Information computer system with a virtual tour for cultural heritage preservation of the Zbarazh Castle Museum's exhibition hall

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Abstract

This paper presents the development and implementation of an information system with a virtual tour of the exhibition hall at the Zbarazh Castle Museum, part of the National Reserve "Castles of Ternopil region". The project aims to digitize and showcase the collection of 18th-19th century sacred wooden sculptures, as many of them have been affected by time and environmental factors, necessitating restoration efforts. Despite their significant artistic and cultural value, these sculptures have never been displayed to a broad audience. Commissioned by the Ukrainian Cultural Foundation, the digitization of these artworks not only aids in their preservation but also enhances accessibility and engagement with the museum's collection for a global audience.

The paper describes the stages of the project, including the conceptual design, technical preparation, data integration, and final implementation. The use of photogrammetry and panoramic imaging techniques, provides a comprehensive method for the documentation and preservation of cultural heritage, setting a new standard for museums and cultural institutions.

Keywords

virtual tour, cultural heritage preservation, 3D modeling, virtual reality, photogrammetry.

1. Introduction

The preservation of cultural and historical heritage is a critical task for museums and cultural institutions worldwide. The Zbarazh Castle Museum, a part of the National Reserve "Castles of Ternopil region", holds a unique collection of sacred wooden sculptures from the 18th and 19th centuries. These artifacts, while possessing significant artistic and cultural value, have remained largely inaccessible to the public due to their delicate condition. These sculptures face various preservation challenges due to their susceptibility to environmental factors such as humidity,

temperature and insect damage. Traditional methods of preservation and restoration are essential, but the integration of modern digital technologies offers additional powerful tools for safeguarding these invaluable objects.

In response to this challenge, a project was initiated to create a digital collection of these sculptures, allowing them to be preserved and presented virtually. This project, funded by the Ukrainian Cultural Foundation, focuses on developing an information computer system to create a virtual tour for the Sacred Wooden Sculpture Hall at the Zbarazh Castle Museum.

The virtual tour aims to provide an immersive experience, allowing users to explore the exhibition hall interactively. The use of photogrammetry to create 3D models of the sculptures enables the museum to document their current state in detail, aiding in both preservation and restoration efforts. Moreover, the integration of these digital tools enhances the accessibility of the museum's collection, enabling a broader audience to experience the cultural heritage of the Zbarazh Castle Museum remotely.

The project utilizes several cameras to capture high-quality images of the sculptures and their surroundings. These images are then transformed into 3D models and integrated into a virtual reality (VR) tour, providing users with an immersive experience of the museum hall. Furthermore, the project incorporates photogrammetry technique, allowing users to interact with the 3D models of the sculptures in a real-world environment through a dedicated application [1]. This integration of photogrammetry and panoramic imaging techniques not only makes the collection more accessible, but also enhances the educational and interpretive value of the exhibits [2].

The purpose of this article is to present the technical approach and practical implementation of a virtual tour system as part of a digitization effort at the Zbarazh Castle Museum. The objectives are to demonstrate how modern technologies can preserve and present cultural heritage, while also showing how these tools can enhance accessibility for a wider audience, allowing remote exploration of the exhibits.

2. Related works

In the context of digitizing historical and cultural objects [3], the primary challenges involve ensuring their long-term preservation and accessibility, while also addressing the physical and logistical limitations associated with their conservation and presentation.

Research [4] has highlighted the significance of virtual reality in the reconstruction of cultural heritage. Tools like Pano2VR facilitate the creation of interactive tours that enable users to deeply engage with historical contexts and interact with cultural objects, thus overcoming the constraints of physical access.

Author in [5] emphasizes the use of 3D modeling and VR technologies for the preservation and presentation of cultural artifacts. These technologies support the development of virtual tours that broaden access to cultural heritage for a wider audience, particularly for those who are unable to visit these sites in person.

Additionally, a study [6] on the use of digital technologies for the preservation of intangible cultural heritage discusses the potential of VR to create virtual tours that faithfully replicate traditional practices and crafts, ensuring their preservation for future generations.

