

## VIRTUAL SACRISTY: THE INTERACTION WITH THE HERITAGE

### SACRISTIA VIRTUAL: A INTERAÇÃO COM O PATRIMÔNIO

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#### RESUMO:

As tecnologias digitais contribuem para o acesso, o conhecimento e a interação com o patrimônio histórico. A partir desse estímulo, o usuário passa a conhecer o bem patrimonial, além de tender a visitá-lo, valorizá-lo e preservá-lo. Isso pode auxiliar o fomento do turismo e o fortalecimento da cultura local. Este artigo visa apresentar diferentes formas de interação com o patrimônio por meio de recursos de comunicação remota e virtual. O bem histórico analisado é o Convento de Santo Antônio de Cairu, localizado no município de Cairu, o qual se encontra situado no estado da Bahia, no Brasil. Este estudo apresenta uma visita virtual ao Convento a partir de panoramas fotográficos. É destacado o lavabo, que foi reconstituído digitalmente pela técnica Dense Stereo Matching (DSM). Os resultados estão disponíveis para visualização e interação em Realidade Virtual (RV) ou Realidade Aumentada (RA). A partir desses, foi produzido um website para que o usuário possa interagir facilmente com os elementos virtuais e acessar informações sobre a história e detalhes arquitetônicos da sacristia. Este conteúdo, disponível no website <https://conventodecairu.wixsite.com/sacristia>, visa facilitar o acesso à informação científica e contribuir para o conhecimento do convento por parte do público geral ou de especialistas.

**PALAVRAS-CHAVE:** documentação digital; patrimônio virtual; realidade virtual; realidade aumentada; plataforma online

#### ABSTRACT:

Digital technologies contribute to access, knowledge and interaction with the historical heritage. From this stimulus, the user gets to know the patrimonial asset, as well as tends to visit, appreciate and preserve it. This may help to promote tourism and strengthen local culture. This article aims to present different forms of interaction with heritage through remote and virtual communication resources. The patrimonial asset analysed is a convent named Santo Antônio do Cairu, located at the municipality of Cairu, in the state of Bahia, Brazil. This study presents a virtual visit to the Convent through photographic panoramas. The lavabo is highlighted, which has been digitally reconstituted by Dense Stereo Matching (DSM) technique. The results are available for visualization and interaction in Virtual Reality (VR) or Augmented Reality (AR). From these resources, a website has been created for the user to easily interact with the virtual elements and to access the information about the historical and architectural details of the sacristy. This content, available on the website <https://conventodecairu.wixsite.com/sacristia>, seeks to facilitate the access to scientific information and to contribute to the diffusion of the knowledge regarding the convent amongst the general public and the specialists in the field.

**KEYWORDS:** digital documentation; virtual heritage; virtual reality; augmented reality; online platform

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## INTRODUCTION

The preservation of historical and cultural heritage is a latent problem in several places in the world, especially in peripheral countries such as Brazil. The architectural heritage reflects cultural, social and economic issues of society in its historical path. Despite its relevance, the heritage is susceptible to being devastated by several factors, such as wear and tear of time, bad weather, attacks by human actions, natural disasters or abandonment. Because of these losses, the importance of the documentation regarding the cultural heritage in order to preserve its memory is evident. However, to develop an awareness of preservation, it is necessary to know the trajectory of the cultural good (regardless of whether it is material or not) throughout history. Stimuli are needed to bring history closer to the daily life of the population, so that people understand the relevance of preserving the past to ensure the continuity of information for future generations, involving the issue of historical responsibility. In this sense, digital technologies can be an important ally in the documentation, access, and preservation of cultural heritage, through the interaction and knowledge necessities to value the historical heritage. Considering this stimulus, the user gets to know, tends to visit, appreciate and preserve the heritage. This can contribute to the promotion of tourism and the strengthening of cultural identity.

The architectural documentation was, for a long time, associated with the cadastral survey by direct measurement. However, due to great technological development, new tools were added to help obtain several types of products. Among the new technologies, it is possible to mention Photographic Panoramas, Videos, Digital Photogrammetry (interactive processes), Dense Stereo Matching – DSM, 3D Laser Scanning, which increasingly facilitate the delivery of products such as rectified photos, orthophotos, drawings and geometric models. Thus, these technologies are extremely important for the preservation of cultural heritage and can also be used in virtual museums (ARAUJO; GROETELAARS; AMORIM, 2018).

In this study, was carried out a website for the Convent of Santo Antônio of Cairu, located at Cairu municipality, in the state of Bahia, Brazil. The website (<https://conventodecairu.wixsite.com/sacristia>) was created to provide different ways of interacting with the virtual heritage, mobilizing, for that, tools such as Virtual and Augmented Reality. The products shared on the website are presented through a virtual tour of the Convent, composed of photographic panoramas, and are based on a virtual reconstruction of the lavabo, using the Dense Stereo Matching (DSM) technique. In addition to these results, the website presents historical information obtained through this study about the sacristy and offers a section with questions and answers for the user to check if the content provided was absorbed. In this way, the heritage can be accessed anytime, in any location, and with additional information, enriching the experience. This virtual experience works as a method that increases cultural fruition on the part of any audience interested in the subject, without, therefore, having to configure a specialist in the topic in question to understand the information provided.

