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A London Charter's Visualization: The Ancient Hellenistic-Roman Theatre in Paphos

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Abstract

The paper presents an attempt at reconstructing the architectural history of an ancient building taking into consideration the London Charter's principles. The case-study is the Hellenistic - Roman theatre of Paphos, Cyprus and the paper describes the main steps in its virtual reconstruction and how the charter's principles have been implemented.

Categories and Subject Descriptors (according to ACM CCS): I.3.5 [Computer Graphics]: Computational Geometry and Object Modeling—Hierarchy and geometric transformations I.3.7Three-Dimensional Graphics and Realism Virtual reality J.5 [Computer Applications]: Arts and Humanities—Architecture

1. Introduction

Three-dimensional digital reconstructions of Cultural Heritage (CH) assets became a common phenomenon in the last decade. However, most are generated by a computer-science driven approach to research, where topics such as improvement of realism, faster algorithms of rendering or new methods of reconstruction are their trigger, whereas the potential of 3D and Virtual Reconstruction (VR) as a research tool in CH studies is still in its infancy. On of the critics commonly expressed by the CH community is that 3D and VR are lacking scientific credibility and the existing tools for their creation have a limited applicability in the CH research domain. For such reasons, the London Charter (LC) [Lon06] has been defined ca. two years ago, setting up a set of principles which, if observed, will enable transparency of the 3D construction process and thus enhance its adoption as a valid CH research tool (see also [THE] [SLI]). Our article focuses precisely on this topic, i.e. the step-by-step virtual reconstruction process of a CH asset, considering the LC's principles.

2. Case Study

The chosen case study is the Hellenistic-Roman theatre of Paphos. It was constructed around 300 B.C by the Ptolemies of Alexandria and survived till the late 4th century AD where an earthquake has destroyed most of its structure [GS02]; in the following centuries to come the theatre was seriously looted [BGG04]. During its ca. 700 years of existence, the theatre's architecture continuously changed, according to variations in performance and styles [Bar10]. The Department of Archaeology of the University of Sydney has been excavating the site, under the auspices of the Department of Antiquities of the Republic of Cyprus since 1995 [USA]. The Science and Technology for Archaeology Research Center (STARC) of the Cyprus Institute have initiated a scientific collaboration with the archaeological team of the University of Sydney aiming at understanding how digital technologies can help for a more accurate documentation of the site and understanding its architectural history [STA] [ADA*10] [GDA*10]. The first step was to create a 3D digital model of the actual state of the theatre (Figure1), which was used as the starting point of the 3D reconstruction.

Figure 1: *The digital model represents the actual physical state of the theatre as it is at the present moment.*

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The consequent research questions were how to 3D represent the various phases in the theatre' life and what are their contribution to understanding its architectural history. It is essential to emphasize that the material used for these reconstructions originates in the archaeological material found at the excavations and not comparisons from other sites.

3. Aim and Objective of the project

The objectives of the project are: understand the architectural history of the site through a 3D and VR based analysis, investigate the applicability of the LC and create a community of practice (web based) where research in these topics is advanced and which will contain the entire raw and interpreted data used for further analytical analysis. Thus, the entire pipeline of research, from data collection to VR reconstruction and online publication is made available, and the 3D models can be scrutinized under scientific requirements at every step of their creation. Digital objects used in the reconstruction were semantically described; the reliability of geometry shape of each individual architectonic feature was mapped into a color-based system that was implemented in the 3D reconstruction and the entire project made accessible online.

4. Methodology

The workflow adopted follows the LC's principles: once aims were defined, the implementation strategy was designed according to the method for the reconstruction ("Implementation - LC 1", "Aims and Methods - LC2"); the scenario follows a complimentary structural methodology for the cohesion of the procedures.

4.1. "Research Sources - LC 3" and Findings

The research sources for the 3D reconstruction are:

- On-site recording (interviews, photographic material, cognitive scenery walkthrough/understanding space).
- Web-online information (audiovisual textual resources) [USA] [DID] [POM] [SLI] [DIA] [Con] [WHI] [THE].
- Scientific articles and publications regarding the excavations at the theatre [GS02] [BGG04] [Bar10] [Bar08] [BS04].
- Ancient theatre architecture books, journals and articles related to Hellenistic and Roman periods [Con98] [Rob69].
- Hand-written and digital architectural plans, sketches and notes created during 15 years of excavations.
- Study of related Digital Heritage projects such as the THEATRON [THE] and Second Life [SLI].
- 3D mesh obtained by the collaboration of STARC and the CH scientific communities (Figure 1) [STA].

