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Virtual Archaeology in Second Life and OpenSimulator

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Abstract

Traditional approaches to virtual archaeology include dealing with research methods to capture information from heritage sites, creating models out of that information and how to present them to the public; these are intense technical procedures which might be too costly for some types of history or heritage-based projects. Virtual worlds allowed new types of models of/for heritage sites to be produced and disseminated at a fraction of the cost.

Second Life®, and its open source counterpart, OpenSimulator, are virtual world platforms with user-generated content. 3D models are created in real time and instantly rendered for all visitors. This allows amateurs and researchers create their own virtual archaeology projects easily and with few costs, and to have the resulting models immediately available to a vast community of users. This article presents an overview of four different approaches to virtual archaeology projects that are present in these platforms and that have been publicly discussed and analyzed; in particular, the last type shows a novel approach to virtual archaeology which is not found in other platforms, and explains how researchers have managed to extend the concept to new areas and develop methodologies to incorporate the validation of historical accuracy to encompass these areas.

1. Introduction

Virtual archaeology is a blend of techniques and methods employed by historians and archaeologists using computer models for visualising cultural artefacts and heritage sites. Traditional models emphasized the focus on realism and accuracy, as well as on haptic interfaces or complex "virtual rooms" to fully immerse a visitor into a 3D reconstruction of an historical site (Frisher, Niccolucci, Ryan, & Barceló, 2002). The advance in photo-realism techniques also allowed the movie industry to rely more and more on computer-generated models instead of building costly scenarios. Gonçalves et al. (2013) go as far as to use detailed flame light analysis and simulation methods and high dynamic range technology to try and convey a most accurate representation of historical settings. And many other such initiatives exist. However, first-generation virtual archaeology projects tended to give more importance to the technical solution than to the historical accuracy of the virtual reconstruction. Methodologies like the London Charter (Beacham, 2006) proposed to create a set of rules and definitions to allow historians and archaeologists to lead the virtual archaeology projects, validate their decisions with adequate documentation, and delegate the technical aspects to a team of developers (modellers and programmers), while keeping the lead of the project. Validating the accuracy of archaeological reconstructions became a fundamental aspect of virtual archaeology projects, more even than the focus on realism or immersion using haptic devices (Ryan, 2001). Frisher (2010) extensively uses this kind of methodology for the *Rome Reborn* project, which used distribution of a low-polygon model through the popular Google Earth service, and which is considered to be historically very accurate.

With this change, new questions were raised about the use of such virtual archaeology projects and how they could be disseminated to a wider audience. Again, traditionally, they were used either for special installations in museums (which, due to the technology involved, could become very expensive) or to film documentaries. While static pictures could certainly convey the findings of a virtual archaeology project — published via the Web or on journals — the element of immersion and interaction with the historical site was not so successfully captured that way.

At the same time, as the capabilities of personal computers continued to advance, putting high-end graphic cards in the hands of everyday users, 3D virtual worlds started to become common, and quickly were put to educational use. Virtual worlds, where users are represented by avatars, allow interaction between users and the environment, and are thus appropriate for simulating environments in real time, and their use in virtual archaeology soon became apparent.

Among the many virtual world platforms, a new class has emerged by the turn of the millennium: virtual worlds with user-generated content. In these environments, there is no separation between the design/modelling/programming stages and the visualisation itself. 3D models are created in real time and immediately available to all users in the same location. There is no need for rendering scenes in advance — a process that might take a long time with several iterations until historians and archaeologists agree with the results produced by the technical teams. Instead, the historians or archaeologists can, by themselves, quickly create the models, and present them to an audience, or discuss it with colleagues by logging in to the same area in a virtual world where the virtual site is being built.

Second Life® (SL), a virtual world created and maintained by the Californian company Linden Lab, opened to the public in June 2003 with this new paradigm in mind. It is a virtual world platform

with user-generated content, where content is persistently stored at Linden Lab's servers. It features visual contiguity (there is just "one" world, shared by millions of users, in a single landscape) and a very complex system of permissions, allowing content to be shared or sold (which, in turn, led to a very rich economy of digital content sales). Its open-source counterpart, OpenSimulator, is based on the reverse-engineering efforts of a team of independent developers who have documented the communications protocol between the Second Life viewer software (which was released by Linden Lab as a free and open source application, thus allowed several independent developers to contribute code to it and spawn their own variants with extra features) and the simulator servers running the virtual world. Both technologies use exactly the same viewer and present 3D content in precisely the same way. The difference is that OpenSimulator is a free and open source server-side application which can be installed on any computer to run a personal virtual world; Linden Lab's simulation software is proprietary and is used to run the Second Life Grid®, where, for a monthly fee, users can lease simulators for their personal use to store persistent content (the actual access to the Second Life Grid is free). OpenSimulator-based grids are run by independent commercial operators, campus networks, or individuals, and are not interconnected with the Second Life Grid.