The integration of digital technologies into the preservation process is further analyzed in another study [7], which advocates for the use of digital solutions such as virtual museums and

3D reconstructions to address the issue of physical access to artifacts. These digital equivalents offer accessibility from any location at any time.

These studies collectively underscore the importance of employing innovative technologies to ensure the long-term preservation and accessibility of cultural heritage in the modern digital environment [7], [8].

3. Development stages of the information computer system with a virtual tour for the sacred wooden sculpture hall

Figure 1 illustrates the step-by-step process for the comprehensive development of the virtual tour for the Sacred Wooden Sculpture Hall at the Zbarazh Castle Museum.
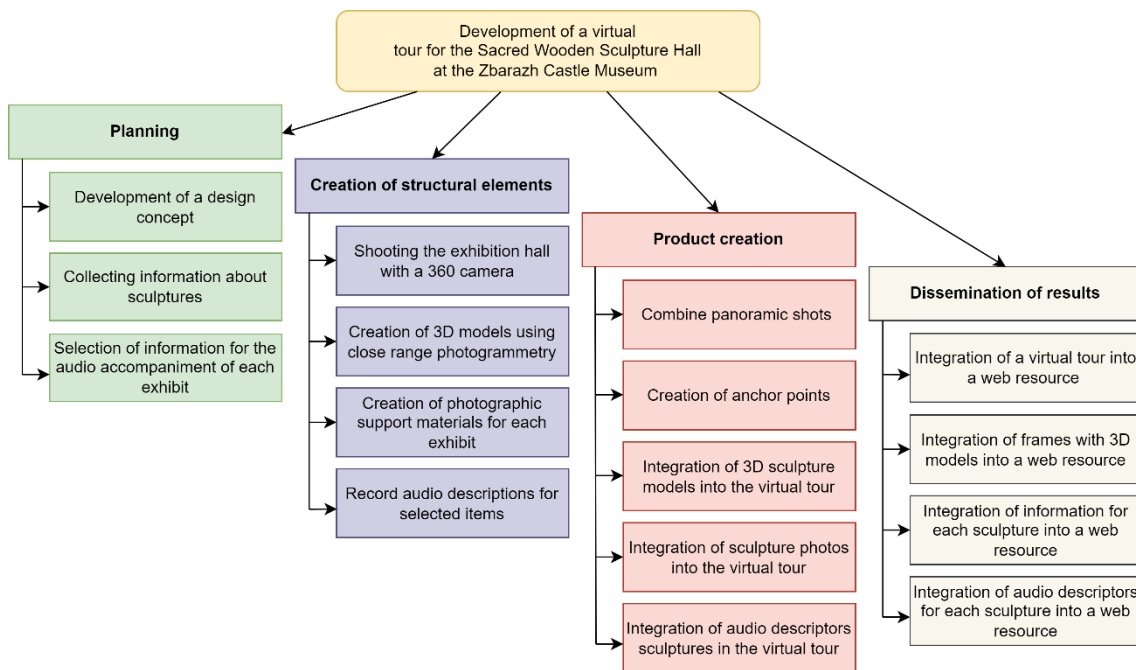

Figure 1: Stages diagram of creating a virtual tour for the Sacred Wooden Sculpture Hall at the Zbarazh Castle Museum.

The process of creating a virtual tour of the premises of Zbarazh Castle includes four main stages. The first stage involves the development of the design concept, the collection of detailed information about each sculpture, and the selection of relevant data for the audio guides accompanying each exhibit. This stage is fundamental in establishing the direction for further actions and forms the basis for creation the virtual tour.

The second stage, concerning the creation of structural elements, includes technical preparation. This involves shooting the exhibition hall using a 360-degree camera, creating 3D models of the sculptures based on photogrammetry, as well as generating accompanying photographic materials and recording audio descriptors. This stage ensures the gathering of all necessary elements to be used in the next phase.

The stage of product creation involves the integration and processing of the collected data. Panoramic images are combined with the identification of anchor points, while 3D models of

the sculptures, along with corresponding photographic materials and audio descriptors, are integrated into the virtual tour. This stage is crucial for forming a complete interactive product.

