EXPLORATION OF DIGITAL HERITAGE STRATEGY BASED ON PREVENTIVE CONSERVATION THEORY

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ABSTRACT:

The frequent occurrence of heritage disasters highlights the necessity of digital preservation of heritage. There are two technical difficulties in Digitization: one is the high cost, the other is the poor applicability of the achievement. This is because the emphasis is only on data volume and accuracy, but neglecting the demand for conservation in the process of digitalization. Preventive Conservation has become the mainstream of heritage conservation. Based on this theory, this paper takes the digitization of several stone tablets in the Forbidden City as an opportunity to explore the strategy of digitization of heritage. Through the assessment of the values and state of preservation, the key points of digitization are obtained. By comparing the collection efficiency, achievement accuracy, expression characteristics, workload and cost of the various technologies, the authors draw a conclusion.

1. INTRODUCTION

1.1 Research Status of Heritage Digitization

In recent years, the cultural heritage is often affected by disasters. This not only challenges the risk control ability of heritage managers, but also highlights the necessity of digital preservation of heritage. At present, various digital technologies are becoming more and more mature, and a large number of research results have been produced in the operation process and later application. However, there are still two deficiencies in cultural heritage digitization: one is the high cost, the other is the poor applicability of the achievement. This is because the emphasis is only on data volume and accuracy, but neglecting the demand for protection in the process of digitalization. Therefore, many urgent digital projects can only be shelved, and a large number of digital achievements are only preserved as data, which are not fully applied to heritage conservation.

The reason is that there are many types of cultural heritages, and their sizes, structures, materials and practices vary greatly. The main reason is that there is a lack of scientific and economic heritage digitization strategy, and the digital achievements can't reflect the value and preservation status of the heritage authentically and integrally.

1.2 Preventive Conservation Theory

Preventive Conservation is mainly achieved through "scientific records", "heritage monitoring", "daily maintenance" and other technical means. Firstly, it analyses the value of heritage and the factors that affect the value, so as to determine the risk factors. Then, on the basis of long-term monitoring, the deterioration law is analysed and the risk assessment is carried out. Finally, through the timely detection and elimination of hidden risks, to achieve the purpose of conservation. Preventive conservation has the following characteristics:

1. Risks arise from nature, society and heritage itself
2. Assessment of the values and state of preservation
3. long-term monitoring and daily maintenance
4. Integrity of heritage and environment

1.3 Digitization of Stone Tablets in the Forbidden City

Based on Preventive Conservation Theory, this paper takes the digitization of several stone tablets in the Forbidden City as an opportunity to explore the strategy of digitization of heritage. Through the assessment of the values and state of preservation, the key points of digitization are obtained. By comparing the collection efficiency, achievement accuracy, expression characteristics, workload and cost of the various technologies, the authors draw a conclusion that how to reduce the cost and enhance the applicability.

This paper mainly carries on the directional research of acquisition stage, and also involves the technical research of processing and application stage.

2. RESEARCH CONTENTS

2.1 Analysis of Heritage Digitization

One of the reasons for the lack of research on heritage digitization is the mismatch between protection needs and achievement standards. Referring to *Ancient building surveying and mapping*, the collection operations include brief surveying and mapping, typical surveying and mapping, and overall surveying and mapping. Different depth surveying and mapping types meet different protection needs, including scientific records, heritage monitoring, minor and major restoration, digital display, etc. Traditional surveying and mapping is mainly used to record the shape of cultural heritage, and only words and pictures can be used to explain the disease. However, digitization breaks through the two-dimensional display mode and realizes the three-dimensional reproduction of cultural heritage.

Although heritage digitization is different from traditional surveying and mapping in terms of record and display, the classification of information collection according to conservation needs is still worth learning. Under the concept of preventive conservation, the digitization of heritage has the following characteristics:

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2.1.1 Scientific records: Digital achievements should explain the value and status of heritage authentically and integrally. In order to realize the scientific record of a certain type of heritage, technicians need to use the established format to establish a database to manage batch data, and the data should be saved according to different levels to meet the needs of various levels. The digital achievements can be used smoothly.