The paper is composed of the following sections: “Introduction”, “Convent of Santo Antônio of Cairu - An historical approach”, “Digital technologies and historical heritage” — in which a state-of-the-art review was made concerning different techniques of documentation, visualization and interaction in architectural heritage —, “Methodology and Results” — part in which the process of creating virtual content is discussed —, and “Conclusions”.

## CONVENT OF SANTO ANTÔNIO OF CAIRU

The municipality of Cairu, located in southern Bahia, 292km (or 140km by ferry boat) away from the capital, is composed of numerous islands, such as: Cairu, Boipeba and Tinharé. In the town of Cairu, there is the Convent of Santo Antônio of Cairu, a highlight in Brazilian religious architecture. The convent was declared a heritage building by the *Instituto do Patrimônio Histórico e Artístico Nacional* (IPHAN) <sup>i</sup> in 1941 <sup>ii</sup>, because of its historical and cultural importance. This convent presents a Franciscan architecture with baroque manifestations and functioned as a prototype for other convents, including those of Santo Antônio of Paraguaçu and São Francisco of Conde.

Its construction dates the 17th century, when Cairu was an important production center of flour, wood and sugar. However, in the 19th century, the convent had already been abandoned. This happened because, since the 18th century, the Portuguese Crown established several decrees to reduce the number of novices in Franciscan convents, resulting in their decadence (ARGOLO, 2009). At the end of the 19th century, the abandoned Franciscan convents served as a stay for religious men during yellow fever epidemics. According to the passage:

*[...] While yellow fever made its victims in the convents of Bahia and Recife, there were religious men not affected by the fever, retired by order of the hygiene to the convents of Paraguaçu and Cairu [...] The novices had gone to the convent of Cairu, with master Friar Niceto Oberborbeck. As old and abandoned as the convent was, its habitability conditions were better than those of Paraguaçu. The young novices had the same needs as those of Paraguaçu, and fortunately they showed the same spirit of sacrifice and love for Franciscan poverty [...] (Santo Antonio Magazine, 1942, p. 84)<sup>iii</sup>*

The Convent of Santo Antonio of Cairu, as well as its counterparts Paraguaçu, São Francisco of Conde and Santo Antônio of João Pessoa, follows the Franciscan façade, marked by the triangular shaped frontispiece, the presence of narthex, recessed steeple and cross. In the 18th century, the interior of the church, the sacristy, the chapter hall, the library and the cloister were decorated (FLEXOR, 2010).



**Figura 1.** Façade of the Convent of Cairu

**Source:** Personal archive, 2019

## THE SACRISTY

Accessed by the Via-Sacra and located behind the main chapel, the sacristy is the noblest room of the convent, where objects associated to the liturgy are kept. It is also used by the priest in preparation for the liturgy. As well as other Franciscan sacristies located in the Brazilian Northeast, this one in Cairu has its furniture composed of a retable, a chest with two modules topped by paintings with religious themes, and two jacaranda built-in closets with drawers. There is the presence of a lavabo in lioz limestone, which, besides its hygienic function, it is also a tool mobilized to the action of purification needed for the preparation of the priest.

The Franciscan convents of the province of Santo Antonio, founded in the Northeast region, in the states of Pernambuco, Bahia and Paraíba, were analyzed. The sacristies of the convents of Olinda and Igarassu, in Pernambuco, João Pessoa, in Paraíba, São Francisco and Third Order of São Francisco, in Salvador, Bahia, have the above-mentioned furniture, with a few variations. The lavabo can be in a dome-shaped niche or not; the floor alternates between rustic ceramics, marble and wooden planks; the walls are covered with tiles at different levels of height and the painted wooden ceiling can be flat, in frames or in central medallion.

**Figure 2:** Façade of the Convent of Cairu

**Source:** Personal archive, 2019



The sacristy of the Convent of Cairu has baroque features and has recently been restored. The walls are covered with Portuguese tiles up to the ceiling, at a height of almost 3,80 m. The illustrations of these tiles frame the doors, windows and furniture, marking boundaries with the ceiling and floor, finished with a skirting of marbled manganese tile. The panels are decorated with whorls, seraphim, cherubim, architectural motifs and rococo designs.

The oil painted wooden ceiling, in the illusionist style, was quite degraded before the restoration. According to Argolo (2009), it presented a thick layer of fungi and grime, and holes caused by xylophagous insects. After interventions, it was possible to recover the painting original colours. The main theme of the painting is a tribute to the patron saint of the convent, Santo Antônio, whom happens to be represented in an image located in the central part of the work of art, along with Child Jesus and Virgin Mary. There is the presence of angels, cherubim and architectural elements represented as well. Due to the richness of the work, Argolo (2009) attributes the authorship to José Joaquim da Rocha, the greatest Bahian painter of the period.