The final stage, implementation, involves the distribution and publication of the virtual tour. The main tasks of this stage include embedding the panoramic tour into a web resource, integrating 3D models, and ensuring the accessibility of detailed information about each sculpture and audio descriptors in the online environment. This structured approach ensures a systematic and scientifically grounded process for creating the virtual tour, which enhances accessibility to the Hall of Sacred Wooden Sculpture for a global audience.

4. Techniques for virtual tour creation

There are two main types of panoramic images: cylindrical and spherical, which can be obtained using linear, rotating panoramic cameras, or 360° cameras suitable for capturing high-resolution images. When using rotating panoramic cameras, photo stitching methods are necessary [9]. The first method is based on 3D scene reconstruction by stitching multiple spherical panoramas. The second involves capturing overlapping images from a single point using a camera rotating around the perspective center on a specialized tripod [10]. When using 360° cameras, photo stitching is unnecessary, as most modern 360° cameras are equipped with automated stitching functions, speeding up the virtual tour creation process.

To create a virtual tour of Zbarazh Castle, Pano2VR software and an Insta360 RS camera were utilized. The selection of Pano2VR was driven by its ability to easily integrate panoramic images and 3D models while providing an intuitive interface for creating interactive virtual tours. Insta360 RS was chosen for its high-resolution panoramic imaging capabilities and built-in photo-stitching, which significantly reduced processing time. However, both tools require careful calibration and adjustment to optimize output quality, especially when dealing with intricate details of sculptures. During development, photos were carefully selected for placement on the website, focusing on those near sculptures (see Figure 2).
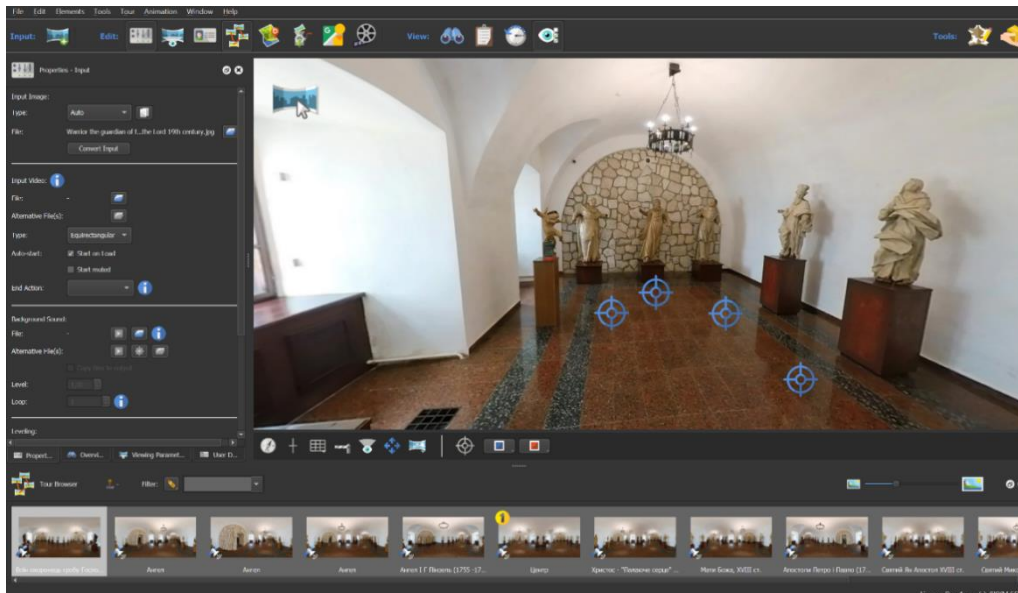

Figure 2: Development of virtual tour in Pano2VR software.

Compression ratios for images were tested to ensure optimal loading speed for the virtual tour without significant loss of quality. The selected images near the sculptures were integrated with the option of transition to a 3D model of the sculpture, enhancing the interactive experience for users.