Since the Second Life viewer includes building and programming tools, designed with amateurs in mind (and not professional 3D modellers or application developers), it is considerably easier to create content on the Second Life Grid than on professional 3D modelling tools (like Blender, Maya, 3Ds Max, among others), even for a non-expert. Additional content can obviously be outsourced to professional modellers or, even better, can be bought from other users, in what amounts to one of the world's largest marketplace for 3D digital content, worth about half a billion Euros annually of sales of digital content. Coding is traditional, but the inclusion of scripts into objects can be done by simple drag-and-drop, and many scripts for various purposes are readily available online for end users to employ. For the researcher, this means that a lot of content is already available; additional content can be either created by themselves or cheaply outsourced to any of the vast amount of content creators in Second Life; and that content is immediately deployed and available in real-time. Researchers can meet in the virtual world to critically analyze the historical accuracy of the models thus created and immediately make the appropriate changes. And, of course, historical sites created in Second Life are instantly available to several millions of potential visitors, thus becoming a very powerful distribution method.

In the published literature that was reviewed, four distinct models of virtual archaeology in Second Life have emerged, of which the latter two will be more thoroughly reviewed. The first two are interesting for further study outside the fields of archaeology, history, and computer science, but they are nevertheless included for the sake of completeness.

2. Second Life "Cyber-Archaeology"

Harrison (2009) discusses how communities in virtual worlds create their own myths, and, based on those, virtual architecture, as being part of the "creation myth", become heritage sites, visited and preserved by the user community as a reference of their commonly held past. The approach is very interesting and follows Boellstorff's seminal work on ethnography in Second Life (Boellstorff, 2008), a book written as a result of several years of studying the Second Life communities from the perspective of an anthropologist. While Boellstorff is more interested in describing aspects of how the communities in Second Life are born, evolve, are tied to a certain virtual location, and create their own myths, Harrison discusses one of the embodiments of those myths — the virtual architecture of "past ages" that

remains in the virtual world for several years because they are reference points for the community. Harrison concludes that the models for selecting and preserving certain virtual buildings in Second Life closely mirror the same process that happens in real life. Thus, certain buildings like the Governor Mansion in the Clementina region, allegedly one of the oldest buildings still existing in Second Life, was ported over from the early alpha testing days of the virtual world platform, when it was built by its oldest user, Steller Sunshine, in July 2002 ("Governors' Mansion," 2006). Like real archaeological sites, the building includes subsequent plaques of information telling the history of the building, showing the extension of the virtual world at the time it was built, and explaining why it was felt to be important to preserve it. Other locations in Second Life, instead of preserving actual buildings or other types of content, are set up as virtual museums, where visitors can see pictures of earlier versions of Second Life, like the "Unauthorized history of Second Life museum"; societies for the historical preservation of content and history of communities are popular, and these produce websites, blogs, or wikis to document the "historical past" of Second Life and its communities.

Harrison argues about this type of virtual archaeology: "[...] that the role of cyber-archaeology is not only to study the 'actual' technologies employed by virtual communities, but also the virtual objects they create within cyber-space [...]"

This leads to a very specific type of virtual archaeology where there is no reconstruction of the historical past using virtual world technologies; instead, virtual buildings, with no physical counterpart, which have been used by an online community in their past, are preserved by the community as part of its own myths.

