VSMM 2008

Digital Heritage

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Short Papers





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Limassol, Cyprus

M. Ioannides, A. Addison, A. Georgopoulos, L. Kalisperis (Editors)

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"The paramount significance of their (the Kanakaria mosaics') existence," said Judge Noland in the Federal Court in Indianapolis, "is as part of the religious, artistic and Cultural Heritage of the Church and the Government of Cyprus, and as part of the national unity of the Republic of Cyprus."

A Case Study in the Preservation of Cultural Heritage in Times of War
The Kanakaria Mosaics (6th century AD)
Photos by Ioannis Iliades, Curator of the Byzantine Museum in Lefkosia, Cyprus.
On the eastern tip of the Karpass (Karpasia) peninsula of the island of Cyprus, lies a small village, Lythrangomi (Lythragkomi). The church of Panayia Kanakaria (dedicated to Virgin Mary) at Lythrangomi, suffered from one of the worst examples of looting as a result of war.
Before 1974, when Turkey invaded Cyprus, the Kanakaria church mosaics were regarded as being among the most important and some of the very few surviving examples of early Christian art.
Early in 1989, however, four Kanakaria mosaics - depicting the child Christ (picture in the cover), an archangel and the Apostles James and Matthew - appeared in the U.S., where they were offered by an art dealer to the Getty Museum for $20,000,000.
The Cyprus Government and Greek Orthodox Church immediately sued the US dealer, who, in front of a US District Court, claimed to have bought the mosaics from a Turkish art dealer. The action of the Government and the Church, supported by a petition of 2,000 prominent US academics and cultural figures, was vindicated when the Court ruled that the mosaics should be returned to the rightful owners.
Source (accessed 02.10.2008):
- http://www.greekvillage.com/hcaao/kanakaria.html
- http://www.brown.edu/Departments/Classics/bcj/15-07.html
- http://www.jstor.org/pss/2847685
- http://www.europesworld.org/EWSettings/Article/tabid/191/ArticleType/ArticleView/ArticleID/20454/Default.aspx
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THE AUGMENTED DIGITAL RECONSTRUCTION OF A XVII CENTURY CONVENT IN BRAZIL

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KEYWORDS: Digital Reconstruction, Augmented Reality, Virtual Reality, e-Museum, e-Exhibition

ABSTRACT:

This paper describes the digital reconstruction of the Convent of São Boaventura, whose construction started in 1660 at the state of Rio de Janeiro, Brazil, and is currently in ruins. The digital reconstruction process is an interplay between extensive historic research and computer graphics technology, serving as a divulgation means of the cultural patrimony of a region with large environmental and socio-economical degradation. The ruins of the current historical site refer to the partial reform realized between 1784 and 1788. The digital reconstruction aims to project and model what should have been the architectonic complex if the construction were concluded. Hypothetic plants elaborated by researchers, as well as original fragments were used as input for the digital reconstruction. A few material and documental registers enabled the virtual reproduction of some original ornamental elements. Additionally, going beyond the available registers, the historically plausible model is being completed using architectonic and ornamental objects of the same style and epoch, whose origins are specified. From the technological point-of-view, the virtual model is a challenge in the sense that it is the stating point for several exhibition possibilities, ranging from interactive navigation to augmented reality. In both cases, the photorealistic real time rendering of such a rich model is a major challenge. In the case of augmented reality, which is the projection of the virtual model over the real one, the challenges are even greater, including markerless tracking, modelling of the real lightning conditions, among others. This paper discusses the ongoing efforts towards the virtual reconstruction of the convent and the related computer graphics challenges.

1. INTRODUCTION

The digital reconstruction of the Convent of São Boaventura and the village where it was located (Vila de Santo Antônio de Sá) is part of a series of cultural and educative multimedia products developed by the Information Center of COMPERJ (Petrochemical Complex of Rio de Janeiro) / Petrobras in partnership with Tecgraf / PUC-Rio. The ruins of the convent (Figure 1) are located in the eastern part of the state of Rio de Janeiro, Brazil, a region with large environmental and socio-economical degradation, currently starting its revitalization with the implantation of a strategic petrochemical industrial park.

