Technology as Means to Recreate Cultural Heritage: An assessment of some current Portuguese projects

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Abstract: This article aims to introduce a number of technological topics, applied to the valuing of several cultural heritage structures in Portugal, that may be used in the context of issues such as conserving, presenting and communicating cultural heritage to the general public. These attend important aspects such as the modeling technique (manual or procedural), the cost (with the support of efficient and low-cost tools), lighting considerations (the use of accurate illumination of the space) and the use of different dissemination approaches (using *in-situ* approaches or the internet for collaborative purposes or to increase the target audience). Most of the results, presented mainly through the means of virtual models, are available in several museums showing their advantages in the interpretation of our national history and providing new ways for visitants to exploit our heritage.

Key-Words: Cultural heritage, Tourism, Procedural modeling, Virtual reality, Augmented reality, WebGL

1 Introduction

The last years have confirmed an increasing concern, mainly of great institutions such as UNESCO or the European Union (EU), with the preservation, interpretation and spreading of the historical and cultural legacy of our ancestors. That is a fact since EU proposed 2018 as the "European Year of Cultural Heritage". Considering that most tourists which travel to our country visit heritage sites, this area is of the upmost importance. Indeed, tourism represents an increasingly important role in the economy of the country, where have been annual increases in the number of tourists in the latest year. These indicators make tourism a strategic sector for the Portuguese economy. An example of this is the more than 20 million guests registered by hotel establishments in 2017 [1].

For these reasons it is important to present and communicate cultural heritage in several ways which may enrich the experience of visitants. This is the aim of this article, regarding to technological

answers, which presents several approaches collected through the work being realized in the past years, by the authors in a collaborative approach together with heritage experts. These are on display in several museums and are all related to Portugal's heritage sites.

2 Portugal's heritage

Portugal is an historically rich country like most of Europe, but unlike the rest of the continent, benefits from the fact that there have been no military operations in its territory since the early 19th c.; the destruction that so many wars have ravaged elsewhere did not occur here.

On the other hand, limited economic development during most of the 20th c. helped preserve landscapes, monuments and historical centers. The country registers more than 3500 sites and/or buildings registered as National Monuments or Sites of Public Interest, which means an average of one such place every 26 sq. km (other figures of legal protection could be mentioned, which would densify the distribution even further).

National heritage includes landscapes, buildings, monuments and sites of all periods and natures, and amongst them Archaeology plays a relevant role, either through the discovery of some of them or on the explanation of the historical evolution of other categories. It also plays an important role in the practice of the present authors, namely through the projects here assessed.

Archaeological heritage is important for the matter at hand for two different but concurring reasons [2]: i) archaeological sites and monuments have a strikingly widespread distribution even in areas where other kinds of built heritage is scarce; ii) archaeology more acutely needs interpretation and explanation to the general public; most of the projects surveyed here hence are of great importance to educational and recreational purposes.

Making available to the general audience(s) who visit or wish to visit Portugal's heritage credible reconstructions of the ancient sites and monuments is a complex task, that involves inventorying and studying the remains, selecting those that can in fact be turned into interesting places to visit, either by the general tourist or by the education sector audience [3], and developing the better tools available for the scientific knowledge to be offered to the public.

3 Modeling

The (virtual) recreation of any heritage site, requires the reconstruction of its geometry in order to achieve an accurate architectural model. In this domain, there are two main approaches: manual modeling and procedural modeling.

3.1 Manual modeling

This is the most common procedure, where the developer, uses authoring tools such as 3DS Max [4], Maya [5] or Blender [6], and generally with the supervision of heritage experts [7]. The main benefit of this working methodology is the production of highly detailed virtual models. In figures 1, 2 and 3 there are some examples of structures developed using this methodology: The House of Cantaber located in the ancient Roman city of Conimbriga [8] (figures 1 and 2) and the recreation of the Roman Villa of Collippo in Batalha (figure 3), available in the internationally awarded Museum of Batalha [9].

Fig. 1: House of Cantaber nowadays

Fig. 2: House of Cantaber virtually recreated [10]

Fig. 3: A glimpse of the Collippo Roman forum

The manual modeling, albeit being time-consuming, allows total freedom in the creating process, facilitating the integration of any desirable feature to the virtual creations and is the best way to introduce features observed by archeologists and architects.

3.2 Procedural modeling

Despite the potential of manual modeling, this methodology is, inevitably, associated with high costs (either in software, when free-source software isn't used, or in human resources), long-winded processes and obstacles regarding the online availability to specific audiences. Manual modeling is also impossible to use in cases where current knowledge is incomplete (as it happens with so many places) but where a general idea has to be provided for the audience.