2.1.2 Monitoring: Monitoring is a long-term and dynamic work. According to the time sequence, it includes pre maintenance monitoring and post maintenance monitoring. Pre maintenance monitoring can be used to study the deterioration law of risks, while post maintenance monitoring can be used to discover the continuous occurrence of risks. The long-term and sustainability of monitoring requires digital technology to be low-cost and easy to operate.

2.1.3 Restoration and Maintenance: Digital achievements mainly express two aspects: on the one hand, they express the structural characteristics, shape, size and surface information of the cultural heritage. on the other hand, they reflect the types, distribution, severity and formation mechanism of cultural heritage diseases. Conservation workers use the digital results to analysis the causes and processes of disease degradation, as well as to evaluate the relationships between phenomena and their nature, and then to make decisions.

2.2 Assessment of Values

As the imperial palace of Ming and Qing Dynasties, the Forbidden City has a history of 600 years. Its architecture and space cover various functions such as governing the country, living, learning, leisure, sacrifice, marriage and funeral, representing the highest level of Chinese architectural technology and art at that time. In the past 600 years, Chinese palace culture has been carried forward and showed strong characteristics of ethnic integration. These stone carvings scattered in the Forbidden City are a strong witness of this kind of history and culture. e.g. Figure 1.
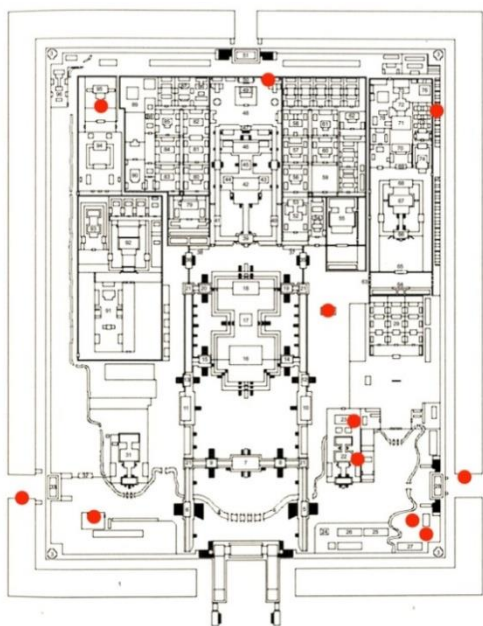

Figure 1. Distribution of stone tablets in the Forbidden City

Heritage value is the basis for conservation, so an assessment of the values is the first step in the conservation process. According to *Principles for the Conservation of Heritage Sites in China*, the heritage values of a site are its historic, artistic, and scientific values, as well as its social and cultural values. The values of the stone tablets in the Palace Museum are as follows:

2.2.1 Historic values: Inscriptions, ancient books, archives and buildings can confirm each other, which is an important basis for studying the history of the palace. For example, *the Gujintongji Tablet* unearthed at *Luanyiwei* in the Palace Museum proves that the location of *Luanyiwei* in the Qing Dynasty is the site of *the Gujintongji Library* in the Ming Dynasty.

2.2.2 Scientific values: The structure of the tablet includes three parts: the head, the body and the base. Some tablets are built as a whole, while others are connected by mortise and tenon joint, It depends on the size of the stone tablets and the material. These examples can provide important scientific and technological reference for today.

2.2.3 Artistic values: Most of the stone steles have dragon, turtle and auspicious cloud as their themes, and their carving skills are exquisite, reflecting the typical aesthetic orientation of the Ming and Qing Dynasties. The ancients often arranged stone tablets according to the space and function of architecture, For example, *the Dismounting Tablet* outside *the Donghua Gate* warns officials to dismount here before entering the Forbidden City, serving to divide the Forbidden Palace from the outside world.

2.2.4 Social and Cultural values: Many inscriptions are carved in both Manchu and Chinese, which show the architectural activities, life styles, ideas, customs and habits of the Ming and Qing Dynasties. These are important witnesses of the history of the court and reflect the diversity of Chinese court culture.

