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The Process of Museum Digitization Technology

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Abstract: Museum digitization, the process of utilizing digital technology to record, manage, and showcase museum collections, represents a significant transformation in the modes of cultural and historical heritage preservation. As pivotal institutions tasked with the preservation, protection, and exhibition of human civilization achievements, museums have traditionally fulfilled these roles. The rapid advancement of information technology has made museum digitization a global, irreversible trend. This process involves the conversion of tangible collections into digital formats, breaking through the physical constraints of time and space, thereby providing the public with a more convenient and enriched cultural experience.

1.Introduction

The digitization of museums not only strengthens the protection and management of precious cultural artifacts but also facilitates global sharing of cultural resources through online platforms, significantly enhancing the social value and public service functions of museums. However, this transformative process comes with technological challenges and continuous updates. This article will explore the key technological processes and empowerment methods in museum digitization, aiming to support the digitalization process of museums and promote the effective inheritance and innovative development of cultural heritage. The arrival of the information age has not only changed people's modes of communication and thinking but has also given rise to a new way of cultural and artistic dissemination: digital information dissemination [6]. Compared to traditional narrative methods, this approach is more easily accepted by modern audiences. With the continuous advancement of the Internet, information and communication technologies, digital media technologies, and interactive design theories, these new technologies and concepts have begun to integrate into museum practices. As a result, the functions of museums have expanded beyond the preservation and display of physical objects, cultural memory inheritance, public education, and information dissemination to include communication and academic research.

Digital museums utilize online digitization methods to provide visitors with a comprehensive and unique experience. This not only enhances interactive entertainment but also becomes an effective means for cultural inheritance and recreation.

2.The Role of Museum Digitization in Empowering Exhibits

Museum digitization plays a crucial role in empowering exhibits. By transcending the geographical and physical constraints of traditional museums, the management and operational content of museums can be completely transformed onto digital platforms. This transformation involves various aspects such as artifact identification, research, and restoration, shifting museums from a "physical object-oriented" approach to an "information-oriented" one. On-site services are expanded beyond the limitations of time and space, enabling virtual services. Digitization significantly broadens the reach of museums [1], comprehensively showcasing the precious value of their collections. The digitization of exhibits improves the preservation status of collections. Utilizing high-resolution scanning and 3D modeling techniques, digital replicas of exhibits are created, reducing the need for physical handling and display and thereby extending their lifespan. Museum collections, typically comprising artworks, artifacts, historical documents, and other valuable items, require strict control of temperature, humidity, and lighting during preservation. With digital replicas and 3D models, researchers can observe and study items without direct physical contact, greatly minimizing physical wear. For exhibits susceptible to environmental factors, digital display serves as an alternative to physical exhibition, preventing damage.

During the digitization process, 3D models provide detailed recording and analysis of the condition of exhibits, particularly offering three-dimensional digital records of damaged exhibits' appearance and structure. This aids in formulating more precise protection and restoration plans. Digitization provides a wealth of high-quality, easily

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retrievable resources, offering valuable material for academic research. Museum digitization enriches educational and research resources, providing modern, interactive means of learning and research, thereby advancing education and academic research. Educational institutions can utilize digital exhibits for online teaching and interactive learning, expanding educational resources and methods.

Digitizing exhibits also enhances collection management efficiency [2]. Digitized collection information facilitates rapid retrieval and management, allowing quick searches through computer systems without the need to go through cumbersome archives and records. Through keywords, classification tags, and other means, staff can swiftly find the required collection information, improving efficiency and accuracy. Digitized collection information can be shared internally among museum departments through network sharing, increasing work efficiency. It also facilitates communication with external organizations such as other museums and research institutions.

3.Model Optimization: Transition from Million-Poly Models to Low-Poly Topology in ZBrush Projection

While 3D laser scanning provides great convenience for digitization, challenges still exist in model processing and optimization. Future technological developments may bring more efficient data processing methods to better balance model quality and computational resource requirements.

In the processes of 3D laser scanning and ZBrush manipulation, despite the ability of automatic decimation techniques to significantly reduce the model's polygon count while preserving a considerable amount of detail, some details may still be lost. To address this issue, point cloud projection techniques can be employed.

Point cloud projection is a process that transfers details from a high-poly original point cloud model to a low-poly model [3]. Specifically, it compares a 100%-point cloud model with a 10% decimated point cloud model, rearranging the low-poly point cloud model through column arrangement and projection. This allows the low-poly model to inherit all the details of the original scanned model, not only retaining the fine details that were decimated but also enhancing stability in other processing software.