The digital reconstruction is part of a project called Patrimonial Education for the East of Rio de Janeiro, aiming the valorization and preservation of the archeological, historic, cultural and environmental patrimony of the region. The project envisions the possibility of connection between the past and the future of local communities by means of educational actions that, at one side construct and recover the cultural patrimony of the region, and at the other side qualify the citizens for the near future.

The difficulty for a plausible reconstruction of the convent is that there are few available material and documental registers. The project also acquires technological challenges because the convent is located in the entrance of the future industrial park, and it will be part of a large complex for public visitation, which must integrate the high technology related to the industrial park with the historic place where it is located.

Figure 1: Ruins of São Boaventura Convent, before the propping process.

This paper presents the ongoing work on the digital reconstruction of the convent (Figure 2) and the technological challenges in the fields of augmented and virtual reality that will be an important part of the visitation center. It is organized as follows. In the next section, we briefly describe some aspects of the archeological site of Vila de Santo Antônio de Sá. In Section 3, we discuss the reconstruction process, and in Section 4 we present some technological challenges for several exhibition possibilities. Conclusions are presented in the last section.

Figure 2: Virtual model of the convent.

2. THE ARCHEOLOGICAL SITE

The area where the industrial park will be located occupies a singular place in the history of the occupation and the economical and cultural development of the state of Rio de Janeiro. In that region, there are archeological vestiges of successive occupations by distinct ethnical groups that reveal the richness and the historic complexity of the environment and culture of the region. Its prosperity and political, economical and cultural importance in the XVII and XVIII Centuries derive from extractive activities, agriculture, and the population flow through the interior of the state. The population increase and the existence of a large number of indigenous tribes attracted religious orders, such as the Jesuits and the Franciscans, which were colonization agents dedicated to the Christian preaching and the catechization of indigenous populations throughout the country.

The Franciscans built the Convent of São Boaventura between 1660 and 1670, synthesizing the religious architecture of a period known as Brazilian Baroque. In 1697 the Vila of Santo Antônio de Sá is established. The convent went through a partial reform between 1784 and 1788, period when the Rococo style prevailed.

In the middle of the XIX Century, the economic decadence and successive epidemic diseases caused the definitive abandon of the village and its surround rural areas. This decadence persisted until recently, laying the region aside the development process of the country in the last century.

The archeological site of the village, including the ruins of the convent, is under governmental trust since 1980. The challenge of this work is to virtually reconstruct, using computer graphics and virtual reality, the village and the convent. At the moment, only the convent has been reconstructed, being therefore the focus of this paper.

3. THE DIGITAL RECONSTRUCTION PROCESS

The ruins of the convent that characterize the archeological site refer to the unfinished reform realized by the monks and their slaves between 1784 and 1788. Therefore, the virtual reconstruction has the goal of not only recreating in computer graphics what has been destroyed by centuries of abandon, but also to project and build what would have been the convent if the reform were concluded.

In the virtual reconstruction process we faced a typical challenge of virtual heritage, which is the tension between authenticity and completeness (Devine, 2007). This arises from the fact of having incomplete historical record. According to the same author: “If a reconstruction is limited to only that which is known to be true then much will be omitted. If hypothesized data is used to fill out the model then, no matter how plausible, issues of historical authenticity inevitably arise”.

Since the archeological studies in the area started recently, no conclusive results have been published yet. For this reason, up to this moment, the virtual reconstruction has been based on historic sources, specific bibliography, and partial analysis of material fragments found in the ruins.

Marks identified in the terrain and in the architectonic structure, together with hypothetical plans designed by researchers in the decades of 1930 and 1990 guided the definition of the floor plans and the modeling of the buildings. Original fragments found in the ruins, such as floor, wall, bay and roof revetments, constituted the basis of the textures. Similarities with the spatial distribution of contemporary convents of the same religious order and architectonic style helped the reconstruction of specific places such as the seclusion ambient.

