CONSTRUCTION OF MANAGEMENT PLATFORM FOR 3D MODEL OF CULTURAL RELICS

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Abstract – with the continuous enrichment of museum digital resources, more and more attention has been paid to the management of them. This article introduces the practice of the National Museum of China in the long-term preservation of high-definition three-dimensional images of cultural relics in terms of data acquisition, quality control, storage and security protection mechanisms.

Keywords – 3D model, Cultural relics, Preservation, Management platform

Conference Topics – Building the Capacity & Capability.

I. INTRODUCTION

Museum is an important place to protect and inherit human cultural heritage. In recent years, the digitization of cultural relics has entered a steady development, lots of work has been done. In addition to the conventional 2D images, 3D model can show the features of cultural relics more intuitively and accurately, that is convenient for the research, display, restoration, appraisal, cultural creation and other work related to museum. Therefore, 3D model has gradually received more attention. For example:

1) *Dunhuang Academy:* Collecting data through digital photography, a digital archive of Dunhuang grottoes fresco image resources is established, which is used to preserve the original information, different types of data and spatial relationships and other important resources of cultural relics, so as to realize the scientific, high-precision and permanent preservation of endangered cultural relics.[1].

2) *The Palace Museum:* The Palace Museum cooperated with Japan to develop the "Digital Forbidden City", the main ancient buildings and treasured cultural relics of the Forbidden City were accurately, systematically and comprehensively acquisition and reproduced by using three-dimensional scanning technology, and a complete three-dimensional digital model and database were established[2].

In the macro planning of China National Museum (2019-2021), 3D scanning is an important part of it. A specialized talent team has been organized into it. After preliminary preparations such as technical training, equipment procurement, site layout, and standard formulation, it was carried out in an orderly manner. At present, the pilot of three hundred fine copper mirrors has been completed. The scanning of precious cultural relics has begun at the end of 2019. It is estimated that more than 2000 pieces of 3D models will be completed every year. In this situation, it is of great significance to create a platform witch is based on a unified standard in order to manage the digital resources to achieve the sustainable preservation and application.

II. REALIZATION

A. *Significance*

3D scanning enables high-definition digital modeling of cultural relics in a contact-less manner. It is of great significance to the protection and application of cultural relics, mainly in the following aspects:

1) Restoration and research: The 3D model can be reduce and enlarge in proportion, facilitate researchers to study defects and disease on the local structure. Also, they can do repair experiment on the digital model to avoid secondary damage.

2) Digital display: In recent years, 3D display has become a common form of exhibition. For example, the 4K HD display of Buddha’s Painted Woodcarving Sitting Statue of Song Dynasty, and the holographic projection of the spraying Zodiac animal head, which effectively increases the interaction between the exhibition and the audience[3].

3) Development of cultural products: The widespread popularity of 3D scanning and 3D printing, reduced the difficulty of mold shaping, improved the development speed of product.

4) Disaster Preparedness: Due to impact of aging, natural disasters, war, economic recession, improper preservation technology etc, it will inevitably cause damage to cultural relics. 3D model can accurately reproduce its original appearance and provide research materials for future generations.

B. Business Process

The business process of 3D model's processing, preservation and application are shown in Figure 1. In order to facilitate the save of semi-finished model and the audit of phased results, we created a temporary storage space for resources on an independent resource server . When the data accuracy and integrity, folder structure and file format meet the audit requirements, the data will be imported into the preservation system, and the temporary files will be destroyed. The goal of the system is to keep the long-term survival of 3D model, to ensure that is authenticity, integrity, availability and security. Taking into account the particularity of the 3D model (lossy compression must be professionally processed), no format transformation will be done after the data completes the integrity check.

III. DATA CREATION

A. Technical Type and Equipment Parameters

At present, the mainstream 3D data acquisition technologies mainly include laser scanning, raster projection scanning, photogrammetry, and industrial computer tomography[4]. Based on the comprehensive consideration of the characteristics of the acquisition objects, technical maturity, accuracy, color reproduction, cost, application scenarios, and environmental requirements, we choose raster technology. Because it uses medium and small objects as targets, the data model is highly complete and can better restore detailed features. After many investigations and tests, we chose ZEISS COMET 8M and ZEISS COMET 16M as the main 3D acquisition equipment. Texture acquisition equipment includes CANNON 5DSR and other models, with effective pixels not less than 50 million.

B. Procedures of 3D Model Acquisition

The procedures are shown in Figure 2. It can be divided into three main process: 3D measurement and model construction, texture collection and color management, texture mapping and refinement.