As to the furniture, there are two jacaranda built-in closets with drawers. They present characteristics of the rococo style, but the drawers display a Renaissance influence. Composed of the same material, there is a chest of two modules divided by a central retable. The chest has drawers and brass handles (FLEXOR, 2010). At the top, there is a backboard with paintings alluded to Mary's life. Concerning the authorship of these paintings, Carlos Ott attributes it to José Joaquim da Rocha, supposedly dating 1786 (ARGOLO, 2009). Flexor (2010) disagrees on this attribution and affirms that the authorship is anonymous. The retable, with the Christ



crucified, was made in baroque carving with traces of rococo. On the upper portion, there is a dossal with a curved cut and lambrequins, similar to the one on the tile that frames the lavabo.

The lavabo, sculpted in lioz limestone and Estremoz marble, has a backdrop cut in curves and has two intertwined dolphins with taps in their mouths. These are replacements for the original spouts. On the upper part, there is a coat of arms of the Franciscan Order and a royal crown, relating the Portuguese monarchy to the Franciscan Order. On the side walls, towel racks with gilded fronts were installed (ARGOLO, 2009). The lavabo is framed by illustrations, on the tile, of seraphim opening curtains, creating a theatrical scene, typical of the baroque (FLEXOR, 2010).



**Figure 3:** Lavabo of the Convent of Cairu.

**Source:** Personal archive, 2019

## DIGITAL TECHNOLOGIES IN HISTORICAL HERITAGE

The architectural heritage is exposed to different weather conditions and different devastation factors. Digital documentation is a way to preserve heritage memory and facilitate remote access to the building. There are different technologies to register a heritage and to allow virtual access. This paper focuses on two types: photographic panoramas and point cloud by Dense Stereo Matching (DSM) technique. This section also deals with two types of visualization and interaction: Virtual and Augmented Reality. Examples of application of virtual technologies in cultural heritage are also discussed.

### DIGITAL DOCUMENTATION

As already mentioned, the main techniques for architectural documentation are: Direct Measurement, Digital Photogrammetry (interactive processes), Dense Stereo Matching – DSM, 3D Laser Scanning, Photographic Panoramas and Videos. The choice of technique to be used depends on a few points, such as the characteristics of the object and the purposes of the model (GROETELAARS, 2015). This section approaches two of them: Dense Stereo Matching (DSM) and photographic panorama.

Dense Stereo Matching (DSM) is a geometric modelling technique based on point cloud generation obtained by automated processing of photographic images. This process consists of the automatic correlation of sets of homologous pixels in different photos, thus resulting in the point cloud or irregular triangular mesh (Triangular Irregular Network - TIN) (GROETELAARS; AMORIM, 2012). Point clouds are the primary products of DSM technique, allowing the surfaces of objects to be represented by Cartesian coordinates (x, y and z). Due to its lack of topology, it is a type of model that presents limitations, and it is generally used as a resource to the generation of other types of products. One of these products is the Triangular Irregular Network (TIN), which is generated from the triangulation of the point cloud. TIN mesh is a type

of model suitable for representing complex and irregular objects. The downside of this type of model is that it requires a lot of storage space (GROETELAARS, 2015).

The DSM technique can be used to document objects of different dimensions and levels of complexity. Each part of the object should be photographed in at least three different positions, so that there is a high overlap between the shots. A complete photographic survey of the object should be carried out under the same lighting conditions, in order to avoid records with variations of shades on the same object. The element to be photographed should have a non-uniform texture surface, so that the automatic correlation is performed correctly, and it is possible to identify the different sets of pixels (GROETELAARS; AMORIM, 2012).

Araujo, Groetelaars and Amorim (2018) present a comparative study of Dense Stereo Matching (DSM) tools to generating point cloud from digital photogrammetric restitution. A comparison was made between four tools: Photoscan (Agisoft), 3DF Zephyr Free (3Dflow), Remake (Autodesk) and Recap 360 (Autodesk). It was possible to evaluate the potential of the DSM technique for the documentation of an architectural element. The four tested tools presented user-friendly interface and generated high quality products. Autodesk Recap 360 is designed to enable editing and viewing of point clouds, either by laser scanning or by DSM (ARAUJO; GROETELAARS; AMORIM, 2018).

The photographic panorama is a photographic record that allows the visualization of the environment in 360°. Thus, the user can browse the virtual environment by moving the camera in three degrees of freedom and with the possibility to zoom in and zoom out. However, the photographed environment can only be viewed from one point: at the station where the photo was taken. To minimize this aspect, the photographic panorama is associated with the virtual tour, an application that makes it possible to integrate several panoramas in a previously established route on a map or location plan. This feature expands the possibilities of viewing the represented space by integrating new observation points (SANTOS; AMORIM, 2010).

