The V-Horus Project

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Figure 1: *The Roman Mummy, artefact from the Egyptian collection of the National Museum of Brazil, in Rio de Janeiro.*

Abstract

The V-Horus Project aims to reconstruct archaeological artefacts using digital technologies and to visualize them in an immersive experience in Virtual Reality. The focus of the project has been the reconstruction and 3D visualization of artefacts from the Egyptian collection of the National Museum of Brazil, in Rio de Janeiro, many of them destroyed in the fire in 2018. In this article, the multidisciplinary development process of the virtual reconstruction of a mummy from the roman period (30 BC to 395 AD) and the partcipants'immersive experience are reported. The results show that this experiment, which explores techniques of virtual reality, digital reconstruction, gaming, and immersive narrative expands the possibilities of visualization and groupings of artefacts in a museum; manages to engage the public; and has great symbolic value in enabling the digital reconstruction of destroyed objects of the collection

CCS Concepts

•*Computing methodologies>Computer graphics>Graphics systems and interfaces>Virtual reality*

1.Introduction

Virtual reality (VR) has played an important role in allowing the public to have access, through immersive experiences, to environments and objects that have ceased to exist due to wars, natural disasters, fires or others [GCR01]. In this article it will be presented the development of an initial experiment of the V-horus project, a virtual reality experience, and the results of the research carried out with 153 participants. In its experimental stage, the V-Horus project focused on the digital reconstruction of a 2000-year-old mummy (Figure1), from the collection of the National Museum, the most important and oldest museum of natural history and anthropology in Brazil. In September 2018, a fire destroyed a large part of its collection, and one of the highlights, the Egyptian collection, considered the largest in Latin America, had many artefacts destroyed. Within this context, the 150 CT scan archives from the CT Scanning Mummies project for the purpose of Analysis and Preservation (CTSMAP) [Sou 09], were fundamental for the viability of the V-Horus project. After the fire, this recorded material represented the possibity to, not merely continuing scientific research, but also allowing the development of the V-Horus project, enabling the faithful reconstruction of artefacts. The greatest contribution of this project is to make possible both the continuity of scientific analysis of artefacts and the contact of the public, even if in digital form, with the most important artefacts from the Egyptian collection of the National Museum, albeit in digital format.

2. Historical context

Egyptian mummies have been the focus of study for the past 200 years and the scientific studies carried out on these artefacts provide information that would hardly be made available by written sources and graphic symbols [TA14]. In the early 2000s, the continuous technical development in CT, made possible a faster image's acquisition, increasingly thin sections and three-dimensional (3D) visualizations. Since 2003, the CTSMAP project has allowed a continuous process of CT scans by the National Museum. [Sou09].

3. Related works

The growing technological development of virtual reality allows, each year, more projects related to archaeology. Many of these, however, focus on the environments' reconstruction [JHC*18]. The V-Horus project, in turn, focuses on the reconstruction and visualization of ancient Egyptian artefacts. The project has as a

particularity, the construction of the 3D models from tomographic files obtained by CT scan performed on the object before the fire. The choice of the Unity environment for the development and the HTC Vive for viewing were aimed at creating an experience in multisensory VR to present items of archaeological heritage, similar to the one described in "Virtual Reality interactions with multiple interpretations of archaeological artefacts" [GPN * 18]. The V-Horus focus, however, is on presenting the details of the artefact's characteristics. There was also a concern to create a multi-sensory experience in which narrative, lighting, music and tactile experience contribute to the participant's involvement. According to studies by Pujol-Tost [Puj19], a narrative involving multisensory immersion can activate visitors' imagination, transport them to ancient cultures and historical events, allowing a personal connection between the public's life experiences and the environments and objects that represent another time and place. In this way, they may be more likely to be memorable and meaningful experiences for the audience. Finally, as a state of the art, we can mention the VR experience "Enter the tomb", in which users visit the interior of Tutankhamun's tomb [Rea 19].

4. The V-Horus Project, development

The V-Horus Project is a collaborative research carried out by a multidisciplinary team, composed of designers, mathematicians, archaeologists, bio-archaeologists and historians. As the project goal is the visualization of lost artefacts, whose main remaining information is volumetric and photographic, the development process chosen for the initial experiment was the three-dimensional reconstruction of the object and its presentation in virtual reality through the HTC Vive glasses. The objective was to create an experience with an emphasis on the presence [Rub18] and observation of the artefact, which had its original proportions preserved and perceived through the look and interactive exploration around it.

