser window. The viewpoint set when each 3D monument or region is initially loaded is specified as the optimal rendering view for the user. The user could zoom-in/out using the scroll wheel of the mouse, or move the position of the camera by drag and drop in order to visualize the 3D model from a different point of view. The 3D models are intended to be clickable adding historical information and further images as the site is being developed.

Appropriate lighting of the 3D scenes significantly enhances the perceived sense of photorealism and presence. After experimenting with various lighting configurations, we set the parameters of the directional lights provided by the Three.js platform, setting their intensity and position in order to achieve the most aesthetically pleasing result.

The shadows are casted by the models as well as the models receiving shadows. In order for shadowing to be implemented, the models are defined as a complex set of surfaces through the code. Therefore, specified surfaces are able to cast shadows and others receive shadows, all belonging to the same model.

In order to keep the web site simple for non-expert users, we use the Three.js's *sprite* which stores in an array the position of the mouse. The position of the mouse as well as the projection of the models on canvas could be combined with an appearing label offering information about each model.

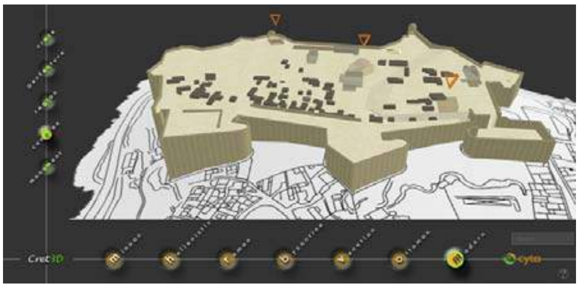

Figure 2 User Interface of the platform, horizontal axis representing historical periods, vertical representing level of detail

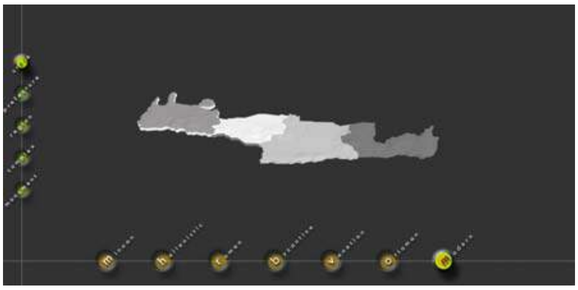

Figure 3 Crete in Modern period

We setup a database for the models and their associated information using Ajax technologies enabling the asynchronous loading of suitable 3D models without reloading the page. Ajax is a group of interrelated Web development techniques used on the client-side to create asynchronous Web applications.

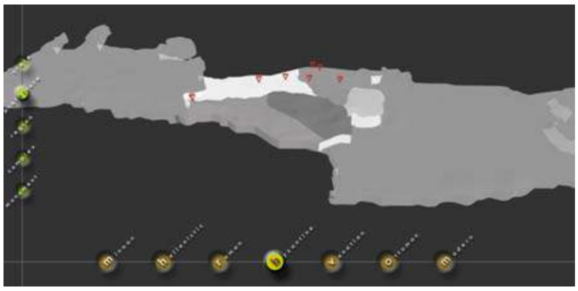

Figure 4 Prefecture in Byzantine period

Figure 5 Rethymno old town: Region in Ottoman Period

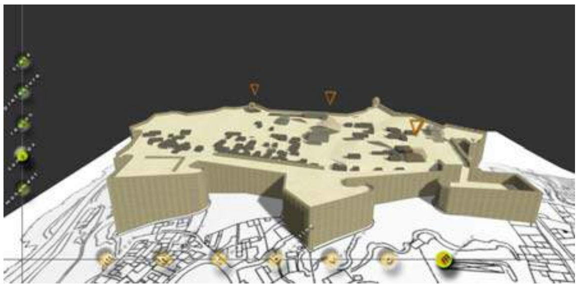

Figure 6 Rethymno old town: Complex in Modern Period

Figure 7 Rethymno old town: Monument (Pirovolio) in Venetian Period

Such technologies are necessary because of the sheer size of the 3D models which require optimized loading so that users do not quit the application. Ajax supports the loading of the application without unaccepted latency.

3.4 User Interface

The user interface was kept simple and easy to be operated by the user. The most important element of the application is the 3D canvas where the 3D models are being visualized (Figure 2).