Unlike the architectural documentation carried out by the DSM technique, the photographic panorama does not collect volumetric measurements. Despite this lack of information, it is a quick way to digitize and to make possible a virtual visit to the heritage.

## TYPES OF VISUALIZATION AND INTERACTION

Mixed Reality is a concept introduced by Milgram and Kishino (1994), defined as a taxonomic line that encompasses the different types of realities. At one end is the real environment and at the other end is the Virtual Reality (VR). In the interval between them are Augmented Reality, the virtual elements superimposed in the real world, and Augmented Virtuality, the superimposition of real elements in the virtual environment. In the Virtual Reality all the elements are virtual as well as the environment.

Pimentel and Teixeira (1995) defined Virtual Reality as the use of high technology to convince the user that he is in another reality. To make the feeling of immersion and interactivity possible, it is necessary to use some devices, such as visualization displays: headset, mobile devices, monitor or Cave Automatic Virtual Environment (CAVE), haptics (digital gloves, controls, mouse, keyboard or touch screen) and hearing aids (integrated or non-integrated phones) (KIRNER; SISCOOTTO, 2007).

The degrees of immersion are different depending on the device. Regarding the experience in Virtual Reality through a computer or mobile device, the user knows that he is not fully inserted in the virtual environment. For visualization to be considered immersive, it is necessary to visualize it through a Cave Automatic Virtual Environment (CAVE) or with Virtual Reality headset. In the last one, the visualization of the screen is duplicated in similar slightly angled

images, which simulate the effect of natural stereoscopy. Stereoscopy is the ability to see in three dimensions from the parallax - difference in the apparent position of an object seen from two different angles. In the brain, there is a combination of the images captured by the left eye and the right eye in a single image with depth (DE FARIA; FIGUEIREDO; TEIXEIRA, 2014). Thus, with the sensation of depth, the user tends to think being in the simulated location, and this sensation increases depending on the quality of the equipment and the image used.

Unlike Virtual Reality, which transports the user to the virtual environment, Augmented Reality is the enrichment of the real environment with virtual objects, using some technological device operated in real time (KIRNER; TORI, 2006). Augmented Reality can be seen in two ways: in direct and indirect vision. In direct vision, real world images can be seen with the naked eye or brought through video, while virtual objects can be projected into the eyes, mixed with real world video, or projected into the real scene. In indirect vision, real world and virtual world images are blended into video and shown to the user.

The devices that can be used are: optical helmets (direct optical view), micro-camera attached helmets (direct video view), monitors or projectors (KIRNER; TORI, 2006). There are also two forms of Augmented Reality tracking: with markers, normally using black and white geometric patterns (QR code), and without markers, through volumetric recognition or georeferencing.

For viewing in Virtual or Augmented Reality, it is necessary to upload the products on an online platform. The 360° panoramas can be viewed in Virtual Reality through various platforms, such as: Google Tour creator, *Meu passeio virtual*, among others. The first platform allows to upload panoramas separately, while *Meu passeio virtual* allows the creation of a virtual tour, with several interconnected panoramas. The 3D reconstruction can be interacted in Virtual Reality through an online platform called Sketchfab, which provides a 3D model viewer that works on any mobile/desktop web page or VR headset. It allows the user to move freely around or within the 3D scene. This platform has a system that provides a high-performance and high-quality rendering engine (SCOPIGNO et al., 2017). Sketchfab is used for interactive viewing of 3D content in general, but it offers a category dedicated to Cultural Heritage & History, which can be uploaded by cultural institutions or amateurs (STATHAM, 2019). The 3D reconstruction may also be viewed in Augmented Reality through the application called Augment. This application generates a QR Code that allows the visualization of the object in Augmented Reality by mobile device. Therefore, the user can view the virtual object in the real environment, get closer to it and look at it from any angle.

## VIRTUAL HERITAGE

As already mentioned, heritage is prone to be devastated by various factors, so digital documentation plays a fundamental role in preserving the memory of a heritage, as well as the geometry and details of the building. An example of digital documentation applied to heritage is the National Museum at Quinta da Boa Vista, in Rio de Janeiro. In 2018, the Museum was seized by a large fire caused by an air conditioning overheating. Consequently, a historical and scientific collection built over 200 years was destroyed. Because of the digital record, it is possible to virtually walk around the museum rooms and see them at their original state, before the incident, through 360° panoramas in virtual reality available on the Google Arts & Culture platform.

Victorio (2019) addresses the use of photo-restitution by Dense Stereo Matching (DSM) in the generation of high-resolution geometric models for terracotta sculptures. The work points the importance of the process of documentation using images as a source of data to meet scientific and investigative demands both in History and in the Science of Art. The study proves that the DSM technique meets the technical demands to produce a high-quality model and can provide

the detailing of topology and texture effectively. Such a conclusion ensures the use of photo restitution as a safe and low-cost technology for the series production of documental representations by geometric models of sculptures, without the need of additional steps concerning the editing software (point cloud and TIN mesh) (VICTORIO, 2019).