To sum up, the digital stone tablets should cover the following value carriers:

Component	Value carrier	Main type
Head	Form	Chinese dragon Auspicious clouds Gui General form
	Content	Top Inscription Hole
Body	Content	Stone Thread
	Inscription	Chinese Manchu
Base	Form	Sumeru Giant land turtle General form

Table 1. The value carriers of stone tablets

2.3 Assessment of State of Preservation

Stone tablets are immovable heritage. From the perspective of conservation concept, the environment in which the tablet is located is closely related to the value of cultural heritage, once it is moved, it will have a great negative impact on the value of

cultural heritage. From the perspective of engineering technology, it is necessary to adopt special technology or disintegrate the cultural relics to move the cultural heritage, which will cause great risks to the value of the cultural heritage. In most cases, conservation can only be carried out on site, so the digitization of stone tablets is often carried out under natural conditions, where the systematization of cultural heritage and environment is reflected.

At present, a series of standards and specifications have been introduced for stone cultural relics diseases, such as *Technical specification for evaluating disease of movable collection-Stone*, *Code for investigation of the protection engineering of the stone monument*, *Classification and legend on the deterioration of ancient stone objects*, etc. The threat of risk to value is closely related to its distribution, and the monitoring requires the protector to analysis the risk from the perspective of development, so the recording needs to be carried out from two dimensions of space and time. According to the location of risk, it includes structural risk, surface risk and material risk，And according to the development trend, it includes stability risk, persistent risk and intermittent risk. The following common risks need to be recorded:

Distribution	Type	Development trend		
		Stability	Persistent	Intermittent
Structure	Incomplete	√		
	Crack	√		
	Hole		√	√
Material	Pulverization		√	√
	Precipitation		√	√
	Separation		√	√
	Corrosion		√	√
	Hollowing		√	√
Surface	Contaminant	√		
	Organisms		√	√

Table 2. Common risks of stone heritage

2.4 Applicability of Technology

The scientific record is the basis for achieving preventive conservation. Under the concept of preventive conservation, the main task of digitization is to record the status information of heritage, including spatial information such as size and shape and surface information such as colour and texture. the advantages are obvious that use digital technology to replace the traditional way in terms of collection efficiency, data precision and later use. The current digital technology mainly includes traditional measurement, dimensionlaser scanning technology, digital Close Range Photogrammetry.

2.4.1 Traditional Measurement: Traditional measuring tools include total station, level, theodolite, ruler and so on. The advantage of these techniques is that they are easy to operate and can record the composition and general shape of the stele. The technical disadvantage is that the amount of information is limited but the workload is large. The accuracy of the data is limited to the millimeter level, and only part of the feature point data can be obtained. That is to say, the information is incomplete, and the text and disease information on the stone cultural relics cannot be accurately collected. The data obtained by traditional mapping can only be two-dimensional results.
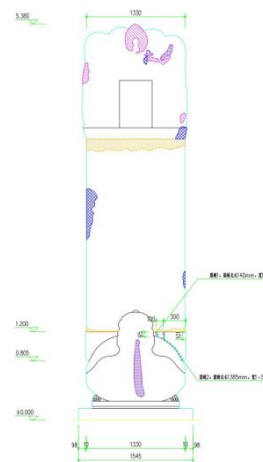

Figure 2. Two-dimensional line diagram

2.4.2 Dimensionlaser scanning technology: The technology is accurate, fast, contactless and automated in real time. The advantage of this technique in collecting three-dimensional information of objects with complex shapes and irregular shapes is very obvious. However, the cost of the equipment is high, the technical personnel should have high professional quality, the processing of mass data is complex, and the ability of this technology to collect colour information is weak. This technology can accurately obtain the size, structure and shape of the stone tablet. The monitoring of structural diseases can be realized, but it is impossible to monitor the changes of diseases such as dissolution and weathering of the surface material. e.g. Figure 3.
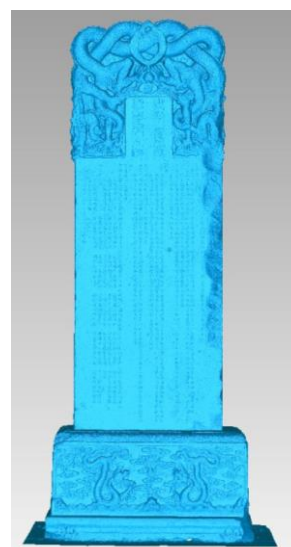