At first we constructed a paper prototype of the interface of our application which helped us to understand the flow between screens and user interactions. A paper prototype enables the visualization of the user interface based on the successful succession of screens. It showcases which interface elements are more important to put emphasis on and how intuitive it is for our typical user, for instance, a tourist.

The paper prototype was shown to a small set of people, mainly the developers and the researchers in the project. The main web page of the application was designed based on the observations related to the paper prototype so as to avoid elements of the user interface that were not completely understood as well as adding elements that were missing. The user interface consists of two main axes; a horizontal which is the time axis and a vertical which is the spatial axis. The time axis is composed by seven buttons that corresponds to seven main historical periods. The spatial axis consists of five buttons, each one of them corresponding to different spatial levels starting from the most general to the most detailed one.

The design of the buttons is simple and abstract. The colors of the clickable buttons were selected for their contrast with the background which is dark grey. The most important elements of this interface are the two axes, therefore, no other elements were added in order for the design to be clean and simple. For the same reason, we placed the buttons over the 3D canvas that led to a problem. The letters of the buttons in full zoom-in mode while interacting with a 3D model were not readable, so we placed a semitransparent box behind the letters of the two axes to enhance their readability. At every level of the spatial and time axis a help button is found. By pressing it the user can locate information and a search bar for easy and quick information access.

When the user selects the last level of detail of the spatial axis visualizing an interactive monument, a menu is appearing offering certain options. At the right side of the screen a double arrow appears and when the user slides it, a slide menu is available including monument information. The user can select photos, videos, historical and general information associated to each monument etc. The user's choice is being displayed on a pop-up window which is viewed over the 3D canvas and by interacting with the arrows at both sides photos or videos can be viewed. The idea behind user interface decisions was to build an interface that is comfortable to use, also through touch screen devices.

4. Conclusions and Future work

We have developed a web-based interactive platform for the 3D visualization of cultural monuments in Crete across regions and historical periods. The platform offers a comprehensive view of the wealth of Crete's cultural heritage and its evolution in time. In the future, the platform may incorporate social media characteristics so as to be more appealing to young people. For example, users could be offered the possibility to leave comments, rate monuments, keep track of monuments visited and also provide recommendations to the users based on their previous ratings.

3D modeling of monuments were mainly based on historical texts, sketches and drawings. Further development of our modeling approach would be to import primary and secondary monument information from different sources. Primary data may include measurements from field observations, mainly survey. Secondary data may consist of information that has already been processed or imported in other datasets. Digital recording in archaeology is widely used and photogrammetry is one major acquisition technique. Data from aerial and close range photogrammetry may also be imported. The idea would be to enrich our prototype with the integration of photogrammetric data, which provide valuable information about the facades of the monuments and the location of the monuments.

An additional component of the system would be the integration of our prototype with a Geographical Information System (GIS). GIS is a powerful tool for data storage, management, analysis and visualization and involves mathematical functions for further analysis of archaeological data. GIS information could be combined with location-based services so that in future extensions, the application is aware of the position of the user and automatically loads the relevant information if, for instance, the user is near or at the area of a cultural site.

Acknowledgments

The project is funded by CYTA based on a competitive grant awarded to the Technical University of Crete. We would like to thank all students of the Technical University of Crete involved in this project.

References

Gonzalez-Perez, C., Parcero-Oubina, C., (2011). A Conceptual Model for Cultural Heritage Definition and Motivation. In Proc. *39th Annual Conference of Computer Applications and Quantitative Methods in Archaeology,"Revive the Past" 2011,* Beijing, China

Parthenios, P., (2012). A Conceptual Model of the Main Archaeological Monuments of Crete. In Proc. *17th Conference on Cultural Heritage and New Technologies 2012,* Vienna, Austria.

Ragia, L., Mania, K., Sarri, F. (2014). 3D Reconstruction of Neoria, Crete, Greece, using Geodetic Measurement and Computer Graphic Techniques. In Proc. *18th conference on Cultural Heritage and New Technologies 2013*, Vienna, Austria.

Sifniotis, M., Jackson, B.,White, M., Mania, K., Watten, P. (2006). Visualizing Uncertainty in Archaeological Reconstructions: a Possibilistic Approach. Technical Sketch at ACM Siggraph 2006, 160-160, Boston USA.

United Nations Educational, Scientific and Cultural Organization International Round Table (2011). *Intangible Cultural Heritage-Working definitions*, Piedmont, Italy