3. Amateur Virtual Archaeology

While Second Life includes several academic projects in the area of virtual archaeology, which follow methodologies employed by historians and archaeologists to establish historical accuracy, Second Life users have been very prolific in creating their own models of the historical past without any method or structure and caring little about historical accuracy. They are "amateur virtual archaeologists", getting inspiration from either real heritage sites, or images popularised by the entertainment industry, namely from movies, TV series, or computer games. Graham (2007) documents some of those sites in Second Life. At the time of publication, Graham found that the amount of amateur virtual archaeology sites in Second Life were by far more dominant than sites created by historians, archaeologists, or academic researchers; this might still be the case, in spite of the reasonably large amount of new academic projects created in Second Life since 2007. Victorian scenarios (with its popular "steampunk" counterpart), medieval reconstructions, or recreating the environment of the Roman Republic and Empire are popular. Most have a specific goal beyond merely visually depicting 3D models of a past (which might just be an imagined past and not a historically accurate one): in many cases, the environment leads to a community interested in a certain aspect of the past depicted by the buildings, and they adopt — using role-playing mechanisms — the costumes, mannerisms, and even the types of events typical of the period. One of the best examples is possibly Caledon, which is set in a mythical Victorian age where steam-based technology has evolved far more than in our own real historical past, and where the cities are laid out according to Victorian preferences and exhibit the kind of buildings typically found in Britain during the late 19th century ("The Caledon Wiki: Archives of the Independent State of Caledon in SecondLife," n.d.). Second Life users inhabiting the region of Caledon lease land for their own leisure, and are expected to behave according a certain etiquette loosely inspired in Victorian morality and code of

conduct. Additional buildings have to be "in theme", meaning that no buildings that do not conform to a Victorian look and feel can be added.

Not all areas depicting buildings of the past are role-playing areas. The Confederation of Democratic Simulators (CDS), for example, aggregates two different themes — Bavarian/Alpine Medieval, and Ancient Rome/Greece — but does not mandate any code of conduct or ethical behavior related to the "theme" ("Confederation of Democratic Simulators (CDS) Portal, a real community in the virtual world of Second Life," n.d.). Instead, the themes have been selected using a democratic process, and teams of volunteers have done their best to reproduce imagined cities using Bavarian/Alpine medieval architecture or ancient Roman/Greek (depending on the location). While the scenarios are inspired by existing archaeological sites, they are not faithful reproductions and do not pretend to be faithful. Nevertheless, it is interesting to mention that in this case, some users with a background in architecture and history have given classes to the volunteers about specific aspects of Roman architecture, thus ensuring a minimal amount of historical accuracy. New projects to be implemented in the CDS require some background research by the teams proposing the project before putting the project to vote by the community; the CDS raises funding for additional projects by leasing parcels of terrain to its users, and, not unlike real grant projects, a certain amount of work is required until a new project (or even a completely new theme) is approved. An elected committee also validates the accuracy of the buildings created by volunteers (or subsequent users who lease terrain and contribute with more buildings) to make sure they keep "in theme", but this validation does not follow any academic methodology.

These and similar projects should be considered, at best, as hard-working amateur attempts at recreating historical sites, or at least sites inspired by real architecture of the historical past. The interesting aspect is that in these cases the purpose of building the reconstructions is to allow a community to "live" in them. Unlike a museum exhibit, or a 3D reconstruction created specifically for a documentary, these amateur virtual archaeology sites, in spite of its flaws and limited accuracy, have the purpose of encouraging interaction between users and letting them participate in the process of creative depiction of historical sites. This, as we will see, is not always the case with most academic projects that have been found so far in Second Life.

4. The Virtual Museum of Archaeology

Exhibits of heritage sites are costly to create and maintain, either on the heritage sites themselves or in real museums. Very early uses of the World-Wide Web included "online catalogues" of museums, where images of real museums were posted on the Web (the Louvre was a pioneer in this area[1]) and visitors could easily "visit" an exhibition, comfortably sitting behind their computers at home, and not requiring anything more than a computer connection. Images, however, just convey one kind of visual experience; and the experience is solitary, without interaction. It is the equivalent to buying a paper catalogue of a museum's exhibit and going through its pages at home; the difference being that far more images can be added for comparatively very low distribution costs, and these can be updated dynamically from a central database, unlike a paper catalogue, which has to be published and shipped to each interested party every time an exhibition is changed. Multimedia elements like movies, sounds, or

[1] For short descriptions of the "Second Louvre", see (Oberlander, Karakatsiotis, Isard, & Androutsopoulos, 2008; Urban, Marty, & Twidale, 2007)

slideshow presentations can also be part of the experience, which would be impossible to replicate on a book; hypertext also allows references and additional information to be presented in a format impossible to replicate on a conventional book. Thus, "digital museums" have some advantages over the traditional paper catalogue, but visitors miss the rich experience of interacting with guides and other visitors.

Virtual worlds like Second Life extend the concept of remotely visiting a museum by allowing both guides and visitors to interact with each other; also, all media available on Web pages can be included in the virtual museum. Additionally, exhibitions can include 3D replicas of real artefacts, and not merely 2D images (or movies) of them. They can be made to scale, allowing visitors to have an idea on how they looked like in reality; real museums, by contrast, are limited to the building dimensions to fit those artefacts inside. Thus, while a vase or some Roman coins can be exhibited in most museums, a full replica of the Parthenon (or even of the Giza pyramids!) is not so easy — museums will need to scale down the replica in order to allow visitors to experience 3D models of them. Second Life has little such restrictions; replicas can be made at almost any scale.