4.1 Artefact selection

Considering that the mummies were the most representative pieces of the Egyptian collection in the National Museum, it was decided that the first experiment would digitally reconstruct the Roman Mummy. This selection was motivated by the unique mummification process used in the preparation of the body, the existence of CT scan files, the vast photographic material available, which would be useful in digital reconstruction, and the amount of information about the piece, gathered in previous research. According to [Sou09], this mummy was of a young woman who lived at the time when Egypt was under the rule of Rome, during the first century after Christ. According to analysis carried out on the CT scan images, [Sou09] she was between 15 and 18 years old, with a skull and round face, which confirms her Mediterranean ancestry, consistent with the Roman period, with records that suggest a Greek origin. There are also records [Sou09] [TA14], which suggest similarities between the mummification process adopted in the Roman mummy and other mummies exhibited in European museums such as the Rijksmuseum van Oudheden, in Leiden, Holland; the World Museum in Liverpool, UK; the British Museum, in London, UK; and the Musée Calvet, in Avignon, France.

4.2 Stage 1: Generation of the 3D asset and narrative concept

The existing tomographic images of the Roman mummy allowed that, a 3D model referring to the surface of the artefact was extracted from the tomographic volume. This file was then exported in high density of polygons, thus allowing its manipulation in three-dimensional modeling and texturing programs. A rapid prototyping of the textured model was carried out and placed on the Unity platform. Thus, in the development of the V-Horus Project, the curator of the Egyptian collection of the National Museum, Antonio Brancaglion Jr, and the bioarchaeologist Sheila Mendonça, coordinators of the CTSMAP project, were invited to visualize the initial digital model immersed in the virtual environment, and make evaluations. This visualization of the prototype was recorded, see figure 3, and the analysis of this material directed some characteristics of the experience:
a) Regarding the model: The need for precision in the characteristics of the artefact, in the representation of materials and in the three-dimensional model. The appearance of the digital artefact should seek to reflect the construction processes of the original.
b) In relation to VR: In the case of the V-Horus project, it was clear that the success of the experience would be linked to the users' perception of details and that this precise reconstruction work would be fundamental.

4.3 Stage 2: The digital reconstruction of the artefact

Although it was not possible to access the original artefact to create the model directly, using photogrammetry, all available information was used in order to create an experience as close as possible to a true contact with the original artefact. Thus, the digital reconstruction of the Roman mummy was carried out based on the records of previous research; the notes of researchers on the mummification process; interviews with bio-archaeologists; the analysis of rapid prototyping made from the model generated by CT-Scan [Sou 09]; and existing photographs of the artefact, from which both the three-dimensional model was retouched and the texture maps constructed as shown in figure 2.

Figure 2: *The model from the CT-Scan (1) was retouched, removing the voxel texture (2), preserving surface's details and touching up the spliced areas (3)*

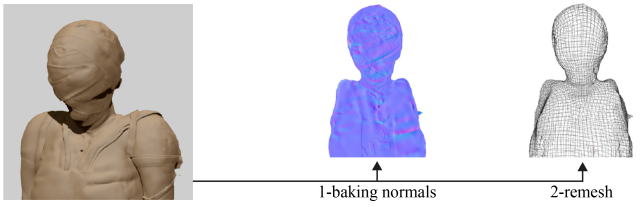

Figure 3: *Baking normals: the details of the high poly (a) were transferred to normal texture maps (b) and a low poly model was generated in remesh, on which a map (c) was applied.*

The initial model was optimized, generating a second model with low geometric complexity to enable the visualization in VR. The details from the original were projected on normal texture maps, to simulate reliefs and details [K0015] (see Fig. 3). For texturing in color, parts of the artefact's photos were cropped projected and applied, completing areas where there was no information available (see Fig. 4 and 5). Textures were also extracted from these images by transforming brightness and contrast into a height map. These textures were added to the normal maps previously generated. In this way, we sought to give the model a texture that reacts to the projection of light and the movement of the eye using PBR (physical based rendering) textures (see Fig. 4).

Figure 4: *The original image (1), the cutout (2) and the projected image mapping the model (3)*

In summary, the model creation was carried out in three stages 1) Obtaining model's surface from CT scan volumetric data. 2) Model retouch and optimization in the geometric mesh. 3) Manual composition of textures from details of photographic images of the artefact and of other materials and its application on the model.

4.4 Stage 3: experience concept, and Unity implementation

In parallel to the model's creation, a team of researchers worked on the conceptual development of the virtual experience, conducting interviews and research on the artefact history. The objective was to build an attractive narrative, with the main focus on the history and artefact's details, so that the immersive experience could involve the audience. According to D. John et al [JHC * 18], many factors contribute to making the VR experience credible: especially the realism of the visual presentation, along with the use of sound, tactile feedback and interaction and the participation of experts to validate the information. Thus, the curator of the Egyptian collection, wrote an initial text based on the prototype's visualization.