To ensure smooth running of digital models on webpages and reduce loading time, further simplification of the model is necessary. This typically involves further reducing the 10%-point cloud model to 1% or less. It's worth noting that the appearance and color texture display of digital models do not depend on a high polygon count. Therefore, low-poly topology can effectively maintain the model's silhouette, laying the foundation for later texture mapping [5].

In topology processing, it is essential to check whether the point cloud covered by the topology quadrilateral is on the same plane. If so, it is retained; otherwise, faces may be added or removed. Additionally, when the arrangement of the point cloud exceeds 90°, the topology quadrilateral can undergo direct single-face topology. If the arrangement is equal to or less than 90°, hard surface treatment is applied at the turning points between faces during topology.

The edges of hard surface treatment not only enhance the traces of turning points but also serve as transition lines for model splitting and texture mapping. Moreover, during the topology process, editing edge flow is crucial to ensuring appropriate spacing between each edge and a well-balanced density between faces.

In the end, such significant model simplification indeed accelerates the loading speed of the model on both mobile and desktop platforms but inevitably leads to a loss of surface details. While the model's silhouette is preserved, the level of detail may decrease compared to the original model. In the field of digital museums and virtual exhibitions, this trade-off is necessary, aiming to achieve a balance between high-quality visual effects and a smooth user experience. With ongoing technological advancements, future methods may emerge to simultaneously retain details and reduce model polygon counts.

4.Normal Baking, Texture Mapping - Providing High-Quality Possibilities for Low-Poly Models.

In the process of 3D modeling and digitization, using textures to transfer details from a high-polygon model to a reduced-polygon model is an effective technique. By converting various attributes of a high-polygon model into texture forms, visual details of the model can be preserved without significantly increasing its computational weight [5][3][4].

Normal Maps: As shown in Figure 1, normal maps are used to simulate details of a high-polygon model without increasing the model's polygon count. This technique alters the reflection of light on the model's surface to simulate the uneven surface texture, visually creating a sense of three-dimensional surface relief.

Curvature Maps: Illustrated in Figure 2, curvature maps are specifically designed to capture and display curvature details of the model, especially at edges and corners. They help emphasize the shape and structural features of specific parts of the model, making these areas visually prominent and layered.

Ambient Occlusion Maps (AO Maps): As depicted in Figure 3, AO maps carry information about the occlusion of light. They simulate how light is obstructed in the crevices or tight spaces of the model, enhancing the depth and three-dimensionality of the model in unlit conditions.

ID Maps (Albedo Maps): Shown in Figure 4, these maps store color information and other surface attributes of the model, assisting in visually reproducing the color and texture of the original scanned model.

These techniques allow low-polygon models to achieve high-quality visuals by leveraging texture maps to simulate intricate details without compromising computational efficiency.

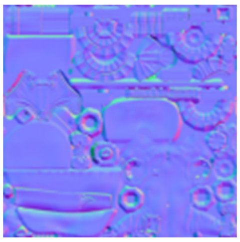


Figure 1 Normal Maps

Figure2 Curvature Maps

Figure3 AO Maps

Figure4 Albedo Maps

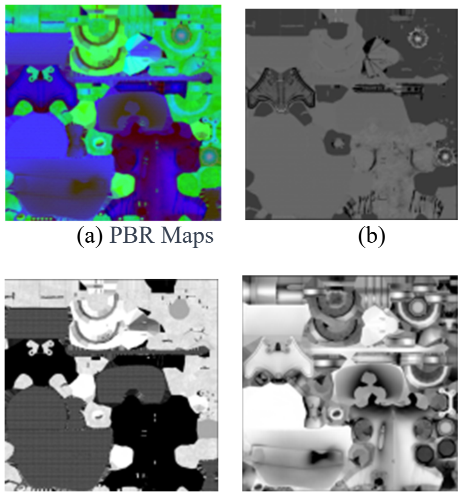
Applying these texture maps to the reduced-polygon model can visually achieve results close to the original high-polygon model while keeping the model lightweight. This approach not only reduces the model's memory usage and processing burden but also makes the model more suitable for online display and interaction, especially in web applications or mobile platforms where quick loading and smooth interaction are essential.