The paper by Gherardini, Santachiara and Leali (2019) addresses the experimentation of recontextualized artifacts and establishes possible links between them, offering engaging experiences to improve accessibility as well as stimulating the fruition of artifacts outside the museums as well, suggesting, then, new approaches. The paper is developed in two stages: first, the digital documentation of real artifacts, and second, their integration into an augmented reality application in order to insert digital artifacts and their annotations in the real world.

A work that highlights the importance of the website to share a virtual heritage is the article produced by Previtali (2019). The paper presents the development of a virtual logbook for the San Clemente archaeological site in Albenga, Italy. The material can be used by experts and tourists and viewed through a web environment by desktop and mobile devices. They have created a shared digital platform to connect all the different types of information in a unique virtual environment aiming to increase the dissemination of these elements to tourists and experts. A large volume of documentation is available on the San Clemente website, such as 360° panoramas, orthophotos, digital drawings, point clouds, historical information, and texts.

According to the examples of the previous cited studies, it is possible to observe the advantages produced by the use of digital documentation and interaction with the architectural heritage. In the National Museum at Quinta da Boa Vista, several photographic panoramas of the environments allowed the preservation of its memory even after the incident that physically damaged the museum. In Victorio (2019) it was proven that the use of photo-restitution by Dense Stereo Matching (DSM) is a safe and low-cost technology. In Gherardini, Santachiara and Leali (2019) was addressed the use of Augmented Reality in digitalized artifacts as a method that stimulates the cultural fruition. In Previtali (2019), the creation of San Clemente website made it possible to compile and provide historical information joined to 3D products about the archaeological site.

In this paper of the Convent, architectural documentation was carried out using the DSM technique and photographic panorama. Two types of visualization and interaction were applied: Virtual and Augmented Reality. A website was also created to gather these products with historical information. The following section detail the whole process of creating the virtual tour of the Convent of Cairu, the 3D reconstruction of the lavabo and the website.

## **METHODOLOGY AND RESULTS**

This section presents the development of the Convent's virtual tour, the 3D reconstruction of the lavabo and the creation of the website to combine these results with historical information about the place. This website aims to facilitate access to scientific information and to contribute to the knowledge of the architectural heritage for the general public or specialists. The goal of this website is not to replace the physical tourism by the ubiquitous, but to stimulate the user to visit the site and to provide heritage information by digital platforms.

### **VIRTUAL TOUR OF THE CONVENT OF CAIRU**

In this study, 20 spherical panoramas were generated, including: façade, narthex, vestibule, nave, main chapel, cloister, via sacra, sacristy, chapter hall, circulations and refectory. This paper focuses on the sacristy, so six panoramas of this same enclosure were created, that is, six different observation points. The path that the user will take derives from the points that were



considered *in loco*, therefore some rooms may have more than one route available, such as the cloister. The user may advance, return and promote rotations in each point of viewing.



**Figure 4:** (a) Simultaneous captures from the front and background camera; (b) Spherical panorama after the unification of the two registers; (c) Spherical panorama viewed from the web platform; (d) Spherical panoramic for the VR headset mode

**Source:** Elaborated by the author

For the development of the virtual tour, photographic records were made by the Gopro Fusion Camera. The camera was positioned at all points of capture in order to get frames from all angles of each particular point. The recorded files are double photographs taken by the frontal and background cameras, which are unified by the Gopro Fusion Studio software. The result is a spherical panoramic photograph uploaded into a web visualization platform, such as *Meu Passeio Virtual*. Through this web platform, it is possible to create a planned path establishing a connection among the panoramas, resulting in the virtual tour. In *Meu Passeio Virtual*, the tour can be viewed through the web interface or in the Virtual Reality headset viewing mode. Figure 4 shows the types of visualization of the mentioned photographic records and Figure 5 exposes the process of creating the virtual tour.

The recorded photographs had interferences related to the presence of people. The most appropriate would be to use a tripod so that there are no spaces hidden by the present people. The resolution of the photographs is not high, which hinders the contemplation of details. However, despite these negative points, the study satisfies the role of allowing the user to know the place and offers cultural information.