On top of that, Second Life can be fully programmed by the curator of a virtual museum; this allows the exhibit to be highly interactive. For example, the *Portus II* project has established a small museum area in Second Life showing its results (Keay et al., 2009). This follows a common layout for a museum, but with a twist: a 3D "miniature model" is reproduced interactively, and visitors can click on buttons to change the era to be displayed, and the 3D model will be created for that specific era. While a similar approach could be used in a real museum with, for example, a computer running a Flash application uncovering image layers depending on the visitor's selection, in Second Life the user gets the impression that the whole 3D model is being specially created out of thin air for them.

Virtual museums are relatively easy to set up in Second Life and new ones are constantly springing into existence and are often short-lived, as is mentioned by Urban et al. (2007). These authors, writing in 2007, summarised that most still employed a 19th century approach for museums, being basically images hung on walls and defining a path for visitors to follow; a short visit to a few museums (a few of which are still in existence) showed that, in general, the approach is still the same. Kuhr, writing on her blog (Kuhr, 2010), reports her impressions about a series of museums and similar exhibition places that she found in Second Life:

- *"Sims[2] that were almost entirely empty. When I went to Non Profit Commons, there were a couple of greeters[3] there — really nice friendly people, ready to help with answering any questions. But few or no visitors.*
- *The usual sort of visual communication techniques and design choices that make most SL exhibits and museums so terribly ineffective — panels and text on walls, objects to click on to get notecards, etc.*
    - *"Environments that did little more than replicate real life educational spaces and exhibits."*

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[2] Abbreviation of *simulators* popularly used in colloquial writing and refers to a region in Second Life. All regions have the same size, 256 x 256m.

[3] Users who spend their time (normally as volunteers) helping other users. In this context, "greeters" are human guides to a museum or exhibit.

Some museums are not merely static displays of artefacts and architecture. The International Spaceflight Museum in Second Life, for instance, routinely hosted events discussing spaceflight, astronomy, astrophysics, or cosmology, usually by inviting researchers in the field to create an avatar and present lectures, which used to be well-attended ("International Spaceflight Museum," 2007). The remaining exhibits, besides displaying models of several spaceships over the decades, also include visual and interactive displays of technological artefacts, like the Hubble Telescope.

Some attempts have been made to extend the concept of the virtual museum; for example, González-Tennant (2010) reports his experiences with the Rosewood, Florida museum in Second Life, where he also encountered the limitations of merely replicating the "museum experience" in Second Life. To make the exhibit more interesting, he suggests (as an example) that the virtual museum curators engage in "digital storytelling": using digital media to tell personal and/or group stories. These can be presented to audiences in Second Life itself; the "museum" acts both as a provider of digital content and as an audience room where lectures, using digital material from the virtual museum itself, can be made in front of an audience of visitors. Other museums follow similar approaches, not unlike real museums, where special events attract visitors to an exhibition (Gaitanou & Tsoubrakakou, 2008).

While no solid conclusions can be made from individual opinions, and some searches did not uncover any published report on the success of museum exhibits in Second Life, informal conversations tend to convey the same impression: virtual museums, like their real counterparts, may not be particularly appealing (Styliani, Fotis, Kostas, & Petros, 2009). Nevertheless, a few polls showed that in the past users were more willing to visit museums in virtual environments than in real life (Loomis & Elias, 2003; Rothfarb & Doherty, 2007) or that visiting the virtual museum lead them to be more willing to visit their real counterpart (Marty, 2007). Anecdotal stories related to the first author over the years, during his exploration of Second Life museums and meeting with virtual curators and visitors, relate similar experiences, lending some support to the idea that the degree of anonymity which is possible in Second Life tends to facilitate certain immersive experiences that users would otherwise never engage in real life (in this case, visiting museums); a discussion of the reasons for that behavior is beyond the scope of this article, but can be found on Boellstorff's work (2008).