1. 3D measurement and model construction

Given the strict requirements for "non-contact", after many attempts, the 3D laser scanner is preferred as the main acquisition device, which actively acquire data on the surface using light sensing technology.

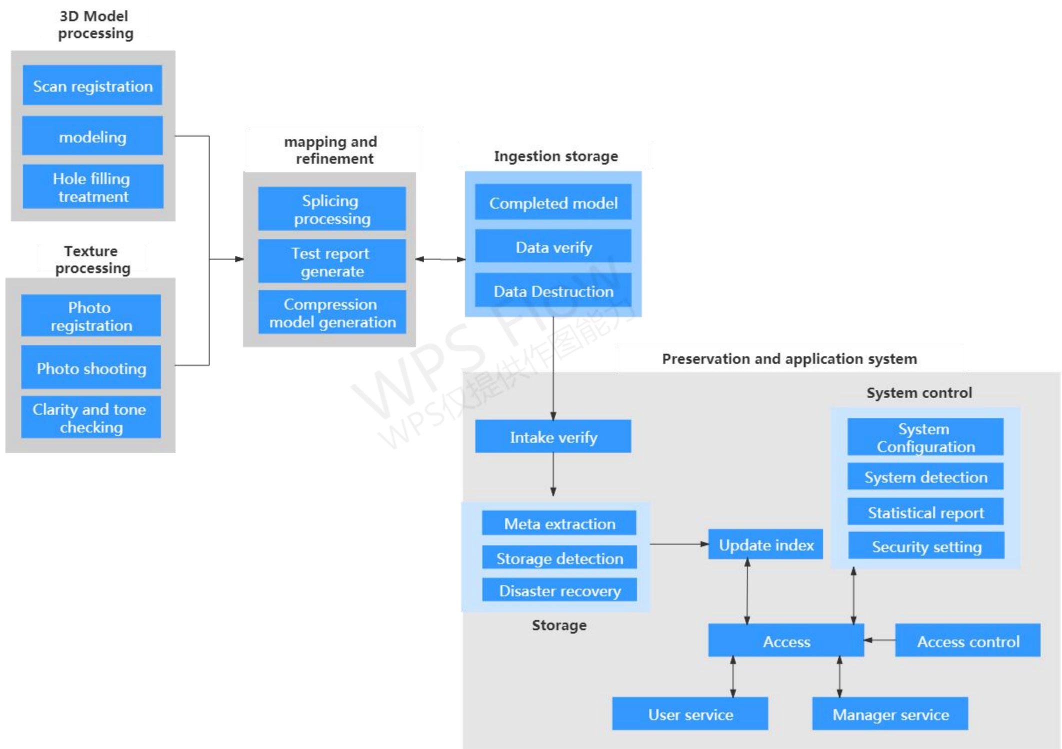

Figure 1 Business process

Then the platform automatic rotate 360 degrees at a uniform speed, to let the machine remember the point cloud for each section of cultural relic in turn. Visualize and convert point cloud data and models to make standard 3D models. The accuracy error is controlled within 0.1mm.