As a solution to this problem, procedural modeling appears as an answer. Knowing architectural heritage rules (using, for example, Vitruvius' "De architectura" [11] for Roman structures) and coding these rules into an algorithmic grammar, procedural modeling is able to automatically generate 2D or 3D content in just a few seconds.

Figure 4 depicts the House of the Skeletons of Conimbriga manually recreated for an online representation (bit.ly/houseoftheskeletons), whereas figure 5, presents a virtual reconstruction of the same historical house achieved through the means of a grammar. As we can perceive, they are almost identical, even though their different creation process – one was manually modeled while the other was procedurally constructed through means of a grammar.
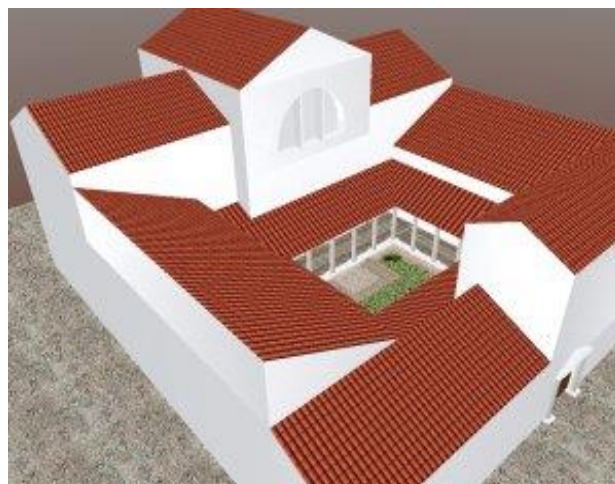

Fig. 4: House of the Skeletons manually developed [12]

Fig. 5: House of the Skeletons procedurally created [10]

Another example of this working methodology can be found in figure 6. This figure, presents an essay of part of the Roman city of Conimbriga, where only three structures (identified by the arrows) where manually modeled (The Flavian Forum, the House of Cantaber and the House of the Apsidal Medianum), while the remaining were procedurally generated. Apart of minor architectural errors detected, this virtual model was validated by several experts in Roman architecture, which, in their opinion, evidence that this procedure is suitable for the recreation of other historical civilizations.

Fig. 6: An essay of Conimbriga using both manual and procedural modeling. The black arrows indicate the manual models. All the remaining structures were generated procedurally.

3.3 Artifacts

To represent a big architectural building, it is not strictly necessary to have interior artifacts, nevertheless these are of great value to improve the virtual experience by given a sense of human presence, enriching the scenario to better recreate the ancient living space.

It is also possible to provide a cheap expeditious approach to develop different artifacts originally used by natives, where a Microsoft Kinect [13] can act as a 3D scanner. This low-cost laser scanning equipment is perfectly suitable to rapidly get a 3D model of an object (figures 7 and 8). This allows automatic creation of the corresponding 3D models, which may then be exported to a common format and easily edited in a 3D authoring tool (such as the ones mentioned in section 3.1). These objects may be used both in manual modeled structures as well as in the procedural generated structures.
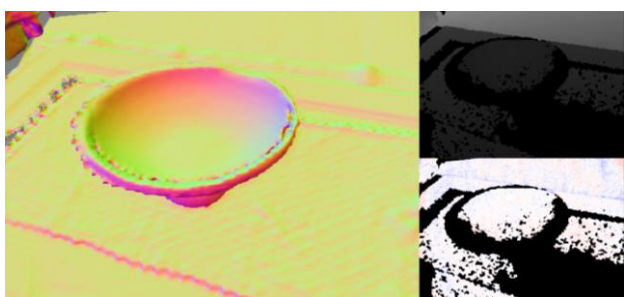

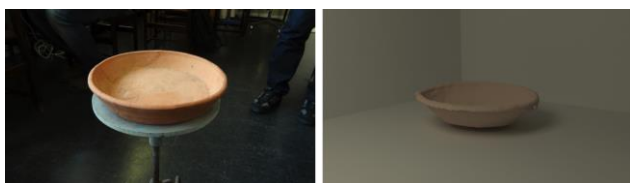Fig. 7: Scanning results of a plate with the Kinect [14]

Fig. 8: A Roman plate: real plate on the left and the virtual replica on the right obtained with a Kinect [14]

4 Illumination

In these last years, the number of projects involving historical reconstruction has increased significantly. The use of recent technologies has become a powerful tool to archaeologists for a better understanding of our cultural heritage legacy and thereby to attain a glimpse of the environments in which our ancestors lived. However, to accomplish such purpose, these reconstructions should be presented to us as they were really perceived by a local inhabitant, according to the illumination and the materials used back then. This item is sometimes neglected in favor of more appealing renderings [15].

