Digitizing Heritage: Evaluating the Effectiveness of the Photoscan Method in Artifact Preservation at Lam Dong Museum, Vietnam

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ABSTRACT

The primary objective of this study is to evaluate the effectiveness of the Photoscan method in digitizing artifacts at the Lam Dong Museum, producing high-quality 3D models that preserve the intricate details and historical significance of the original items. The research employs photogrammetry techniques to capture multiple high-resolution images of artifacts from various angles. These images are processed to create detailed 3D models, ensuring accuracy and fidelity to the original artifacts. Key findings reveal that the Photoscan method successfully generates accurate and detailed digital replicas with minimal deviations from the physical artifacts, typically within acceptable limits of less than 1%. This level of precision confirms the reliability of Photoscan in creating digital replicas suitable for various applications, including academic research, virtual exhibitions, and conservation efforts. Additionally, the study highlights the advantages of the Photoscan method, such as its cost-effectiveness and accessibility, making it an attractive option for museums and institutions with limited budgets. The integration of high-resolution photographs into the 3D models further enhances their visual fidelity, providing realistic and detailed digital replicas. The study concludes that Photoscan is a highly effective method for artifact digitization, offering significant benefits for museums in terms of preservation, public accessibility, and educational opportunities. The implications of these findings underscore the potential of Photoscan technology to enhance the documentation and dissemination of cultural heritage in museum settings. Future research should focus on optimizing the workflow to reduce processing time and improve the handling of large datasets. The potential for 3D printing of digital models also presents exciting opportunities for creating accurate physical replicas for display and educational use while preserving the original artifacts.

Keywords: Artifact digitization, Photogrammetry, 3D Modeling, Cultural Heritage Preservation.
I. INTRODUCTION

The digitization of artifacts in museums has become an increasingly important endeavor, particularly for institutions like the Lam Dong Museum, which houses a diverse collection of cultural and historical items [1-5]. Digitizing these artifacts serves multiple purposes: it preserves the items' physical condition, enhances public accessibility, and facilitates educational and research opportunities [6-8]. As physical artifacts are prone to deterioration over time, digitization offers a sustainable way to document and conserve their current state, thus safeguarding cultural heritage for future generations.

This study addresses the specific challenge of effectively digitizing the artifacts in the Lam Dong Museum using photogrammetry technology. The primary problem lies in finding a cost-effective yet accurate method to create detailed 3D models of these artifacts, ensuring that their intricate details and historical significance are preserved in digital form [9, 10]. The objectives of the research are to evaluate the effectiveness of the PhotoScan method in digitizing museum artifacts, to produce high-quality 3D models that are both accurate and detailed, and to explore the practical applications of these digital replicas in museum settings.

The central questions this study aims to answer include: How effective is PhotoScan in capturing the intricate details of museum artifacts? What are the advantages and limitations of using PhotoScan for artifact digitization? How can the resulting 3D models be utilized to enhance museum operations and public engagement?

PhotoScan is a method of photogrammetry that creates 3D models from a series of 2D photographs [11-13]. This technology is advantageous due to its ability to produce highly detailed and accurate 3D representations without the need for expensive and specialized equipment. By capturing multiple images of an artifact from various angles, PhotoScan processes these images to generate a comprehensive 3D model [14]. This study explores the application of PhotoScan technology in the digitization of artifacts at the Lam Dong Museum, assessing its practicality, accuracy, and potential benefits.

II. MATERIALS AND METHODS

Materials

This study focuses on the digitization of 200 representative artifacts selected from various thematic areas within the collections of the Lam Dong Museum (Figure 1). The chosen artifacts include items from the mineral specimen display area, which showcases a diverse range of geological samples, and the animal and plant specimen display area, highlighting the region's biodiversity. Additionally, artifacts from the "Old Dalat" exhibition provide insights into the historical and cultural evolution of the city.

Prehistoric archaeological artifacts from Lam Dong, including items from the Phu My archaeological site and the Cát Tiên archaeological site, illustrate the region's ancient human activities and societal development. Burial artifacts from Dai Lang and Da
Don and Loc Chau sites offer further understanding of ancient burial practices. Cultural artifacts representing the distinctive traditions of various ethnic groups in Lam Dong are also included, showcasing their production activities, traditional handicrafts, and daily life practices.

The spiritual life and cultural practices of these ethnic groups are documented, as well as the significant attention paid by provincial leaders to ethnic minorities in Lam Dong. Artifacts from the French colonial period and the formation of Communist Party cells in Lam Dong are examined, alongside items from the August 1945 Revolution and the anti-French resistance period.

Moreover, artifacts reflecting the affection of the people for the Party and Uncle Ho, the efforts of the Lam Dong people and military during the resistance against the United States, and major military campaigns in Lam Dong are included. Recognition awards conferred by the Party and state are also digitized. Post-liberation Lam Dong is represented through various artifacts, as well as achievements in security and defense. The collection concludes with contemporary artifacts showcasing the current landscape of Lam Dong and some of its famous products from Da Lat City, Vietnam.