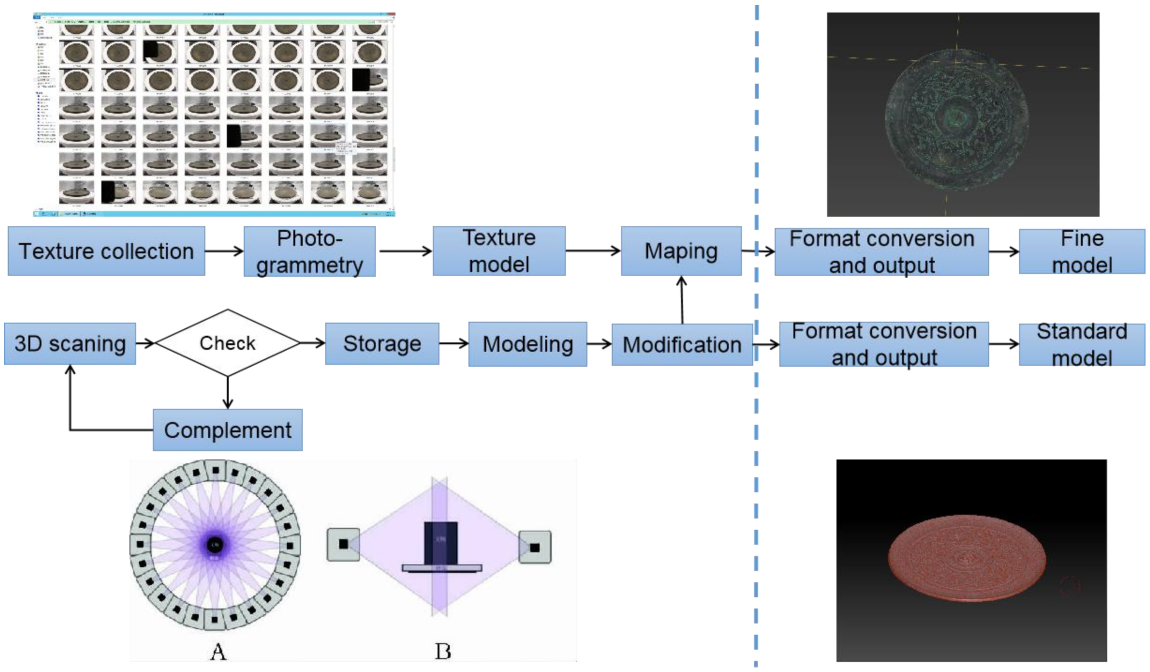

Figure2: 3D model acquisition process（Take Ma's self-made mirror as an example)

2. *Texture collection and color management*

Texture data collection, include top, bottom, Surround and partial angles. It is also collected using the 360-degree uniform rotation platform. Sometimes in order to capture more accurate data, a surface needs to choose multiple shooting angles. Collecting textures must not only restore the color and effect of the culture relic itself, but also try to achieve multi-angle collection. The number of photos of each collection object is controlled between 25~50.

3. *Texture mapping and 3d model refinement*

Texture mapping usually uses professional 3D mapping software. Using the perspective projection calculation of software and manual correction, realize point-to-point matching of 3D model and texture coordinates. Therefore, the 3D model made by using raster technology is lower than the photogrammetric technology in terms of texture and color reproduction. After passing the final test, the generated 3D model is converted into a unified format and stored in the management platform of digital resource.

IV. Quality Control

A. *Model Accuracy Detection*

In order to avoid repeated data acquisition from damaging cultural relics, high accuracy is required. It is considered from the Single frame accuracy, Splicing error, Data integrity. The error should be controlled within 0.02 mm. In addition, the image composition must be correct, and the effective pixels must be greater than 90%. For complex relics, separately acquisition is needed.

For texture data, the resolution should be greater than 22 megapixels to ensure the accuracy of the texture after the completion of the fit. Due to the limited conditions, the standards for cultural relics of different materials, types and volumes are slightly different.

Taking "China Daning" bronze mirror(Collection number Y205) as an example, the detailed parameters retained in the test report are shown in Figure 3[4]. In addition, the 3D model acquisition equipment, lens specification, inspector's name and detection time should be indicated in the detection report to keep the original data as complete as possible. In order to ensure the data accuracy, Point spacing, Texture mapping Accuracy need to be retained three sets of measurements. The lossy compression level should check whether there is deformation in addition to the data volume requirements.

In order to ensure the authenticity, validity and reducibility of the data, the names and versions of the data post-processing software and the testing software are recorded in detail in the testing report, and the software environment is saved separately.

Three dimensional dimension	Relative distance(mm)	X=187.038 Y=186.828 Z=12.818
Data volume	Number of Point clouds	74749659
	Number of triangles	31083900
	File size	2.64G
Raw model	Point spacing (mm)	0.015814
	Splicing error (mm)	0.013
Research level data report	Texture mapping Accuracy (mm)	0.077529
	Texture clarity	8192X8192

Figure3. The accuracy test report of "China Daning" bronze mirror

B. *Cataloging Data Check*

Data cataloging has an important effect on the availability and comprehensibility of 3D digital objects. To this end, we have made strict metadata description specifications for the identity information, content attributes, technical attributes, structural attributes and historical information of 3D digital objects. Core metadata includes, but is not limited to: model level, number of triangles, data volume (MB, GB), average point distance, storage format, acceptance time, post-processor, acquisition site, cultural relic status verification, start and end time, reviewer, data cataloging time and personnel, and collection number (unique identification).

C. *File Format and Structure Check*

The 3D data after processing should be organize into a unified structure and format before entering the preservation system. The archive of 3D data is named after collection number(ID). The first level directory is shown in Figure 4. In order to facilitate resource utilization, the finished product generated by the model processing is divided into three sub-files of Reproduction level, Research level and Browse level for storage. In the process of generating browse level files, it needs to reduce a large number of unnecessary point cloud data on the basis of the original 3D model, resulting in the reduction of the integrity of the model. In order to ensure the browsing effect of the model, it is necessary to save the normal map and basic color map of the model separately.