**Figure 5:** Workflow of the Virtual Tour development

**Source:** Elaborated by the author

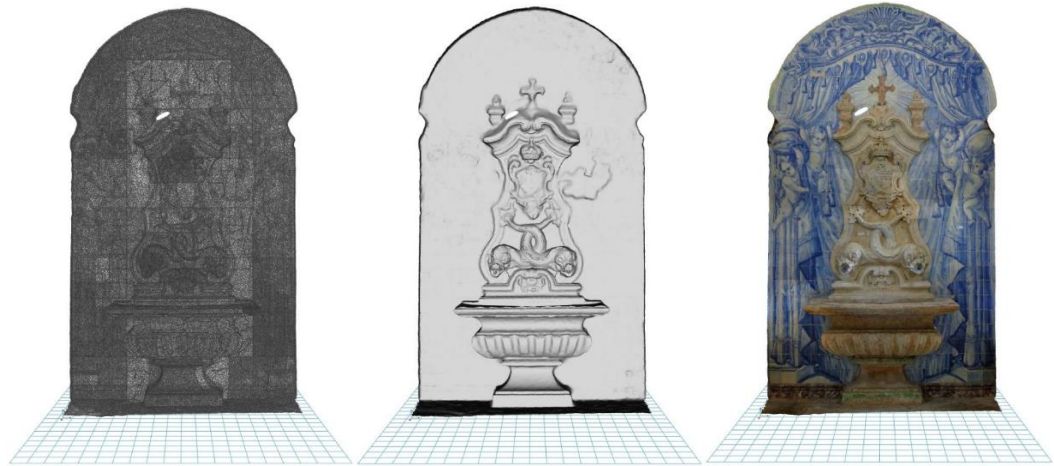
### 3D RECONSTRUCTION OF THE LAVABO

From the analysis of the sacristy of the Convent of Cairu, it is possible to observe the importance and complexity of many elements. Each piece of furniture, or coating, represents a

historical and cultural context that is admirable in terms of artistic appreciation. However, the lavabo has been chosen to be digitally reconstructed because of its geometric complexity, richness of details and theatrical scene, reinforced by its location in a dome-shaped niche and by the illustrations on the tiles that frame the artistic item.

**Figure 6:** Lavabo virtually reconstituted viewed in the following modes: wireframe, solid and textured

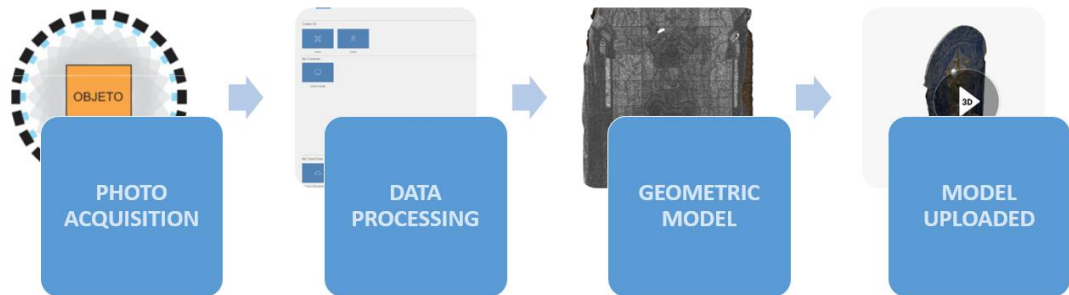
**Source:** Elaborated by the author



The lavabo, element of the sacristy, was virtually reconstructed using the Dense Stereo Matching (DSM) technique. The element was photographed by a Sony DSC-W630 camera, following the requirements to reconstitute multiple converging photographs, what demands photographing the object in various overlapping positions. From the capture of geometric information, Autodesk Recap software was used to read the data, process it and automatically create a geometric model. The generated model is shown in triangular mesh (TIN - Triangular Irregular Network) and was obtained from three-dimensional coordinates of the point cloud. Figure 6 shows the geometric model of the lavabo virtually reconstituted and Figure 7 illustrates the process of its digital documentation.

**Figure 7:** Workflow of digital documentation from the DSM technique

**Source:** Elaborated by the author



The geometric model achieved a satisfactory level of refinement, with a high density of points, and allowed the whole reconstitution of the lavabo. There were only a few small parts difficult to capture, on the top and sides. In the coat of arms, a detail in the lavabo, there was lighting interference, which is not appropriate, making some parts of the textures more illuminated than others. However, this problem does not totally injure the understanding of the model. The model of the lavabo was cut out, leaving only the wall where the lavabo is installed. The volumetry was exported in OBJ format and uploaded in the Sketchfab webpage<sup>iv</sup> (Figure 8a). On this digital platform, it is possible to add hotspots with text information about the lavabo. The user can observe it, zoom in, zoom out and rotate the entire geometric model lightly and easily. Through interactivity, it allows the observation of a greater number of details and the understanding of the object as a whole.