**Technology and equipment used**

Photogrammetry technology played a crucial role in creating accurate and detailed three-dimensional models of the museum’s artifacts. This technique involved capturing numerous photographs of the artifacts from multiple angles, which were then processed using specialized software to generate precise 3D models [15-18]. The photogrammetry method relies on the principles of stereoscopy, where the software identifies common points across the photographs and calculates their spatial positions to reconstruct the object's geometry. This approach allows for high-resolution 3D models with detailed textures, preserving the intricate details of the artifacts [19, 20].

The digitization process employs advanced photogrammetry technology, specifically using the PhotoScan method. This method is utilized for processing digital images to generate 3D spatial data, including highly detailed models of artifacts. In addition to the PhotoScan method, several other software programs are integrated into the workflow to enhance the quality and efficiency of the digitization process. Meshroom, an open-source photogrammetry software, is used for its user-friendly interface and robust capabilities in generating 3D models. COLMAP, another open-source software, offers advanced structure-from-motion and multi-view stereo algorithms that are critical for reconstructing accurate 3D models from multiple images. MicMac, developed by the French National Institute of Geographic and Forest Information, is employed for its precise photogrammetric processing capabilities, particularly in large-scale projects. VisualSFM, known for its speed and ease of use, facilitates the reconstruction of 3D models from a series of overlapping photographs.

These software tools collectively contribute to the meticulous digitization process by allowing the capture of high-resolution images, alignment of photos, generation of dense point clouds, and creation of detailed mesh models. The integration of these tools ensures the preservation of intricate details and accuracy in the digital replicas of the artifacts, thereby supporting comprehensive analysis and documentation.

**Digitization Process**

The digitization process using PhotoScan, begins with the meticulous preparation of the artifact. The artifact is thoroughly cleaned to remove any dust or
debris that could interfere with the imaging process. It is essential to ensure that the artifact is free from obstructions and that its surface is adequately prepared for high-resolution imaging [21-23]. Proper lighting is set up to minimize shadows and highlights, which could distort the photogrammetry results. The artifact is placed on a stable surface or a turntable, allowing for consistent and comprehensive photographic coverage from multiple angles (Figure 2).

Fig. 2. Data Collection

The next phase involves the photographic process, where the artifact is captured from numerous angles to ensure complete 3D reconstruction. High-resolution cameras are employed to take detailed photographs, ensuring that each image overlaps sufficiently with the adjacent ones (Figure 3) [24-27]. Consistent focus and exposure settings are maintained throughout the photographic session to guarantee uniformity across all images. The camera's position is carefully adjusted around the artifact, capturing it from various perspectives to ensure that all details are adequately documented.

Fig. 3. Image overlaps (minimum 70%)

Following the photographic process, the collected data is processed using the PhotoScan method. The images are first aligned within the software to create a sparse point cloud (Figure 4), where the software detects and matches common points across the images, thereby estimating the camera positions. This initial alignment is crucial for setting up the framework for the subsequent steps.

Fig. 4. A sparse point cloud

The software then generates a dense point cloud by refining the initial sparse point cloud, capturing the surface details of the artifact with high precision [28-30]. This dense point cloud is used to create a mesh, which forms the 3D geometry of the artifact. The mesh undergoes further refinement to enhance its quality, such as reducing noise and increasing the polygon count to capture finer details. Finally, the high-resolution photographs are mapped onto the 3D mesh to create a textured model, providing realistic surface details. The resulting 3D model is then
subjected to quality checks to ensure its accuracy and fidelity to the original artifact (Figure 5).

Moreover, qualitative analysis is carried out by visually inspecting the 3D models to ensure that all significant features and details of the artifacts are accurately captured. This involves comparing high-resolution photographs with the corresponding areas of the 3D models to confirm that textures and surface details are faithfully reproduced. The final models are also subjected to validation by experts in the relevant fields to confirm their accuracy and usefulness for further applications, such as virtual exhibits, educational purposes, or detailed studies (Figure 6).

![Fig. 5. Digitization Process Steps](image)

**Data Analysis**

The data analysis phase in the digitization process using PhotoScan involves several critical steps to ensure the accuracy and integrity of the 3D models. Initially, the generated dense point clouds and meshes are evaluated for completeness and fidelity to the original artifacts [31, 32]. This evaluation includes a thorough inspection of the point clouds and meshes to identify any gaps, distortions, or artifacts that may have arisen during the data capture and processing stages. Any detected anomalies are addressed through additional data processing techniques or by re-capturing the necessary images.

Quantitative analysis is conducted by measuring key dimensions of the 3D models and comparing these measurements with the physical artifacts. This step verifies that the digital representations maintain the accurate scale and proportions of the originals. Advanced analytical tools within the software are utilized to perform geometric analysis, which includes checking for deviations in surface topology and verifying the consistency of texture mapping. Statistical methods are applied to assess the precision of the point cloud alignment and the fidelity of the mesh generation.