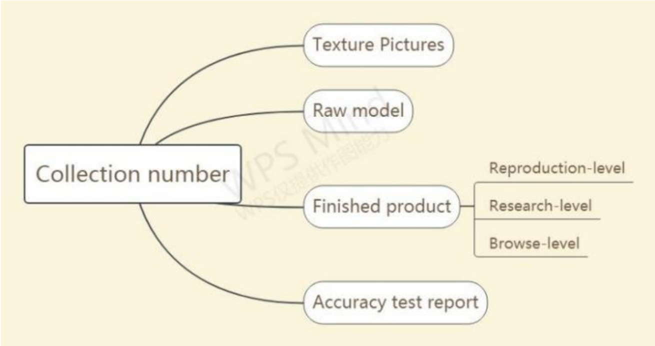

Figure 4 Archive structure

When the processed archive enters the ingestion storage, it will be finally checked by the auditor in accordance with the regulations. The main contents of the inspection include:

1) *Archive integrity check:* Check whether the number of files in the archive is complete, whether the naming rules of each file, the format used and the version of the format meet the requirements.

2) *File readability check:* Check whether the 3D image files in each archive can be rendered normally in the software. If you find damaged files, you need to contact the provider in time and ask them to re-submit.

3) *Data validity and consistency check.* Make sure that there is a one-to-one correspondence between the collection number(ID) and its 3D model; Browsing-level data must comply with the corresponding compression specifications.

V. STORAGE AND PRESERVATION

A. *File Management*

The system traverses and monitors the changes in the volume of data and file directory structure in the ingestion storage every day. After discovering new data, it is taken into the system for preservation. At the same time, extract metadata to update the catalog and index. The system will generate a unique identifier for each file object, and use the MD5 algorithm[5] to generate a check code. MD5 check code as the digital fingerprint of the file object has the following purposes.

First, since the MD5 value of each file is unique, it can ensure that the file will not be uploaded repeatedly; Second, when the content of the file changes, the MD5 code will also change accordingly. MD5 guarantees that the content, structure and byte stream of the digital objects in the system are complete, have not been illegally tampered with, and there are no missing or damaged situations.

The main file format requirements are as follows:

1. *OBJ*

We choose OBJ as the preservation format of the 3D model. As a text file format, OBJ as an open geometry definition file format, uses a dictionary-like structure to describe polygon, lines, surfaces and free-form Curves and performs well in storage. [6]In the process of data acquisition, model refinement, texture mapping, and simplification of 3D data, 4 to 5 kinds of software are required. OBJ format embodies better inter-conductivity and compatibility in mainstream 3D software.

2. *MTL*

The MTL file is used as an attached file of OBJ to store the color and texture information of multi-color geometric models. MTL files are ASCII based and facilitates in computer rendering by describing light reflecting properties of a surface using the model of Phone reflection.[7] Although this file format cannot fully support new technologies such as mirror mapping and parallax mapping, it is still the preferred save format due to its openness and intuitiveness.

3. *TIFF*

Original texture photos of cultural relics are stored in TIFF format. Tiff is one of the commonly used formats in graphics and image processing. As a complex bitmap file format, the tiff structure is flexible, and the compression loss rate is low. It has been widely used in most image systems.

4. *JPEG*

JPEG is a lossy compression format, which compresses the data in a smaller storage space by removing redundant image and color data. JPEG is used for normal and color rendering of browse-level and research-level 3D models. Its has the characteristics of low distortion rate, good image quality, and fast transmission and presentation speed, which can effectively save storage costs[8].

B. *Storage Mechanism*

3D model of cultural relics is a typical large volume of unstructured data. For this reason, for the first time, we chose Amazon s3 cloud computing storage as Storage mechanism.[9] In practice, we found that object storage has the following advantages. First, object storage removes the complexity that comes with a hierarchical file system with folders and directories, effectively improves retrieval speed. Second, objects are stored in a structurally flat data environment, we can simply add more devices or servers in parallel to an object storage cluster for additional processing and to support the higher through-puts required by large files. Third, the storage capacity can be expanded according to resource storage requirements by adding buckets, and the HD resources that are not frequently used can be saved economically and effectively. Forth, data can be replicated within nodes and clusters and among distributed data centers for additional back-up off-site and even across geographical regions. To ensure that the system continues to run without interruption or performance degradation.

Other storage strategies include:

1)Storage detection: The system has an error check function to ensure that the components of the storage object will not be damaged in the database or internal data transmission, and provide the data management module with operation statistics on equipment, storage capacity and usage, and generate logs and reports. With disaster recovery function, data recovery can be realized by storing redundant data.