Figure 3 illustrates the integration of images on a map within a virtual tour is a crucial element of enhancing users' spatial perception and navigation accuracy. This approach not only establishes a visual connection between the physical locations of objects or points of interest but also contributes to a deeper understanding of the site's context. Mapping the images allows users to gain more precise understanding of spatial relationships, leading to more thorough and informative analysis of the site. Additionally, the ability to integrate such tours on platforms like Google Maps significantly broadens the accessibility and popularization of cultural heritage, enabling users worldwide to interact with the virtual environment through familiar and accessible interfaces. This enhances audience engagement and supports the preservation and study of historical sites on a global scale.
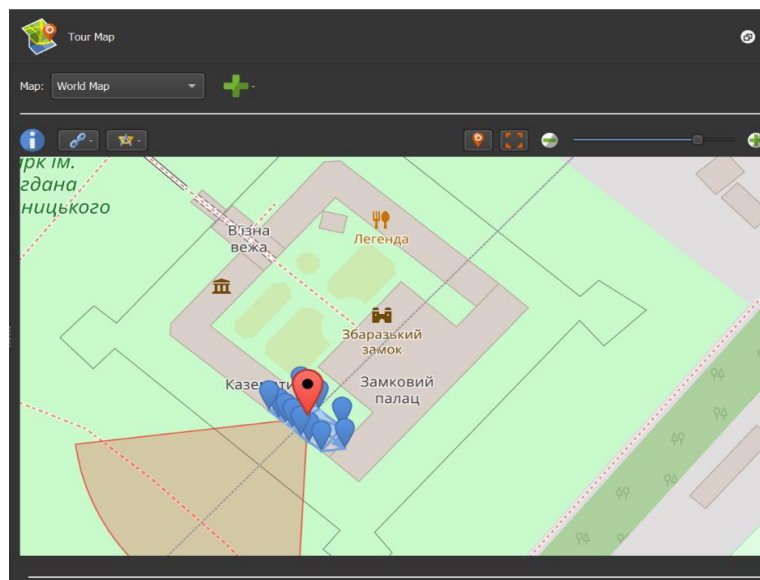

Figure 3: Placement of virtual tour points on the map.

5. Creating digital 3D models of sacred sculptures using photogrammetric method

One of the important activities of the National Reserve "Castles of Ternopil region" is the preservation and popularization of sacred heritage. The existing collection of sacred sculpture includes more than 40 exhibits of the 18th-19th centuries. However, some of these works of art have lost their exhibition appearance under the influence of time and various physical factors, and therefore require immediate restoration. The vast majority of exhibited sculptures are wooden, however, this material is prone to the destructive influence of external factors (humidity, temperature, insects, etc.) over time. That is why there is an urgent need to use modern computer technologies at present for the digitization of objects of historical and cultural heritage before carrying out conservation and restoration measures.

One of the ways to preserve the authentic look of sculptures is to create 3D models, for example, using close range photogrammetry. Photogrammetry is a powerful tool that allows to create detailed three-dimensional models of objects using a set of photographs (for a detailed introduction to the specifics of the technique when applied to museum exhibits, see, for example, [11], [12]). Such a modern and effective approach allows detailed documentation, analysis and preservation of cultural heritage, which is important for preserving unique works of art for future generations. In the case of preservation of sacred heritage, in particular wooden sculptures, this method has a number of undeniable advantages. First of all, there is a detailed recording of the state of the exhibits, you can record the smallest details of the sculpture, including cracks, chips and other damages. The resulting 3D model is a high-quality digital counterpart (with high-resolution texture) that can be used to monitor future changes and develop effective conservation plans. It is also worth noting that unlike traditional documentation methods, photogrammetry does not require physical contact with the sculpture. This is especially important for old and damaged objects, as it minimizes the risk of further damage. Let us point out that periodic scanning of the sculpture using photogrammetry allows monitoring changes in its condition, identifying potential problem areas of the exhibits and taking the necessary measures to eliminate them. The obtained photogrammetric data allow the creation of accurate three-dimensional models of the sculptures, which can be used for analytical detection of hidden defects, estimation of volume and other parameters, as well as the creation of digital templates for the restoration of lost fragments in case of restoration work.

According to the feedback of visitors of Zbarazh Castle, they would like to see more museum exhibits in free access, which are not presented in museum exhibitions. Therefore, at the request of modern society and with the development of new technologies and the gradual process of digitization of the cultural sphere, museums and other institutions that preserve cultural heritage have long needed modernization and the introduction of innovative forms of work with visitors. Close range photogrammetry, in combination with appropriate software, is able to generate 3D models that will serve as content for creating virtual tours and interactive models for studying sculptures from different angles.