5. Interactive Virtual Archaeology

The last type of virtual archaeology in Second Life is considerably more elaborate and generally more interesting. Instead of replicating the "museum experience", researchers have tried to reconstruct historical sites in Second Life, and take advantage of its unique medium. In contrast to reconstructions using 3D models, as said, users in Second Life can interact with the environment and with each other: Ferreira (2012) argues that "immersion occurs through engagement with other users and with territory, and is achieved when residents are able to interact in a dynamic and memorable way with and within the digital settings". As we will also see, on these projects, researchers can even talk directly to their visitors while the exhibit is being built; researchers can be simultaneously present in the same virtual environment, discuss with their colleagues the accuracy of the model, and change it in real time.

One well-researched project is the replica of Çatalhöyük, a Neolithic tell site located in Turkey, which was first modelled using traditional 3D tools and later created from scratch in Second Life (Morgan, 2009). Morgan describes in detail the experience of leading a virtual reconstruction project where archaeologists — not professional 3D modellers nor software engineers — do all the building tasks. She praises Second Life's relative ease of use for amateur modellers (even though she points out

the many limitations of the technology), and how archaeologists, used to de-construct historical sites in its component parts, have now the opportunity to put the pieces together again inside the virtual environment of Second Life, and do that interactively, piece by piece, like assembling a giant puzzle. This process led to asking a lot of questions about the actual concepts that historians and archaeologists have always assumed about Çatalhöyük since the first excavations started in the 1960s. New hypotheses, formulated during the modelling phase, were quickly put to the test and rejected or confirmed; even small details, like the way the Second Life sun moved across the reconstruction and illuminated certain areas, or put them into deep shadow, revealed new concepts about how the historical site must have looked like, or what uses certain areas would have needed to have in order to make sense in the overall complex. Morgan's work, full of enthusiasm, pretty much describes a new tool for archaeologists and historians: a laboratory, where hypothesis can be put to test and visually confirmed by having avatars interacting with the reconstructed space. A lot of information can thus by validated or rejected that way, very quickly. Frisher reports similar experiences (Frisher, 2010), even though, in the *Rome Reborn* project, historians and archaeologists had to formulate the questions first, ask the modellers and technicians to implement them, and visualize the final rendering to evaluate the correctness of the hypothesis. Thus the need for historians and archaeologists to experiment with 3D models in order to visually validate their hypothesis is very valuable. The difference is that, in Second Life, there is no "delay" — researchers can immediately put their hypothesis to the test by shuffling buildings around in real time.

This was certainly also the case with the *City and Spectacle: A Vision of Pre-Earthquake Lisbon* project (Câmara, Pimentel, Murteira, & Rodrigues, 2009). Developed by the Portuguese Centre for Art History and Artistic research (CHAIA, U. Évora), this is an ambitious project, originally developed in Second Life but now running on a private OpenSimulator grid. It aims to recreate most of the city of Lisbon just before the earthquake of November 1, 1755. The Baroque Lisbon of the 1750s completely disappeared during the earthquake and the following tsunamis and fires, and there is a certain lack of documentation (or even images and engravings) about the period. Landmarks like the Opera House, which only existed for about six months, were never captured in any painting — there are only engravings from the ruins, as well as scattered letters describing the magnificent building. Other documentation has unknown accuracy; some images from the early 1750s, for instance, are generally accepted as being faithful representations of Lisbon at the time, but there is no simple way to validate them, except by correlation with other documents. Textual descriptions of historical spaces can often be very inaccurate due to lack of context and subjective experience (Baker, 2010).

From all the existing data, CHAIA researchers attempted to build a 3D representation of Lisbon. Ferreira (2012), independently analyzing the amount of information required to accurately creating the models, comments that "(...) the two main characteristics of this project are rigour and accuracy. The research done in order to perfectly recreate the different places is impressive". Due to the ease of navigation in Second Life, it would be possible to match the model to existing images, and see if these were correct. Or, to take another example, using as background a textual description made by a traveller across the streets and the landmarks of 18th century Lisbon, would that description make sense, if an avatar followed the same path? Would they see the same scenes described on those letters? And if the model is changed to accommodate a certain description or a particular image, would it still be consistent with other images? Current historical research in pre-earthquake Lisbon just posed those questions and tried to answer them by comparing documents. As the researchers found out, it was only with a 3D model of the historical city that it was finally possible to validate some of the documents and images,

and utterly reject others. Long-admired paintings were found to be completely inaccurate by introducing wrong perspectives and showing details that would be impossible for a viewer of the scene; a lot of "embellishment" was thus uncovered, as well as concluding that in many cases, certain images and engravings must have been created from the artists' memory of the place and not in physical presence of the city buildings.