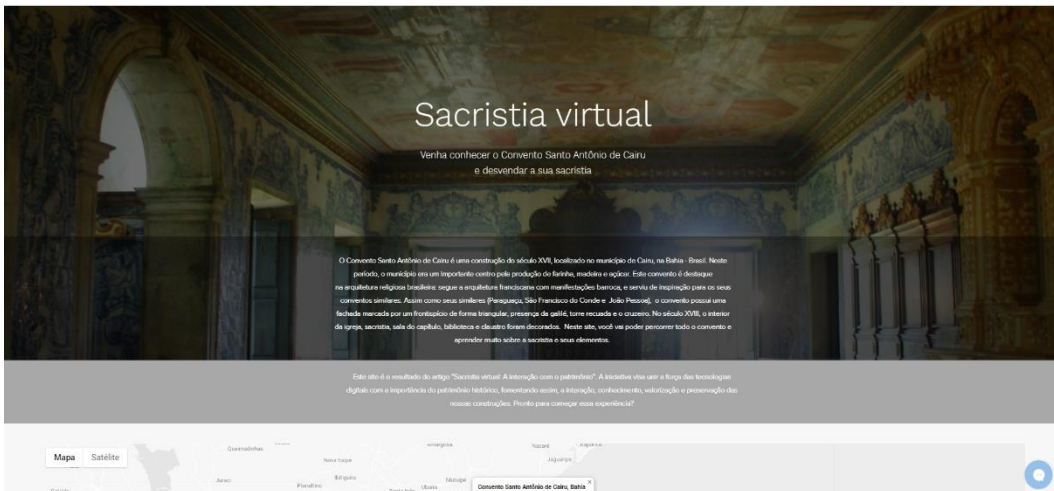
**Figure 8:** Lavabo viewed from Sketchfab (a), from Augmented application (b) and the QR code (c)

**Source:** Elaborated by the author

Besides this type of interaction, it is possible to view the object using another method: Augmented Reality. The volumetry exported in OBJ format was also uploaded in the Augment webpage. This platform generates a QR Code that allows the visualization of the object in Augmented Reality by a mobile device. The Augmented Reality enables to view the virtual object in the real environment, as shown in Figure 8b. Through the mobile’s camera, the user chooses the place to fix the lavabo in the environment. Once the object is fixed, it is possible to get closer to it and to look at it from any angle, as if the lavabo was in the real environment.

**THE WEBSITE**

From the digital documentation of the Convent of Santo Antônio of Cairu and the deepening of the architectural and historical content of this heritage, it was possible to have enough material to create a website. The website brings together the results obtained in this study and enables the virtual interaction with the convent. It may be accessed through the link <https://conventodecairu.wixsite.com/sacristia> and is divided into the following sections: Cover; Sacristy; Lavabo; Quiz; Participate.



**Figure 9:** Cover of the website

**Source:** Elaborated by the author

Cover: The cover of the website (Figure 9) presents a photo of the sacristy with the title: “Virtual Sacristy: Come and visit the Convent of Santo Antônio of Cairu and discover its



sacristy”. Then, there is a text that addresses the historical context of the convent and its characteristics. There is also a location map and a brief explanation of the development of this study. In the initial page, there is the possibility of accessing four sections, as seen in Figure 10.

**Sacristy:** In this section, the visitor is directed to a virtual tour through the convent and is encouraged to circulate through the rooms to find the sacristy. Upon arriving at the sacristy, there are some hotspots distributed by the photographic panoramas with information about the room, coverings and furniture. In the initial section, there is a “more information” button, which takes the user to a new page with a description of how the virtual tour was created.

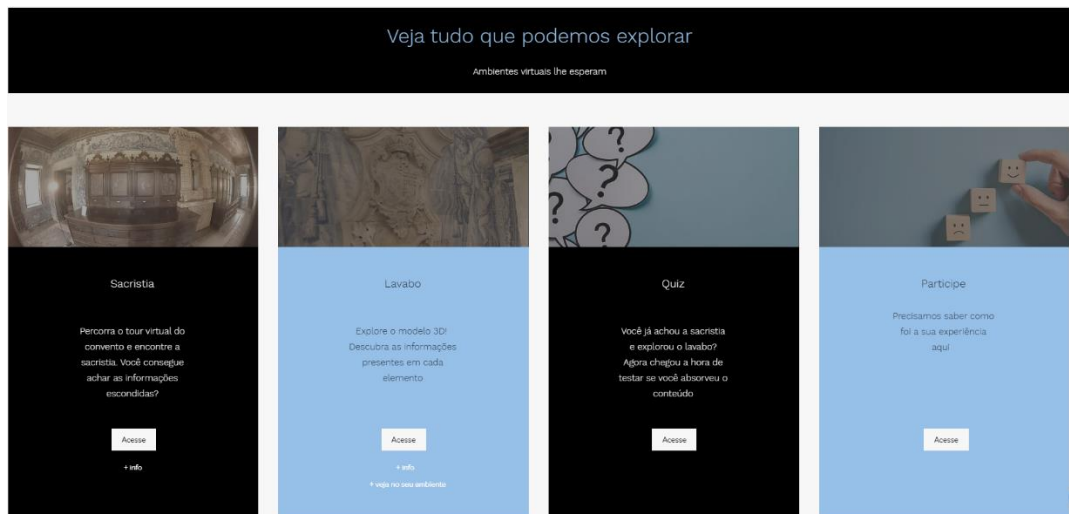
**Lavabo:** This section allows interaction with the 3D reconstruction of the lavabo. In the initial section, there are three buttons. The first one is “Access”, which takes to the Sketchfab page. In Sketchfab, there is the 3D reconstruction of the lavabo with hotspots containing descriptions. The second button displays “More information”, and exposes the process of creating a geometric model. And the last one, “View in your space” leads to the Augment page. In this page, there is a QR code to access the model through the camera of the mobile device.