Based on the photogrammetric method, 3D models of fifteen exhibits from the collection of sacred sculptures of the Zbarazh Castle were created within the project. When creating each model, processing of several hundred photos taken with the camera in high resolution was carried out (a Nikon D7000 SLR camera was used, which is equipped with a 16.2-megapixel Nikon DX format CMOS image sensor, which allows you to obtain realistic images with vivid colors and reduced noise level, the AF-S 18-105 mm f3 lens was used). The process of photographing the exhibits was carried out from an adjustable tripod (at least five circular passages at different heights), photographing involved partial overlapping of image zones taken at different viewing angles relative to the scanning object so that the appropriate software could accurately align the image. To obtain photographic materials for detailed texturing, additional pictures of important areas and details of each sculpture were taken.

Reality Capture software was used to create 3D models of exhibits from the sacred sculpture collection [13]. Based on a set of photos using a specialized algorithm, the program automatically analyzes the photos, detects common points between them, performs alignment (if necessary, errors can be corrected manually by adding control points). The generated dense point cloud, which represents the three-dimensional shape of the sculpture, is cleaned from noise and serves as the basis for a structured mesh – a three-dimensional polygonal grid, which

is a digital replica of the object (if necessary, the number of polygons is optimized to balance the detail and speed of working with the model). An important stage is the correction of errors related to the geometry of the model, for example, sometimes it is necessary to close holes, smooth out irregularities on the surface, etc. A high-resolution texture (not lower than 8k) is applied to the high-poly mesh after creating a low-poly model, the process of re-projecting the texture onto it is carried out (see image processing results in Figure 4).
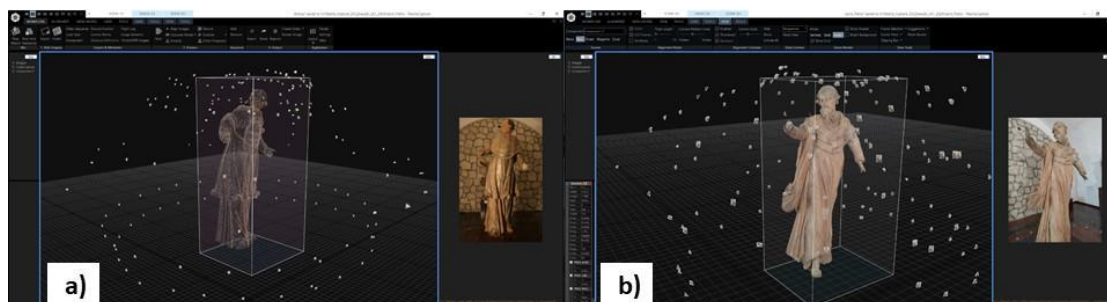

Figure 4: The process of creating 3D models of sacred sculptures in Reality Capture: a) work with a dense cloud of points; b) texturing of the model.