Accomplishing the same kind of "history laboratory" would have been very expensive using any other technology, mostly because of the iterative approach of 3D model building using traditional approaches. Similar to Morgan's case, "puzzle pieces" were assembled from documentation, quickly figured out that they would not match, and a different attempt modelled in Second Life, until it looked "right". This was relatively inexpensive and produced rather good results, which were also validated by following a methodology similar to the one described by the London Charter.

The *City and Spectacle: A Vision of Pre-Earthquake Lisbon* project is not limited to be a "history laboratory". Its purpose is to also address educational uses and leisure. Further stages of the project will re-enact public spectacles typical of Lisbon in the 1750s, by using avatar actors, and allowing visitors to attend, optionally dressing up their avatars in costumes. In a sense, these events are like theatrical representations that nevertheless fully allow visitors to interact with the "actors" and participate in the event along the same lines that 18th century Lisbon dwellers would have done.

The possibility of using historical reconstructions in Second Life for further purposes beyond merely a display of architecture is very strongly present in the *Theatron 3* project. The Theatron 1 and 2 projects by the Kings' Visualisation Lab aimed to produce historically accurate 3D models of about 20 European theatres of all epochs, from ancient Greece to the 20th century. The third iteration of the project was concerned about recreating the same theatres (which had to be rebuilt in Second Life based on the original 3Ds Max models) with a specific purpose in mind: allow students of drama to rehearse historical plays in the environment they were originally written for. Tools were developed in Second Life for researchers to schedule a slot for using the models, and, on the appointed date, the selected theatre would automatically be generated inside a region; visitors, outside of the scheduled events, could browse through the collection of theatres and visualize them one by one, and visit them in turn.

Another set of tools was developed to implement choreographies, according to the students' interpretations of scene movements in historical plays. Thus, the students would act as directors, feeding simple commands to manipulate avatars across the stage, animate them with gestures, have them recite the appropriate lines, and synchronise the whole ensemble according to a "master plan" closely tied to the actual play. Visitors could enter the region and watch an "automated play", and, since everything happened in real time, it was possible for teachers to be simultaneously online while their students marked scene positions and configured the choreography device, and offer instant advice. This use of virtual archaeology as an educational setting has been peer-reviewed and a suggestion for evaluating similar projects has been presented (Childs, 2008).

The Sydenham Crystal Palace in Second Life developed by the University of Bristol is a similar project involving interaction in the virtual world with the goal of providing a more fuller educational experience (Earle & Hales, 2009). In this project, a replica of the Pompeian House, as built inside the Crystal Palace during the London Exhibition of 1854, was replicated in Second Life, mostly based on existing 3D models. But the aim of the research was not to merely show the architecture; the historians wanted to expose their students to the actual experience of Victorian visitors experiencing a replica of an ancient Greek historical site. Due to the historical context and different moral values, Victorians

evaluated what they saw based on their own set of perceptions and prejudice of the epoch, thus reacting quite differently than modern visitors to the same environment. To simulate the contrast, the project plans to introduce intelligent agents to "role-play" the Victorian mentality when confronted with the exhibit; in this case, the research was aided by actual reports made in the location and recorded for posterity — the reactions were recorded in many cases and can be simulated. Thus, on this particular virtual architecture project, not only the buildings and environment are replicated, but even the human interaction is reconstructed based on documentation, following established guidelines for validation of historical documentation. Historical sites are thus exhibited in Second Life with models of human behavior as well.

A full software solution to train future archaeologists has been developed by the Laconia Acropolis Virtual Archaeology (LAVA) project (Getchell, Miller, Nicoll, Sweetman, & Allison, 2010). It is using a platform combining "an institutional learning management system (MMS), an immersive 3D virtual world (Second Life), and web-based interactive multimedia". The aim of this project is to allow students (potential archaeologists) to address not only the issues regarding the excavation of a historical site from a technical perspective, but also to deal with funding, resource allocation, team management, and so forth. Students were furthermore required to critically analyze the resulting 3D model (in Second Life) and how accurately it depicts the actual ruins, based on the (virtual) excavation that has been done. In this project, the role of the virtual world was to provide an immersive and interactive environment where students could interact among themselves and with the digital artefacts created inside the 3D platform. The evaluation of the students' engagement and the usability of the platform, was measured using "questionnaires, structured interviews, individual and group observations, co-participation, and written records", over a period of three years. It showed that in general students showed "high levels of engagement with the scenarios presented". This evaluation also included domain experts who recommended the usage of the LAVA platform in the curriculum.