Figure 5: *Details extracted from photos aplied over 3d model*

This material was formatted to become a script and be in sync with the visualizations.The final narration had the curator's voice, with the goal of generating credibility to the experience. The narration, the musical score, and the 3D model of the mummy were imported into the virtual platform Unity. In this process, cinematographic and game techniques were used in order to engage the user in the experience. In the first stage of the project, it was decided to focus the team's attention on the the artefact production, so that the result was as realistic as possible. In this way, the lighting was designed with the objective to highlight the main aspects of the mummy that were being mentioned in the narration and to guide the user. Intentionally, a three-dimensional scenario was not built, since it could disperse attention. The soundtrack was selected from Egyptian instrumental songs. This process resulted in a 3'50" experience. In this first experiment, there is no active interaction between the user and the experience, but there is the possibility of including participative and new interactive processes in a next version.

5. User experience

The VR experience developed was exhibited for the public in two events. First, during the 7th Seminar on Egyptology of the National Museum, September 30 to October 4, 2019, when 200 people were able to experience it. Secondly, at Pontifical Catholic University of Rio de Janeiro, during the Design Week, November 4 to 7, 2019, when 150 people participated in the experience. The set up of the experience included a computer to play the VR video, headphones, VR oculus and a table, which functioned as a physical, tactile reference in the virtual environment. In the experiment tangibility and great realism were being tested as elements to bridge the gap between the physical and virtual spaces, as discussed in [VLC17] . One person at a time participated in the experience and he or she could explore freely the virtual enveironment.

5.1 Evaluation of the user experience

In order to evaluate the experience, a questionnaire composed of 18 questions was assembled, 16 of which were closed and 2 were open. From the total of 350 participants, 153 answered the questionnaire immediately after viewing the VR experience, using a mobile application previously installed on a smartphone available on site.

5.2 Participants'profile regarding age and familiarity with VR

The first two questions, regarding age and VR familiarity were multiple choice. From the 153 people surveyed, more than 40% was between 20 and 35 years old. In cycle 1, the second largest group, representing 25% of the participants, was between 50 and 69 years old. In cycle 2, the second largest group, comprising 30% of total, was people under 20 years old. Regarding previous experience with virtual reality, 58% of participants had little or no experience (1 to 3 times). The cycle1 group was less familiar with VR. In this group, 42% (38) affirmed that was their first experience. In the responses collected in cycle 2, 42% (27) said they had more than 5 previous experiences with VR and 31% (20) said they had 1 to 3 experiences.

5.3 Evaluation of the VR experience and VR technology

This part of the survey adopted a Likert-type scale in which respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements. In this study, a five-item scale ranging from "strongly disagree" to "totally agree" was adopted, because according to [DV13], it presents more precision and reliability in the answers. The 14 statements evaluated using this technique were classified into three themes: A) Evaluation of the V-Horus experience; B) Evaluation of the

quality of the artefact and the credibility of the experience; C) Evaluation of the virtual reality technique. Responses were considered positive when the participant chose "totally agree" or "agree" and negative when choosing "disagree" or "strongly disagree". Although the samples have different profiles in terms of age and familiarity with VR, the participants' involvement in the experience, in the two exhibits, proved to be very similar, since more than 90% of respondents in both groups had the feeling of actually seeing the mummy; agreed that enlightenment helped to guide their attention and that music and narration contributed to the involvement in the experience. In addition, 95% of the total participants were involved with the experiment (100% from exhibition 1 group and 95% from exhibition 2). The evaluation of the artefact's quality and the credibility of the experience indicated that the quality of the artefact and the tactile stimulus in the physical environment contributed to the credibility of the experience. It also indicated that the curator's narration, together with the sharpness of the details and the possibility for the participant to get closer to the digital artefact in the virtual environment, more than it would be possible to the physical artefact in the museum, allowed participants to perceive details that were barely visible in person. Although the experiment focus was on a single object, it was possible for users to relate the experience to a virtual museum visit. Within this context, more than 90% considered VR a more realistic and enjoyable way than exploring a virtual museum through a desktop. The same percentage also responded that they would like to see other objects from the National Museum through VR and that this technology can contribute to the democratization of knowledge. Only 5% of participants answered that they felt some discomfort with the experience. For these, there was an open question, about the type of discomfort felt. In most responses, the discomfort was related to the use of virtual reality glasses. Only one participant replied that he felt discomfort in relation to the narrative.

6. Conclusion

The digital recovery of an important artefact from the Egyptian collection of the National Museum, with precision, and its visualization through a Virtual Reality experience was only possible through the practice previously used by this institution to digitize the artefacts in its collection. According to the survey results, the process used in the V-Horus project created an engaging experience and sparked public interest in seeing other artefacts from the collection lost in the fire. Consequently, the methodology tested in the project proved to be scalable and adaptable to other artefacts of the National Museum, and can be used as a guideline for other institutions that may suffer loss of artefacts due to fires, wear or other causes. Future developments of this experiment point to the inclusion of new layers of interactivity; potentiation of the tactile experience through the inclusion, in the real world, of a 3D printed model equivalent to the virtual model; the feasibility to show the inner part of the mummy and other artefacts from the collection of the National Museum of Brazil
For further details of this project, acess: https://www.visgraf.impa.br/v-horus/

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