Up to the 18th century only two types of illumination were used by Man: natural light (sun, moonlight) and a more artificial one using fire/flame (hearths, lamps, candles, torches, etc.) [16, 17]. Consequently, in the absence of natural light, flame light, and no other illumination method, should be used for relighting past historical scenarios, since they produce significantly different visual results. At this stage, it is clear that the way we see such reconstructed environments can be extremely important to establish a correct interpretation of that particular historical setting [18].

Figure 9 presents a room (known as the "Hunting room" due to a hunting scene portrayed in the floor mosaic) in a typical opulent Roman *Domus*, the House of the Fountains in Conimbriga. On the left we can observe the entrance of the ruined room (only the floor mosaic remains intact, whereas the wall frescoes are very degraded). On the right a laborious, yet a nowadays common virtual reconstruction, is shown, where the scenario is usually illuminated by sunlight or electric light. In fact, this digital recreated image presents a scenario (at least in the floor mosaic) very similar to what visitors of this archaeological space perceive nowadays.

Fig. 9: Left: The actual entrance of the Hunting room of the House of the Fountains. Right: A virtual recreation of the room using electrical light

To create a foresight of the visual scenario of an inhabitant of this house in that period, a physical replica of a *lucerna* found during the excavations in

Conimbriga was used in order to virtually replicate this very particular low intensity light in the virtual model. To keep the spectral properties as close as possible to the original light all, materials were gathered very thoroughly:

- The *lucerna* was manufactured in clay, like the original ones;
- As fuel it was utilized olive oil, since it was the most utilized fuel in Roman lamps. Pure olive oil (without any kind of additives) from olives from the region of Conimbriga was used in the experiments;
- Since salt was frequently added to the fuel for example, to increase the intensity of the flame, clear pure salt was obtained directly from salt mines;
- Finally, due to its importance on the quality and physical attributes of the flame, also the wick was carefully obtained, and wicks made from cotton and linen were utilized.

After a process of digital conversion of the spectral properties of the light irradiated by this flame, figure 10 illustrates a scientific possible visual scenario of the "Hunting room" in the eyes of a 1st century local Roman inhabitant.

Fig. 10: The "Hunting room" illuminated by Roman light

As stated earlier, relighting our ancient relics as close as possible to the period in question, can bring new and more accurate interpretations of that cultural heritage scenario. This can be observed in figure 11: notice that the circumferences viewed in the mosaic floor are perceived in light brown when one utilized electric light to illuminate the room, and the exact same circumferences are noticed as light red when the method to illuminate the room is the Roman *lucerna* [19, 20].

Fig. 11: A closeup to the mosaic and frescoes of the "Hunting room". Left: Illuminated by Roman light. Right: Illuminated by electric light

5 Dissemination

The purpose of all these recreations is the dissemination to actual and future generations of the past legacy that mold us to what we are now as human beings and as a society. Therefore, the dissemination method is of upmost importance to reach each specific target audience.

5.1 *In-situ* Recreations

One of the levers of tourism is the ability to attract tourists to a specific heritage site, museum or an iconic ancient structure. Therefore, it is studied and proved that disposing, locally, this kind of virtual reconstructions in strategic spots, has the potential to prize visitor's experiences enhancing their satisfaction levels [21].

Some examples that can be stated are, for example: the video which reports the construction of the UNESCO World Heritage Site Monastery of Batalha (figure 12) [22], available on the Batalha Museum; the recreation of the life in a Lower Paleolithic pre-historic camp, "Casal do Azemel" in the aforementioned museum (figure 13); and the recreation of the world famous dinosaur footprints from 175 million years ago in the Pangea which is now the center of Portugal (figure 14), presented in one of the exhibits in "The Alviela Science Center – Carsoscópio" [23]. For a more immersive sense, the spectators of this video in Carsoscópio are settled in a 16-seat hydraulic moving platform.

Fig. 12: The virtual reconstruction of the Monastery of Batalha

Fig. 13: The recreation of the Paleolithic camp "Casal do Azemel"

Fig. 14: The dinosaur footprints in Carsoscópio

Gradually, the use of augmented reality (the combination of real with virtual content) strategies to present cultural heritage structures is emerging in museums or archaeological sites around the world. One such example is the DinofelisAR application [24], which positions the (virtual) Flavian Forum of Conimbriga accordingly with the real scenario of the ruined site (figure 15). This application has other interesting feature since it uses a handy mobile device, such as a smartphone, to conduct the experiment, becoming possible to be within the real ruins and explore 360-degree view of the virtual reconstruction. This makes it suitable for any visitor/tourist of this archaeologic site, since generally visitors have these equipment's. At this stage, this project is evolving to the use of other senses (audition and smell) to provide a more immersive and accurate sensation to its users.