Bogdanovych, Ijaz, & Simoff (2012) examine in their research the importance of immersion in a virtual environment, developed in Second Life, replicating not only the architecture of the ancient city of Uruk, but also simulating human behavior, by measuring the test marks of a group of students interacting in this fashion, compared to students using traditional learning methods. Human behavior was simulated based on "detailed discussions with subject matter experts and history consultants", allowing the researchers to define roles, interaction protocols and social norms for the artificial agents.

Although the researchers also provide a detailed model for programming interactions, the goal of the project was to quantitatively and qualitatively "test the learning effectiveness of using virtual worlds and virtual agents in history education". For this test, two groups of students were set up: the first reading a text about the city of Uruk, and the second group being asked to immerse themselves in the virtual reconstruction of Uruk in Second Life and interact with its intelligent agents simulating the engagement in daily activities. By comparing the marks of a post-test written exam applied to both groups, the researchers concluded that students engaging in the immersive virtual environment populated by intelligent agents had a better performance in the exam, as well as being "more engaged and willing to spend more time on learning".

Kennedy et al. (2012) use the model of serious games to provide an entertaining educational experience within OpenSimulator, using game controllers to appeal to a younger audience. Avatars representing historical characters in a detailed reconstruction of St. Andrews Cathedral introduce a narrative aspect and propose tasks that visitors have to complete. The purpose of the project, in this case,

was to "deepen the understanding of the monument" and "serves as a focal point for educational investigations into local history and culture". Thus, unlike the previous examples, it was not limited to exploring the educational potential of immersive virtual archaeology for students, but for other kinds of visitors as well. The article, besides detailing the methodology employed, reviews the feedback not only from the students, but also from their teachers, parents, and other adult visitors. It concludes that the same model, deployed in a virtual world, can be employed in a variety of different ways and appeal to a wider audience, allowing "history (…) [to] be brought alive and made accessible to new generations".

A similar model was used by Allison et al. (2012), exploring other subjects besides virtual archaeology, but presenting a case study of the virtual recreation of Linlithgow Palace in Scotland. Created by a multidisciplinary team of "historians, computer scientists, educationalists and graphics designers", the model, developed using OpenSimulator, was populated by students familiar with historical re-enactment done in the real castle as it stands today. The students helped to create not only the 3D models of the palace, but also included a geo-caching educational game where visitors — mostly other students — would interact with their avatars: so, in this project, not only historians and experts contributed their knowledge for the accuracy of the model, but the students themselves, through their familiarity with the real-world environment, were allowed to contribute digital content to it (videos and images), a characteristic which, as we have seen, is not so common among similar academic projects, even though it is easily implemented by virtual worlds that allow user-generated content. Students uploaded their own digital content, but they also staged in-world events related to specific aspects to the Linlithgow Palace's history, mirroring historical re-enactment events similarly done in the real world. As a result, the project allowed much more interaction between the many kinds of users — from domain experts, technical teams, and students as end-users — that would be possible in more traditional kinds of heritage representation. Students were viewed as co-authors of the project, and the students themselves furthered the expansion and dissemination of the project on their own.

6. Conclusions and Recommendations

The early attempts of virtual archaeology tended to focus on two aspects: how to best replicate 3D models of historical sites, and how to let the public visit them. As computer graphics evolved, the first projects put an emphasis on technology — both in terms of powerful scene rendering in real time, with as much realism as possible, and in complex haptic interfaces, or "virtual room" exhibits, where the visitor would be fully immersed in the reconstructed historical site. This produced expensive solutions — expensive in development and in presentation — which were appropriate for laboratory experiments and later for deployment as part of an exhibit of a real museum. The technology for capturing 3D information from historical sites and to render a replica as faithfully as possible was profusely used in the movie and game industry; besides documentaries, popular entertainment used 3D models inspired on historical sites. The accuracy of those models was however disputed. Initiatives like the London Charter established methods for validating models where the role of the historian or archaeologist was being the leader of the project, delegating the actual modelling to teams of technicians.

The resulting models were naturally much more historically accurate, sometimes at the cost of less photo-realism; these were not very popular with the entertainment industry, which departed from historical accuracy in favour of more eye-catching solutions for their audience.