Five distinct construction phases of the theatre were identified [BS04]. A preliminary XML based description of the various components used for modeling was created, describing the overall key structural components/elements that synthesize the architectural space of the theatre during its life span. In other words, a *components-per-total* database is implemented, based on theoretical "deconstruction" of the word "THEATRE". It has a hierarchical (cladistics) structure and is sub-divided starting from the "parent" component (THEATRE), into various levels of "children" or sub-children. This can be also understood as from the geometrical dimension of each component; the smaller the dimensions of a particular component that exists in its "parent" context, the lower the level in the hierarchy. All architectonic phases have the same "parent" but different "children" due to the evolution and metamorphosis of the theatre through time and space resulting its expansion and adaptation to a particular architectural style of that specific period of existence. In this case, a re-classification of the components is done in order to create *components-per-phase* XML databases and schematic diagram models of each of the periods, thus aiding as a foundation guide to the 3D reconstruction/modeling process.

A typical ancient THEATRE, independent of its period of existence, has three major "first order children" [WHI]: *Cavea*, *Orchestra* and *Stage*.

In our case, the THEATRE is divided in to seven orders/levels of sub-children; logically more orders can occur, with higher complexity, resulting a relative bigger error for the reliability of the visualization outcome; nonetheless revealing more architectural detail that makes it more pleasant to see but a potentially risky operation [HND05].

4.2. Practical Implementation - LC 4, 5 and 6

There are technological and CH barriers that are taken into consideration for conceptualizing the design specification, created based on findings, sources, and available tech-tools. The outcome of the actual digital implementation is shaped upon the last three LC principles: "documentation - LC 4", "sustainability - LC 5" and "access - LC 6". The starting point of the reconstruction is the three-dimensional creation of the components/primitives hierarchically documented into our XML components-per-phase database (LC 4.1, 4.2), semantically based on CIDOC-CRM and using the CARARE schema [CAR], of each architectonic feature (LC 5).

Each architectural phase was reconstructed/modeled manually using Autodesk 3Ds studio MAX design environment [MAX]. The reconstruction is for the time being only geometrical, without physical texture parameterization (Figure 2). A virtual check-matching process was applied by XYZ superimposing the 3D mesh of theatre on the reconstructed representation of the hypothetical model during the last phase of its existence. The tools available are Mesh Lab [MES] and 3Ds MAX (LC 4.6, 4.8). Superimposition will

show the missing parts of the theatre, such as the *Cavea* (Figure 3). Experimental color mapping, based on engineering metrology and a color grading system (Figure 4), was applied on each architectonic component, in order to visually separate and identify features with different levels of reliability (of their shape and characteristics) [NH04]. A reliability chart is computed for showing the total Index of Reliability for each of the phases(LC 4.4, 4.10)(Figure 5).

The following step was exporting to multi-resolution reliable and sustainable formats for easy access and correct translation through various 3D design/viewing applications with the characteristic of a platform independent model (PIM) (LC 4.11, 4.12 and 5). ISO formats such as: Collada [COL] and X3D [X3D] that have an XML-encoding nature [FLN10], and the Wavefront OBJ that compliments the others by offering a simple data-format of the 3D geometry. Considering interactivity, X3D is our choice for the virtual exploration of the ancient site by using the instant reality X3DOM (`http://www.x3dom.org`) framework, which is used by the 3D-Coform Project [3DC].

Next is the communication of the ancient theatre through a dynamic, user friendly, metadata aware and rich multimedia web-platform partly conforming to the technologies mentioned above(L.C 6). The initial prototype platform can be found at `http://www.3dpaphostheatre.cyi.ac.cy`.