The created models were exported to FBX format in order to further create content for the exhibition VR environment, which will be developed on the Unity platform. A separate stage of the project is the integration of the created models of sacred sculpture into the 360-panorama and web resources of the National Reserve "Castles of Ternopil region". For this, the models were exported to OBJ format for placement on the Sketchfab platform [14] in the "Sacred Art" collection (see Figure 5) and linked to the relevant platforms through the integration of frame structures.
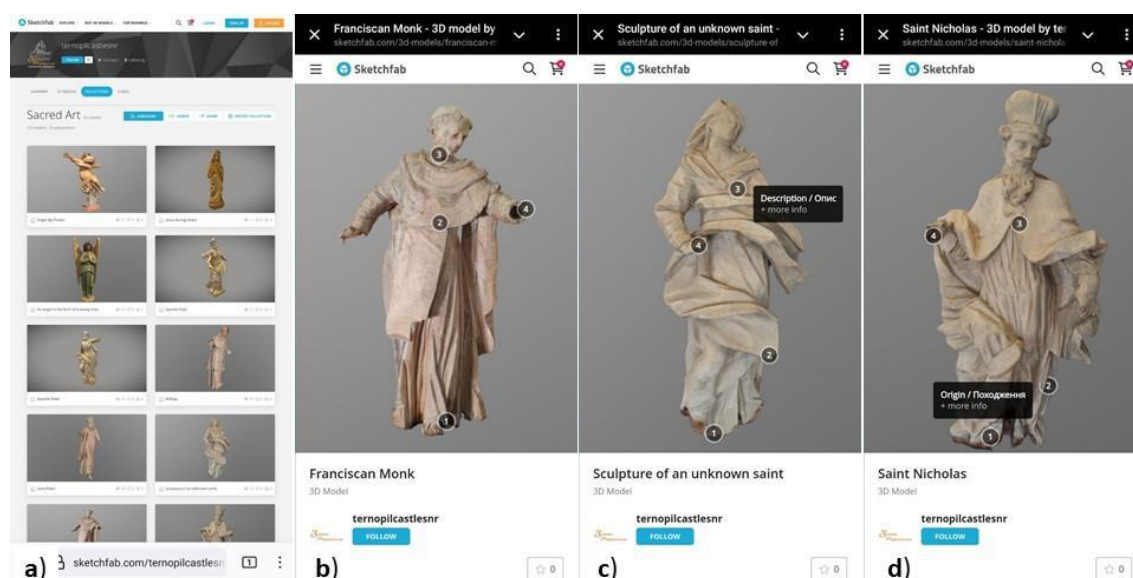

Figure 5: 3D models exposition of sacred sculptures of the National Reserve "Castles of Ternopil region": a) General view of the collection on Sketchfab; b) 3D model of Franciscan Monk sculpture; c) 3D model sculpture of an unknown saint; d) 3D model of Saint Nicholas sculpture.

The integration of the ability to transition to 3D models from specific points located near sculptures within the virtual tour significantly enhances the interactivity and informativeness of the user experience. This feature allows users to select specific objects within the tour and directly view them as detailed 3D models. This not only improves visualization and access to information but also facilitates a deeper understanding of the architectural and cultural elements of the site, enabling users to closely examine the structure and features of each element.

6. Results and discussions

As a result of the project, all outcomes were successfully integrated into the final version of the virtual tour for Zbarazh Castle Museum's exhibition hall. Particular attention was given to the creation of 3D models of sacred sculptures, which were meticulously generated using the photogrammetric method and incorporated into the virtual tour. The completed virtual tour has been published on the web portal [15], enabling users to take virtual excursions and explore the historical and cultural heritage of the castle in depth. In addition to basic navigation, the portal allows for detailed viewing of 3D models of the sculptures, significantly enhancing the level of interactivity and detail, thereby deepening users' engagement with the cultural context of the site. For a better understanding of the tour's structure and functionality, Figure 6 provides a screenshot from the web-browser, illustrating the portal's interface and key features.
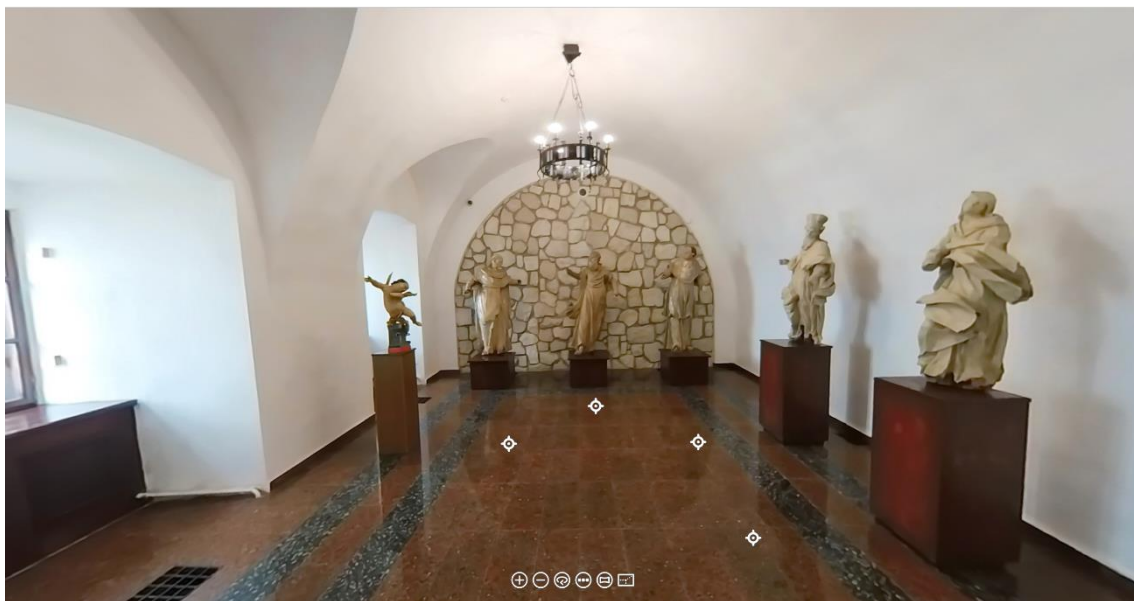