Fig. 15: Left: Facing the ruined temple of the Flavian Forum of Conimbriga. Right: The DinofelisAR application combine the virtual replica of the Forum with remaining (real) scenario

5.2   Internet

Engaging these kinds of contents over the web requires extra care since these, usually, involve the usage of numerous computational resources of the machine and the network. Thus, in this case, during the modeling phase, issues related to optimization are of upmost importance.

As an example of this methodology one could mention an older reconstruction of the Flavian Forum of Conimbriga (figure 16) [12], available at bit.ly/forumconimbriga, or the reconstruction of the House of the Skeletons mentioned in section 3.2 (figure 4). One important aspect to mention is that, to visualize and interact with the virtual recreations, both require the installation of a specific plugin in the computer.

Fig. 16: The online available virtual reconstruction of the Flavian Forum of Conimbriga [10]

Notwithstanding, more recent technologies such as HTML5 and WebGL, which allows a browser to take advantage of the GPU capabilities and represent interactive 3D virtual models without the need to install additional plugins, are becoming more adequate to be used in a cultural heritage recreation procedure.

In a first attempt to take advantage of this new HTML feature it was recreated the exterior of the House of the Trident and the Sword in Conimbriga (figure 17), available at bit.ly/CasaTridenteEspada [14]
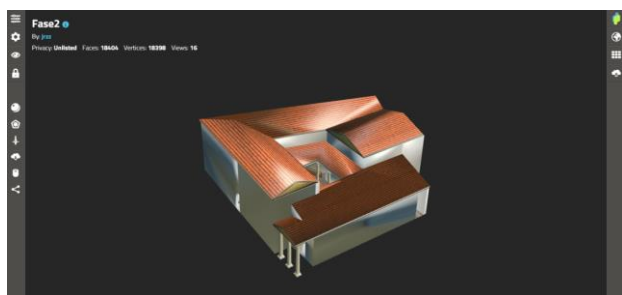

Fig. 17: A WebGL reconstruction of the House of the Trident and the Sword in Conimbriga

The use of this technology was deepened to create a full reconstruction of the Leiria Castle (castle, surrounding buildings and exterior walls), available at bit.ly/casteloleiria [25] (only Portuguese version available at the moment) as perceived in figure 18. Other interesting feature of this model is the fact that it recreates the environment (vegetation, lighting conditions) according to the time and period of the year in which the user is making its visit. Moreover, it has the addition of audio with the sounds of the birds that usually inhabit the castle surroundings in that exact visiting period. This audio is positional, meaning that, as the users approaches to the birds, the sound becomes more intense and vanishes as the user goes away.

All these features contribute to give the 3D model a dynamic feature to the virtual tour and making each experience unique.
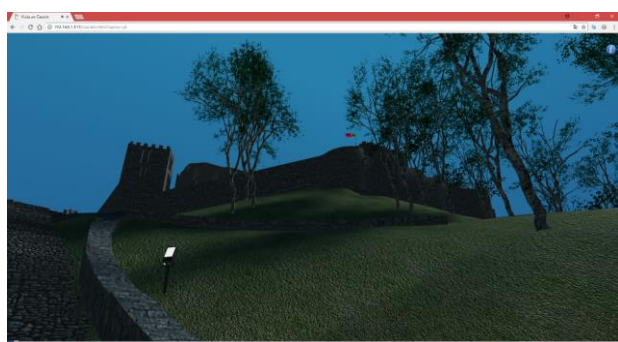

Fig. 18: An image of the WebGL guided tour to the Leiria Castle

At the moment, an early stage of a collaboration with an international team, in order to develop the first virtual recreations of some houses in the quite recent excavated Roman town of Miróbriga (figure 19), is in progress [26]. The interest in this Roman town is, according to the experts, the peculiar houses' architecture from this site.

Fig. 19: The ruins of Miróbriga nowadays

6 Conclusion

Since the Renaissance, at least, the questions related to the historical and cultural past, namely archaeological findings, have exerted an enormous and mysterious allure on Man. Ever since then, Man has come up with methods and forms to recreate such places, in order to satisfy this recognized natural and ancestral curiosity associated to the human being.

Therefore, a large amount of available technological solutions may be considered to deploy and, therefore, identifying the options available, is important to address. This article presented some of these solutions that should be considered when forecasting new implementations for heritage spaces. Nevertheless, in order to select suitable and good solutions, a set of requirements and goals for each situation is important to ascertain to end of selecting the most appropriate ones.

In these last decades the use of technologies, such as Virtual and Augmented Reality, had a larger role towards a better comprehension of our cultural heritage legacy. The usage of the referred technological solutions among this article, come forward as solutions and facilitating conditions to enhance their experiences in cultural heritage spaces becoming an important stimulus to attract and satisfy their visits. The interest expressed by institutions and heritage experts ascertain that technological approaches still have a target to plan, improve and enrich a wide range of cultural spaces all over the Portuguese country.

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