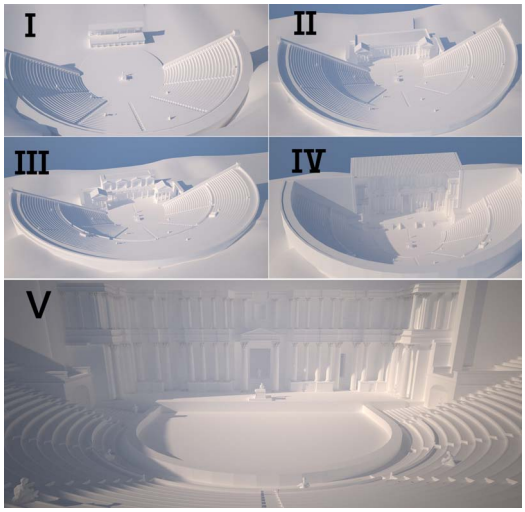

Figure 2: *Still image PBRT- rendering using LuxRender engine (Open Source) [Lux] of the final 3D reconstruction phases. The 5th and final phase of the theatre's stage is based on the architect's hypothetical 2D reconstruction architectural blueprints and notes [GS02].*

5. Evaluation of the Results

The article proposes a workflow for a history of architecture, archaeology and social history research based on 3D visualization. By creating relatively simple tools for "reading" the visual representation (e.g. changes in colour reflecting changes in reliability indices), XML schemas for describing metadata of primary sources and superimposition of real/hypothesized, researchers in Cultural Heritage are able to perform throughout research otherwise inaccessible with traditional tools. As such, new insights on the development of the ancient theatre and its role in the ancient Greek and Roman society are made available through the 3D visualization.

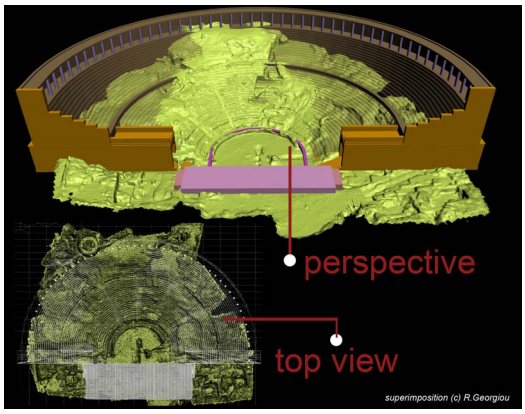

Figure 3: *Image showing the Cavea superimposition from a perspective and a top view angle.*

COMPONENT GRADING – THEATRE/CAVEA	YES – 0.66 RED 1.0.0 255.0.0	MAYBE – 0.33 GREEN 0.1.0 0.255.0	NO - 0 BLUE 0.0.1 0.0.255
Lower Cavea/ ANALEMMATA		✓	
Lower Cavea/ CUNEI	✓		
Lower Cavea/ Cunei/SEATING ROWS	✓		
Lower Cavea/ Cunei/ VOMITORIA			✓
Lower Cavea/ Cunei/ PROEDRIA			✓
Lower Cavea/ Cunei/ STAIRWAYS	✓		
DIAZOMA			✓
Upper Cavea/ANALEMMATA			✓
Upper Cavea/Cunei/SEATING ROWS			✓
Upper Cavea/Cunei/VOMITORIA			✓
Upper Cavea/STAIRWAYS			✓
Upper Cavea/PORTICUS			✓

Figure 4: *Color Grading procedure for the "Cavea"/ first-order child and the hypothetical components that might have synthesized its existence for phase number one.*

6. Conclusion and Future Works

The article described an attempt on the use of 3D visualization approach to understand the architectural history of an ancient theatre, create a digital platform for presenting together the entire production pipeline of research (raw data used during the analysis, interpretation of this data and its publication). This platform should help maintaining "alive" the scientific dialogue around the research on the ancient theatre of Paphos, by enabling new "features", such as architec-

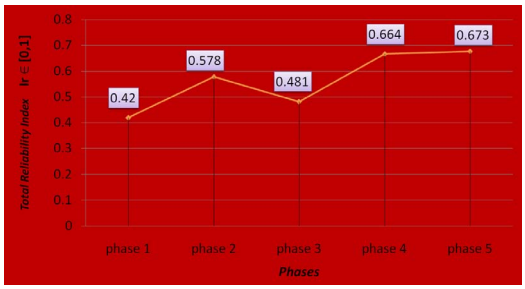

Figure 5: *Chart composition for showing the total Index of Reliability value of each of the simulated reconstructions. Based on the figure the most reliable is the fifth phase having a total value of 0.673 and the least the first phase having a total of 0.42.*

tonic components, updated reliability indices etc. Moreover, it is planned to publish the entire workflow and its components online. The entire process was based on the LC principles, which should guide researchers when dealing with 3D visualization in Cultural Heritage research. Each step of the research was related to the relevant principle of the LC. The article presented a practical solution to the challenge of implementing the LC into research exercises.

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