2)Data backup and disaster recovery: After the accident, in order to ensure that the data in the system can be restored to use, we have developed two data backup measures. First, data redundancy backup. Use RAID (Redundant Array of Independent Disks) storage strategy to avoid data loss caused by physical failure of a single hard disk and improve storage reliability. Second, an independent data backup server is created, and an incremental backup of data is made every 24 hours. Third, applying data snapshot technology, after data is damaged, it can quickly roll back to the state before the disaster to reduce losses.

VI. Others

In order to ensure that data is not obtained illegally, the system has been designed to strengthen the security system and authorization management mechanism. The main content includes:

A. *Security Setting*

The security strategy of the system is as follows:

1) *The entire process is completed on the intranet:* Ensure network security through firewall, intrusion detection, anti-virus, anti-DDoS, vulnerability detection, etc.

2) *Establish a data security domain:* Using virtualization technology to build a secure environment that can access and manipulate data, users within the organization can complete the necessary viewing and data analysis without the need to extract or download the original data to the local.

3) In the data transmission link, the encrypted transmission link between different security domains is established through HTTPS, VPN and other technologies, and the data can also be directly encrypted and transmitted in the form of cipher text to ensure the safety of the data transmission process.

4) Using the real-time monitoring of abnormal behaviors to realize the "pre-event" and "in-the-event" link monitoring and early warning and real-time disposal. The abnormal behavior monitoring system should be able to conduct real-time monitoring of dangerous behaviors such as unauthorized access to data and sensitive operations of data files.

B. Authority Management Mechanism

1) Ensure the security of management from the aspects of security management system formulation, organization setting, staffing and data management security strategy.

2) Through the assignment of authority to personnel at all levels and different workers, each person can only see the data within his authority; the system provides a complete log function, and the log data must be retained for important operations in the system.

3) The system has a complete multi-level security system, with a user login security verification mechanism, which can realize multiple security policy mechanisms such as login password policy verification, IP address login verification, hard encryption verification, and verification code.

4) The system has a safe and reliable business model and operation process, and provides functions such as page verification, data weighting, data submission and approval, etc., to ensure that the system will not be affected by misoperation during normal use.

VII. Concluding Remarks

The system is currently running in the intranet environment, and preserved 3D models of 1041 cultural relics. For ease of use, users can retrieve and browse 3D models (browsing-level) through the application interface, but they do not have the download permission. If you need to download high-definition 3D models, you need to submit a download application on the system. After the application is approved, the administrator will copy the image resources from the system to the applicant, and sign a copyright use agreement as required.

The system has established a relatively complete data storage strategy, which effectively solves the problems of diverse resource formats, scattered storage locations, inconsistent storage media, and difficulty in retrieval and acquisition. But there are also the following shortcomings:

1) Complexity and diversity are characteristics of museum collections. In addition to the three-dimensional image information of the collection, it also includes multiple resource types such as text files, two-dimensional images, audio files, and video files. In the future, a unified management strategy should be designed and artificial intelligence related technologies should be used to reduce the difficulty of data acquisition.

2) The long-term preservation of digital resources is a comprehensive project whose purpose is to gather the resources and research results of multiple institutions to realize the cooperation and sharing of resources in a certain field. But at present, the system only provides services to the staff of the museum.

3) In the future, we will study in depth the migration of 3D data formats. When the technological environment and carrier undergo major changes, it is ensured that the data can be correctly presented to the user in an appropriate manner.

The Xinjiang Uygur Autonomous Region Museum submitted an application to our museum to copy the bronze mirror of "China Daning".[10] Since the bronze mirror has been bonded and repaired after being unearthed, it is not suitable to use the traditional remolding process for copying. To this end, we retrieved the three-dimensional research-level data of the bronze mirror from the system, used 3D printing technology, combined with the traditional color-coded process to complete the process.

The museum takes the preservation, display, research, and education of cultural relics as its basic functions. The purpose of the museum is to protect various cultural memories for future generations and to ensure their right to equal ownership and inheritance of human cultural heritage. Under the requirements of the new mission of "Smart Museum", and the country's call to "Make cultural relics come to life" to realize the creative transformation and innovative development of culture, the importance of the digital form of cultural relics and their digital derivatives continues to increase, becoming the largest one of the effective means to restore the original information of cultural relics and achieve permanent preservation. Therefore, at the start-up stage, we should aim at ensuring the authenticity, integrity, long-term availability and safety of cultural relics digital resources, establish a complete digital resource preservation system, and implement its requirements and concepts into the process of intelligent construction.

In the future, we will conduct more systematic and in-depth research in this field to improve the preservation and application environment of data resources.

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