![Fig. 6. Data Analysis Steps](image)

The comprehensive data analysis ensures that the 3D models produced are not only accurate and detailed but also suitable for a wide range of uses, from academic research to public display. This meticulous approach guarantees that the digitization process preserves the historical and cultural significance of the artifacts, providing a reliable digital archive for future generations.

**III. RESULTS**

The digitization process yielded highly detailed 3D models of the selected artifacts, demonstrating the effectiveness of photogrammetry techniques using the PhotoScan method. Each artifact was successfully transformed into a digital replica, capturing intricate
surface details and structural features with remarkable precision. The models exhibit high fidelity to the original artifacts, with surface textures and geometric shapes accurately represented (Figure 7). The dense point clouds generated during the process provided a robust foundation for creating detailed meshes, which were subsequently refined to enhance the accuracy and resolution of the final 3D models.

Quantitative analysis of the 3D models involved measuring key dimensions and comparing them with the physical artifacts. The results indicated that the digital models maintained a high degree of dimensional accuracy, with deviations typically within acceptable limits of less than 1%. This level of precision ensures that the digital replicas are reliable representations of the original artifacts, suitable for various applications including academic research, virtual exhibits, and conservation efforts.

Qualitative evaluation further confirmed the accuracy of the 3D models. Visual inspections revealed that significant features, such as fine carvings, textures, and color variations, were faithfully reproduced. High-resolution photographs were mapped onto the 3D meshes, resulting in realistic and detailed surface textures that closely match the physical artifacts (Figure 8). Expert validation of the models corroborated these findings, indicating that the digitization process successfully preserved the visual and structural integrity of the artifacts.

Overall, the digitization process produced high-quality 3D models that accurately reflect the physical characteristics of the original artifacts. These digital replicas provide a valuable resource for ongoing research, education, and preservation initiatives, ensuring that the cultural heritage embodied in these artifacts is accessible to future generations.
Further analysis of the 3D models included examining their usability for various practical applications. One significant application is in virtual museum exhibits, where these high-fidelity models enable interactive and immersive experiences for viewers. Users can explore the artifacts in a virtual space, gaining insights into their features and historical contexts without physical constraints. Additionally, the digital models serve as an essential resource for educational purposes, allowing students and researchers to study the artifacts in detail, regardless of their geographical location (Figure 9). The models also proved beneficial for conservation efforts. The detailed 3D representations facilitate monitoring the condition of the artifacts over time, providing a baseline for detecting and assessing any degradation or damage. By comparing successive 3D scans, conservators can identify changes and take proactive measures to preserve the artifacts.

Furthermore, digital replicas can be used to create physical reproductions through 3D printing technology (Figure 10), enabling the display of accurate copies in various educational and exhibition settings while preserving the original artifacts.

The robustness of the digitization process was tested by applying it to a diverse range of artifact types, including complex geometries and varying materials. The results showed that the PhotoScan method is versatile and effective across different artifact characteristics, producing consistent and reliable 3D models. This versatility underscores the potential of photogrammetry as a standard method for digitizing cultural heritage artifacts, providing a scalable solution for museums and institutions worldwide.

**IV. DISCUSSION**

The effectiveness of PhotoScan in digitizing artifacts was compared with other digitization methods, such as laser scanning and structured light scanning. While laser scanning and structured light scanning offer high precision and are effective for capturing fine details, they often require expensive and specialized equipment. In contrast, PhotoScan provides a more cost-effective solution, leveraging photogrammetry techniques that utilize standard digital cameras to produce highly accurate 3D models. The primary advantage of PhotoScan is its accessibility and affordability, making it an attractive option for museums and institutions with limited budgets.

PhotoScan’s advantages include its ability to produce detailed 3D models with high-resolution textures and its flexibility in handling various artifact sizes and shapes. The software's user-friendly interface and robust processing capabilities streamline the digitization workflow, allowing for efficient image alignment, point cloud generation, and mesh creation.
Additionally, the integration of high-resolution photographs into the 3D models enhances the visual fidelity, providing realistic and detailed digital replicas.

In conclusion, while PhotoScan offers a cost-effective and accessible solution for artifact digitization, it is essential to address its limitations and challenges to maximize its effectiveness. The technology's practical applications in museums, combined with its ability to produce high-quality 3D models, underscore its potential as a valuable tool in the preservation and dissemination of cultural heritage.
Future research and applications of PhotoScan technology in artifact digitization should focus on optimizing the workflow to further reduce processing time and improve the handling of large datasets. Investigations into automated image capture and processing techniques could streamline the digitization process, making it more efficient and accessible. Additionally, exploring the integration of PhotoScan with other emerging technologies, such as augmented reality (AR) and virtual reality (VR), could provide new ways for audiences to interact with and experience cultural heritage. The potential for 3D printing of digital models also presents exciting opportunities for creating accurate physical replicas for display and educational use while preserving the original artifacts.

VI. REFERENCES


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