In summary, by combining reduced-polygon models with detail-storing texture maps, it is possible to effectively convey the visual information of the original scanned model while keeping the model lightweight. This is crucial for applications such as digital museums and virtual exhibitions.

When transforming museum exhibits into virtual objects for web-based visualization and interaction, a series of processes is needed to ensure that the model not only has mobility and fast loading capabilities but also realistic materials and textures. To achieve this goal, detailed editing and rendering of the model's materials are required, in addition to the mentioned model simplification and texture mapping processes.

Base Color Texture: Texture maps obtained from laser scanning are often used as base color textures, directly applied to the simplified model. However, such processed models often lack sufficient texture and volume. Lighting can enhance the model's three-dimensionality and create light and shadow contrasts. However, for web-based HTML formats where the model can be viewed interactively from all angles, single-angle lighting may become a limitation, affecting the comprehensive display of the model. Tools like Adobe Substance 3D Painter can be used to add global lighting effects to the model. Baking texture maps can create light and shadow contrasts and three-dimensional effects for the model without relying on external light sources.

Final Adjustments: Make final adjustments to the textured model, such as adding hue modifiers, color balance filters, color correction filters, sharpening filters, etc., to ensure that the material characteristics of the model closely resemble the real appearance of the exhibited item when displayed on the web. This results in the output of a PBR (Physically Based Rendering) triple map, as shown in Figure 5a. The PBR map consists of a roughness map (Figure 5b), a metallic map (Figure 5c), and an ambient occlusion map (AO map) (Figure 5d). Using a single map allows for a nearly realistic reflection of material properties.



(a) PBR Maps (b)

(c) (d)

Figure 5 (a)PBR Texture production passed R\G\B single channel(b)Roughness(c)Metallic(d)Ambient Occlusion blend the stickers into one

Through these comprehensive processing steps, virtualized museum exhibits can not only demonstrate excellent performance on webpages, such as fast loading and interactivity, but also present highly realistic visual effects. This, in turn, provides webpage users with a rich and authentic experience.

5.Texture Assignment and HTML Format Output for Models

Using Marmoset Toolbag for rendering and display is an efficient way, especially suitable for virtual exhibitions of museum artifacts. This process involves adjusting the material in Adobe Substance 3D Painter: First, detailed adjustments are made to the model's material. This includes setting and fine-tuning various material properties such as normal maps, curvature maps, ambient occlusion maps, ID maps, (PBR) maps, and base color maps. These textures provide the necessary visual details for the model, such as texture, color, and lighting effects. Next, output textures: After adjustments, export all textures. These textures include normal maps, curvature maps, ambient occlusion maps, ID maps, PBR maps (R+M+AO), and base color maps. Apply textures to the reduced model: In Marmoset Toolbag, directly apply these exported textures to the reduced model. With these textures, even heavily simplified models can acquire rich details and vivid colors. Then proceed with high-quality rendering: Rendering in Marmoset Toolbag achieves high-quality visual effects, further enhancing the model's texture and realism. Finally, output in HTML format: Lastly, export the rendered model in HTML format, making it easy to showcase and interact with on webpages. The choice of this format ensures that the model can be seamlessly accessed on various devices and platforms, providing a good user experience.

Through these steps, it ensures that the reduced model not only has excellent loading and interactive performance on the webpage but also possesses highly realistic and visually appealing representations, crucial for digital museums and virtual exhibitions.

6.Conclusion

Model reduction and texture mapping: Despite modern technology's ability to significantly compress high-polygon models, manual topology is still required to ensure consistency in the model's silhouette, meeting the needs of webpage usage and transmission. Although time-consuming, this process is crucial for maintaining model quality and details.

Texturing scanned 3D models involves a series of operations to impart texture, including adjusting color, diffuse reflection, metallicness, roughness, height, and transparency. Layered optimization of textures is a high-precision and manual operation, with relatively low efficiency but resulting in high-precision, rich-textured, and clearly volumetric models.

Model output and application: Digitized models can be converted into HTML format files of several hundred megabytes in size, greatly facilitating the online construction of digital museums. This processing method significantly reduces the storage space occupied by digital artifacts, allowing the entire museum's collection to be easily stored on small storage devices such as USB drives.

Overall, while the digitization process of cultural artifacts remains a complex and labor-intensive task, its results free museum exhibits from physical space constraints, providing the public with a high-quality cultural experience. This not only contributes to the preservation of cultural heritage but also provides valuable resources for education and research.

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