**Quiz:** The section offers a quiz about the content presented in the virtual tour and in the 3D reconstruction of the lavabo. The quiz allows the user to check how much has been absorbed from the content available on the website. The questions refer to the architectural style of the sacristy, furniture, details on the coverings and paintings.

**Participate:** This section presents a form for users to share how the experience was. The data were not collected in this study, however, they may be used for a future work. In the form, the user is asked to fill in his or her name, profession, city and state. The four items for evaluation are the virtual tour, the 3D model, the 3D model in your space and the quiz. The user can evaluate each item on a score from 1 to 5, being 5 the highest score. At the end, there are three questions: “Were you interested in knowing more about this convent?”, “What did you like most and least about this website?” and “Did you read our scientific article?”. The website also has a chat window, so that the visitor has the possibility to contact the author.

**Figure 10:** Sections of the website

**Source:** Elaborated by the author



## COMPARISON OF RESULTS

During this paper, were created different products with the intention of gathering and sharing several ways of interacting with the virtual heritage. Visualizations in Virtual and Augmented Reality were easy to implement and user-friendly. Both tools enable dynamic interaction with virtual heritage and can be easily accessed from any mobile device.

The photographic panorama and 3D reconstruction are two different ways of registering the heritage. These two products complement each other and are used for different purposes. Experimentation through photographic panoramas is more limited because it has pre-defined paths, something that does not happen with reconstitution by DSM technique. However, the use of the panorama is faster and easier to carry out because it only requires one photograph of the place which can perfectly portray it. In this work, the virtual tour made it possible to get to know different environments in a noticeably clear way. It would be interesting to have more panoramas, such as, for example, to give the user the possibility of going around the cloister. In addition, it would be even more enriching if there were more hotspots with information along the virtual tour and not only in the sacristy. As for the means of visualization, the user will probably use the monitor or mobile device, but for the immersive experience, it is necessary to use Virtual Reality headset.

The 3D reconstruction, by DSM, generates a file that allows the user to have more freedom. The object can be seen from any point and at any distance. However, this last experiment produces more errors during its development since a 3D reconstruction of the existing volumetry is a more complex process. Some surfaces were not processed correctly, probably due to a lack of sufficient photographs. However, the use of the DSM technique to document objects proved to be valid. The reconstruction of an entire environment with a lot of details, or the representation of a large building, depends on several pictures taken correctly and results in a heavy and difficult file to be handled. Moreover, upload platforms for online viewing have a maximum limit regarding the size of the file to be uploaded.

## CONCLUSIONS

Cultural heritage has been lost due to the absence of value attributed to traditions as well as due to the lack of a sense of belonging and weak heritage education. This paper deals with an initial work and offers only a sample of what can be done for the dissemination of a heritage. Mobilizing the association between a heritage displayed through 3D visualization and cultural information, it was possible to share the importance of documenting, interacting, and preserving historical patrimony to ensure its longevity, either virtually or physically. As a result of the fact that digital content can be shared with an audience at any location, knowledge about a given construction may be available to a greater number of people. The material can be viewed through a web environment by desktop and mobile devices. This work did not collect statistical information about the validation of the interaction with the developed content. However, it was shared with a small group of people, including professionals in the field and the general public. Both audiences were interested in learning more about the Convent of Cairu after interacting with the present content of the website, developed during the realization of this paper.

This would only be the first stage in the process of cultural enjoyment of heritage through digital technologies. A possible unfolding that would complement it would be a deeper development of the gamification associated to the heritage through the software Unity or Unreal. For architectural heritage that cannot be physically documented, or because it no longer exists or due to its state of ruins, it would be interesting to generate a computer-based visualization. It would be a 3D reconstruction made from paradata, following the recommendation letters of the Sevilla Principles and the London Charter. This paper does not aim to exhaust the subjects of heritage education, digital documentation and types of visualization, neither focus on historically undress the heritage, but to demonstrate, from a visual experimentation, different ways of virtually interacting with the heritage. The study ratifies the relevance of preserving historical heritage and seeks to contribute with the



dissemination of the Convent of Cairu through the utilization of its website, namely <https://conventodecairu.wixsite.com/sacristia>.

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## Notas

<sup>i</sup> Brazilian Institute of Artistic and Historical Heritage.

<sup>ii</sup> Under process 258-T, registered in the **Book of Fine Arts**, page 55, on 17 October 1941.

<sup>iii</sup> Text was translated by the author. The passage of the Santo Antonio Magazine was taken from the online platform **Memoria Bn**. This website puts together several magazines and newspapers scanned from different centuries.

<sup>iv</sup> Available at: <<https://skfb.ly/6RZwl>>.