Figure 6: Resulting virtual tour for the Sacred Wooden Sculpture Hall at the Zbarazh Castle Museum.

The portal provides users with the capability of transitioning directly to 3D models from specific points within the virtual tour. This feature enhances interactivity, allowing users to select particular objects, such as sculptures, and view them in 3D model format. This transition enables a more detailed examination of the textures and details of the object, contributing to a deeper understanding and immersion in the cultural context of the castle. This functionality

increases user engagement and makes the exploration of the castle more informative, as shown in Figure 7.

Within the virtual tour, provided audio guides have also been integrated, offering detailed descriptions of the sculptures and their significance. These audio guides are synchronized with the user's location in the virtual environment, ensuring a comprehensive and informative experience for users.

Figure 7: Links to 3D model and audio file.

The implementation of the virtual tour for the Sacred Wooden Sculpture Hall at the Zbarazh Castle Museum has demonstrated the potential of combining photogrammetry and panoramic imaging techniques to enhance the preservation and presentation of cultural heritage. The project successfully developed a comprehensive digital representation of the exhibition hall, allowing users to engage with the collection in a novel and immersive way.

Overall, the project highlights the importance of combining traditional museum practices with modern digital technologies. The success of this initiative underscores the potential for other cultural institutions to adopt similar approaches, leveraging digital tools to preserve and promote their collections.

7. Conclusions

The development and implementation of a virtual tour for the exhibition hall at the Zbarazh Castle Museum represent a significant advancement in the digital preservation and popularization of cultural heritage. By employing state-of-the-art technologies such as photogrammetry, panoramic imaging, and 3D modeling, the project has created a

comprehensive digital archive that not only documents the current state of a valuable unique collection of 18th-19th century sacred wooden sculptures but also enhances their accessibility.

The integration of virtual and augmented reality techniques in the museum's digital strategy has provided an innovative way to engage with the public, offering immersive experiences that bridge the gap between physical and virtual spaces. This approach has proven to be effective in broadening the audience's reach, allowing individuals worldwide to explore the museum's collection from the comfort of their homes.

The results of this project underscore the importance of adopting digital technologies in cultural heritage preservation. The detailed 3D models created through photogrammetry provide a valuable resource for conservation efforts, enabling accurate monitoring and restoration planning. Moreover, the use of virtual tours as an educational tool fosters a deeper appreciation and understanding of historical artifacts, contributing to the ongoing preservation of cultural heritage.

The successful implementation of the virtual tour for the Sacred Wooden Sculpture Hall demonstrates the feasibility and benefits of integrating modern digital tools in museum practices. It sets a precedent for future projects aimed at preserving and promoting cultural heritage, highlighting the need for continuous innovation in the face of evolving technological capabilities.

This article contributes to the field of digital humanities by providing a case study that demonstrates how virtual tour technologies can complement traditional conservation efforts. The use of 360-degree panoramas and photogrammetry for museum exhibits showcases practical methods for enhancing accessibility and engagement with cultural heritage, making it accessible to a wide range of museum visitors, including those who may not be able to visit the museum in person.

8. Acknowledgements

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