A few material and documental registers enabled the virtual reproduction of diverse ambiences and some original ornamental elements. For example, the main chapel was modelled using reports of travellers that were there in the XVIII Century (Figure 3). The bells and the images of the conventual chapel were modelled based on the original ones identified in the historic sources, which were localized in churches of the proximities. The same happened with the recreation of the wall tiles of the conventual seclusion, whose fragments were stored in another convent in the city of Rio de Janeiro.

Additionally, going beyond the available registers and material fragments, the historically plausible model is being completed using architectonic and ornamental objects of the same style and epoch, whose origins are specified. Since the digital reconstruction is guided by the reform of 1788, period of Rococo, the carving of the altarpiece and additional ornaments follow this style.

The model of the virtual convent was built using the 3ds Max, and then exported for the appropriate visualization in virtual or augmented reality.

Figure 3: Reconstructed main chapel.

4. THE AUGMENTED RECONSTRUCTION – EXIBITION AND INTERACTION CHALLENGES

Once the extensive historic research gave us enough material for the computer graphics modeling of a historically plausible virtual model, the next step is the definition of the use of this model for exhibition purposes, according to the project of patrimonial education and to the high technology demands of the visitors' center of the industrial park.

According to (Zara, 2004), cultural heritage techniques can be classified by the nature of the examined objects and the methods used for their visualization. This author classifies presentations in four categories: image, movie, model and scene. The first two categories explore the real scenario, while the last two explore virtual objects. The difference between model and scene categories is that the first one is related to the examination of single objects, while the second is the navigation in 3D scenes consisted of many objects

Although the focus of our work is on the virtual convent, we may say that we want to cover almost all of the four categories described above, using concepts of mixed reality, integrating real and virtual visual information.

The mixed reality continuum was defined by (Milgram and Kishino, 1994) as a spectrum having the real world at one extreme and the virtual reality at the other (Figure 4). Along this spectrum, there are also the Augmented Reality (AR) and the Augmented Virtuality (AV). AR is based on the real world enhanced by virtual information, while AV is based on the virtual world enhanced by information of the real world.

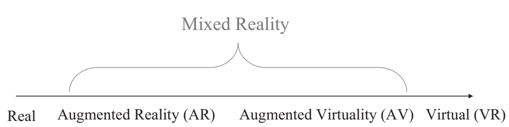

Figure 4: Mixed Reality Continuum

For exposition purposes, we are going to focus on AR applications, making good use of the fact that the real convent are located next to the visitors' center building. Therefore, we started to develop some preliminary AR applications, described in the following subsections.

4.1 Panoramic AR

The first application we developed makes use of panoramic images of the ruins, integrated with the virtual model and the terrain map. The idea is to have a global vision of the archaeological site and see the 360^o image of the convent from several predefined points on the site. While seeing the panoramic images, the users may also superimpose the virtual model with a variable transparency level, to compare the current ruins with the original building (Figure 5).

Figure 5: Panoramic AR application.

This application uses only the external parts of the convent model, since the panoramic images are based on points of view outside the building. The yellow point in the first image of Figure 5 shows the point of view for the panoramic images shown in the second and third images (there are other points of view available). The second image shows the image with a preliminary virtual model superimposed, and the third image shows the real photography.

For exposition purposes, this application may be viewed in two interactive 180^o displays, such as illustrated in Figure 6. The idea is that multiple users obtain additional information about the convent, the region, and the ecosystem by touching different parts of the screen.

Figure 6: Interactive curved display for the panoramic AR application.

4.2 VR Navigation Application

The second application uses only the virtual model, and is a typical scene navigation application, where the users may walk through the reconstructed convent.