With the advent of virtual worlds, historians and archaeologists gained a new medium for disseminating their projects. Virtual worlds with user-generated content, where there are no intermediate

steps between "modelling" and "visualizing", like Second Life and OpenSimulator, opened new venues for exploring the whole concept of virtual archaeology. Beyond the original goals of faithfully rendering heritage sites and presenting highly realistic scenes for visitors, current projects focus on the new possibilities that virtual worlds can bring to researchers: using the environment as a laboratory to test hypothesis in real time; allowing historians and archaeologists to do the modelling themselves without needing to hire technical teams; allowing visitors to interact with the virtual reconstruction of the heritage site and become participants; exploring new ways of disseminating information; as teaching aids; for recreational use using "gamification" of a virtual visit; and even for replicating human behavior in virtual environments.

Second Life (and its open source equivalent, OpenSimulator) has been a test bed for different approaches in presenting historical reconstructions in virtual worlds. (Ferreira, 2012) analyzed the types of locations more visited by Second Life users and concluded that replicas of heritage sites "are among the categories (…) that residents develop the most". Thus, even amateurs have explored the possibilities of interacting with historical buildings and creating communities around them. Virtual museums, closely following their real counterparts, are relatively easy to establish in Second Life, and can attract visitors using techniques similar to the ones employed in real life — real life curators have successfully run events in Second Life to bring visitors to their virtual museums.

But the latest generation of virtual archaeology projects show completely new uses for virtual archaeology projects, and they have no physical counterpart. These explore not only the 3D aspect of virtual worlds and the easy way content can be distributed, but they start to incorporate characteristics uniquely found in Second Life to make the experience of visiting a model of a heritage site much more enriching and immersive. These can be explored as new "laboratories" for the purpose of further research, using tools never before available to historians and archaeologists. Furthermore, the same content can be immediately deployed for educational and leisure use, at a fraction of the cost of more traditional methods. In particular, the relevance of the impact of using immersive virtual archaeology projects in the context of education, in terms of knowledge acquisition and skill increase of the participating students, mirrors the views of Morgado et al. (2010), and their overall scope, regarding the use of interactive virtual worlds for training and education in the context of physical world activities.

The success of those new approaches to virtual archaeology is still being evaluated, but the evaluation procedures follow well-established guidelines in the history and archaeology research communities, as well as on the education communities.

Due to the maturity of the technology and its good track record at enhancing the experience of interacting with virtual recreations of heritage sites, it is our belief that the approaches used in the many examples cited, have shown that they are worth considering as being part of any current and future attempts to preserve the memory of heritage sites. It seems to be clear that the road ahead for virtual archaeology is to go beyond the mere representation of historical artefacts — which began with bi-dimensional images and later included three-dimensional models — and move to fully immersive experiences, where the visitors (students or the general public) not only interact with the environment but also with a simulation of the human population within that environment — be those intelligent agents or actual humans engaging in virtual historical re-enactments. Certainly more quantitative research and use cases are welcome to clarify the actual improvements over more traditional approaches (from text books and lectures on history, to museum displays, both static and interactive, to videos of digitally recreated 3D models). However, in establishing the memory of a heritage site, in successful

conveying information about the current state of knowledge about it, and to convey this kind of knowledge to students and even to the general public, as well as allowing them to enhance their skills, the research so far already shows very promising results. To this date, no other platform or environment besides virtual worlds is able to address all these areas simultaneously, and definitely not for the low cost of production and the relatively short time involved in the development – albeit augmented reality tools look also promising on this regard.

While other virtual world technologies have been occasionally employed for the same purpose, the rapid advance of technology has set a pace that made most of them quickly obsolete, and many faded to relative obscurity in a course of a few years. Second Life has a solid track record for a decade, with its million regular users. OpenSimulator, Second Life's open-source counterpart, boasts seven years of development, continues to be fully compatible in terms of the viewer application, and replicates almost the whole set of features presented in Second Life, while adding a few more — but being comparatively cheaper due to the lack of licensing costs or recurring fees, when installed on a researcher's computer. The future might reveal new platforms for immersive virtual worlds, or existing platforms (like Google Earth, Unity3D virtual worlds, Cloud Party, etc.) might become better adapted to include the full range of features available in Second Life and OpenSimulator. Yet, Second Life and OpenSimulator remain the most mature products in the area and the ones which have been successfully employed more often, more researched, and with longer-lasting environments that will be available for visiting and experiencing after many years, even if both platforms (and especially their viewers) are constantly being upgraded and updated. It is the sheer size of its users and developers mass, maintaining the maturity of the technology and adapting it to new needs that allow the authors to recommend these platforms for any future virtual archaeology projects.

Immersive virtual worlds have already showed to be a powerful tool in other fields of research, namely as simulation platforms for training and educational use. It is our belief that the area of virtual archaeology can and should be included in the list of successful use of virtual worlds.

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