However, once this model is aimed at the valorization of the patrimony and cultural heritage, more than simply a virtual space, it was necessary to build a virtual place. Here we are using the definition of (Harrison and Dourish, 1996): "space is the opportunity; place is the understood reality", or, "a place is a space with meaning". The recreation of places, and not just spaces is one of the challenges for virtual heritage (Devine, 2007).

In order to transform the model into a place, we created a navigation application with an introductory video explaining the historical context and the objectives of the reconstruction, following a videogame-like approach. Moreover, during the navigation the users may access textual information about the area they are visiting or the objects they are facing. Figures 2 and 3 are screenshots of this application.

The two applications presented above, although relevant for the project, do not represent difficult computer graphics challenges, since we used current available technologies. The following two applications represent more sophisticated challenges in terms of research in computer graphics and VR.

4.3 3D Photo Album

The third application is called 3D Photo Album, a navigation application where the users navigate through the model and move to positions from where a set of pre-calibrated pictures were taken. This application is inspired by Microsoft's Photosynth (Microsoft Live Labs, 2008) originated by Noah Snavely's work (Snavely et al., 2006).

Photosynth's input is a dense set of pictures of an object with overlapping regions. It retrieves clouds of three-dimensional points and camera models of these pictures based only on the matching features among them. Even though this technique is successful, it imposes an operational condition that is not desired in our application: it assumes the availability of a dense set of pictures with overlapping regions, and it requires a long processing time. We assume the model's geometry to be known, implying a substantial difference in relation to Photosynth purposes, as well as allows a simplification of the camera reconstruction process.

We match models and images of buildings using a set of integrated techniques, with camera reconstruction as the main strategy. To perform such reconstruction and successfully match and catalogue the pictures, first we needed to solve the problem of identifying correspondences between elements of the image and the model, which is one of the fundamental problems in computer vision. The approach proposed to solve it was to use the building's model, positioning it in order to restrict the search for matching features on the image. This strategy assumes the virtual model to be manipulated by the user in such a way that the edges can serve as guidelines to locate corresponding features in the image, using a local search strategy in the neighborhood of the projection of the model's edges (Figure 7).

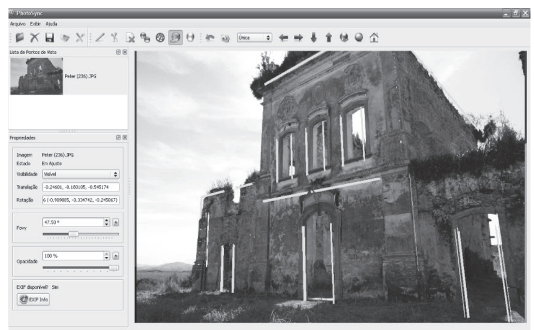

Figure 7: Model superimposed by an image with opacity of 100%. The guidelines are visible and the model can be manipulated.

The method is semi-automatic, beginning with an initial solution provided by the user which allows a local search for image-model associations rather than exploring the model's global information. If the input image contains significant noise and the photographed model has complex geometry, solving the matching problem becomes naturally difficult, and the method proposed herein becomes more dependent on user actions and prone to some degree of imprecision. In simple cases, on the other hand, the process is largely automatic and robust in relation to the model's initial position, as it is simpler to compute image-model correlations.

As final result, we have developed an application that implements the proposed method and provides a complete solution for the camera registration problem over pictures related to their virtual model. The system also provides various mechanisms to help the user compare pictures with the model, and navigate spatially over the several registered images (Figure 8).

Figure 8: A match between the model and a picture of the convent.

4.4 Markerless AR application

In an AR system, the composite of real and virtual images can be made using head mounted displays or video (Rolland et al., 1994). A challenge is to position the virtual and the real objects in the 3D scene in order to produce a coherent visualization of the mixed reality; this is a hard problem to be solved (called registration problem).

To solve the challenging registration problem, some well-defined steps have to be studied. The recovery of the user initial position relative to the real scene is known as camera (or user position) calibration. The subsequent tracking of its movements to update the camera position in the real world is the tracking phase. The virtual object to be projected onto the scene has to be modeled, and many techniques to recover geometry of real objects can be used, from CAD systems to 3D photography techniques. The final step is the visualization of the real world composite together with the virtual object; if the alignment and registration has been well solved in the previous steps there is the occlusion problem left to be solved in the visualization phase.

A characteristic that influences on the project development decision is related to the real ambient where the augmented reality system intends to be used. Indoors and outdoors environments have fundamental differences related to the possibility of controlling illumination. The possibility to positioning fiducial markers to help the calibration and tracking phases is also a characteristic of the real ambient that influences on the AR system.

There are two main distinct approaches concerning feature tracking in image or video sequences:

- Tracking based on markers
- Markerless tracking

A marker is a predefined object present in the scene that can be automatically detected by image processing. Since markers started to be used to help in solving computer vision tasks, several distinct types of markers have been proposed to facilitate the tracking task. The main characteristics of a good marker are: 1) it should be easy to detect in the scene; 2) it should be easily distinguishable from other markers present in the scene; 3) it should be robust to detect in case of partial occlusion. Another consideration is about the tracking technology – that influences on the marker design – among them we can cite mechanical, magnetic, acoustic, inertial and optical devices.

We will focus on optical devices. When using this kind of device, an approach used to obtain information useful to calibrate the camera position is to extract special patterns from the scene that are known in real world. Here the use of markers splits the approaches into two classes: one uses synthetic markers completely defined by user, meaning that its real dimensions are also pre-defined by user (Thomas et al., 2000) and the other look for geometric characteristics naturally present on the scene that can be detected and tracked in subsequent images (Kobayashi et al., 2007; Dick et al., 2004; Vlahakis et al., 2002)

This second approach is to look for features naturally inserted into the scene of interest, that are good candidates to be used as markers. These features can be tracked in the image sequence and will be used to infer the camera position relative to the scene. These scene features can be object silhouettes based on basic line segments as well as vanishing points.

The tracking based on features of the image is the most adequate for scenarios like the convent ruins. At the moment, we are preparing a simpler application, based on the AR visualization at position-fixed semi-transparent displays, which may have their rotation tracked to produce the AR visualization directly over the convent view (Figure 9).

Figure 9: Illustration of an AR station looking at the real convent.

We are currently working on a hybrid system that tries to get the best of both marker and markerless tracking approaches. Invariant properties of retroreflexive spherical markers patterns are used to detect the markers in the object. The inclusion of these markers in known polygonal areas of the tracked objects helps the detection of intrinsic characteristics of them, providing more robustness to the tracking process. A case study using a mock-up of the convent ruins is presented in Figure 10.

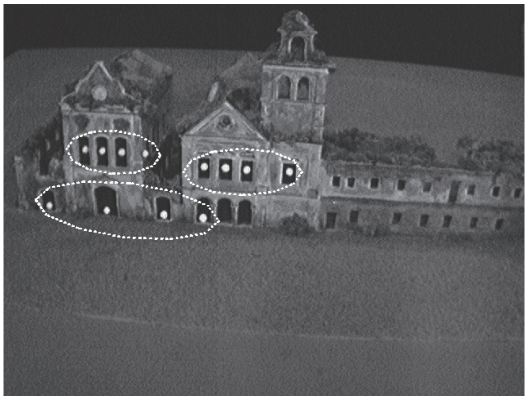

Figure 10: Convent mockup with 3 collinear patterns of markers, to be used for an AR visualization.

5. CONCLUSION

This paper presented the efforts towards the digital reconstruction of the Convent of São Boaventura, Brazil, in a project aiming to valorize the cultural patrimony of the region. We discussed the historical and technical challenges of this reconstruction, which must integrate the high technology related to the industrial park to be constructed near the ruins.

Regarding the historical research, the challenge is to find a plausible balance between authenticity and completeness, since historic records are limited. Regarding computer graphics and VR/AR research, the challenges are the creation of attractive and meaningful applications that uses the state of the art in these technologies.

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