Figure 3. Three-dimensional laser model

2.4.3 Digital Close Range Photogrammetry: It is a branch of photogrammetry, mainly studying the theory and technology of photographing all kinds of close range objects and determining their shape and size. With the characteristics of non-contact, the image information is rich and vivid, the data is easy to process and save, and the collection efficiency is high. Close range photogrammetry has been successfully applied in projects such as *Dazu Stone Carvings* in Chongqing and *Mogao Grottoes* in Dunhuang. The disadvantage is that for objects with complex shapes, while there are analytical errors. It is also very flexible in the use of the later stage. e.g. Figure 4.

Figure 4. Digital image with common risks

Digitalization based on the concept of Preventive Conservation is a long-term task，Therefore, we should try our best to choose the economic and practical technology with simple operation, but we can't reduce the achievement standard. The digital achievement should be able to accurately express the value carrier and risk situation. By comparing the collection efficiency, achievement accuracy, expression characteristics, workload and cost of the various technologies, The conclusions are as follows：

Component	Type	Traditional measurement	dimensionl aser scanning technology	photogrammetry
Head	Form	√	√	
	Content	√	√	√
Body	Content	√	√	
	Inscription			
Base	Form	√	√	
Risk	Structure		√	
	Surface			√
	Material			√

Table 3. applicability of Technology

3. TECHNICAL PROCESS

3.1 Process

Considering many factors such as application, site conditions, acquisition accuracy, efficiency, cost, the authors choose close-range photogrammetry as the main technology for acquisition which is supplemented by dimensionlaser scanning technology or traditional measurement according to the heritage itself. The process are as follows:

3.1.1   Control Survey: Control points are laid in the flat parts of the stone tablet without special decoration diseases. If the above conditions cannot be met, the feature points on the stone tablet will be selected as control points. The total station is used to measure the control points for stone tablets with wide field acquisition space, while the three-dimensional laser scanning method is used to scan the positions of some structures   for stone tablets with narrow surrounding space, , and the scanning data precision is less than 0.2 mm, which is used as the control data of photogrammetry.

3.1.2   Artificial Facility: In order to ensure the accuracy of the colour of the data collected in the later period and avoid the change of natural light on the image of the colour of the stone tablet, we choose the time when the light change is small to shoot, or build a fence around the stone tablet to obtain an artificial light environment. e.g. Figure 5.

Figure 5. Artificial Facility

3.1.3   Acquisition Preparation: Before the collection of three-dimensional spatial data and texture data, the general information of each face of the stone tablet was shot to record the overall situation and status information of the stone tablet. Then the technicians took the colour restoration images with 24 colour cards on each side of the stone monument in the facility. If the light changes, the colour card photos were taken in time. e.g. Figure 6.
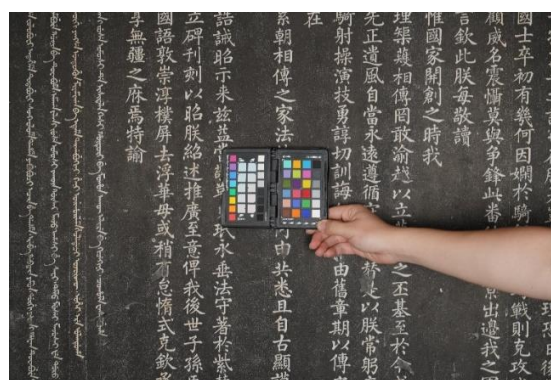

Figure 6. Original image with colour card

3.1.4   Data Acquisition： The high-resolution digital camera was adopted to shoot the close-up image of the stone monument with the navigation belt method, and the overlap rate of heading and side direction was not less than 60%. The resolution of the shot image was determined according to the specific requirements of the results, and the resolution of this shot was not less than 300 dpi.

3.1.5 Data Processing: In order to ensure the colour consistency of images taken in different light environments and at different times, the colour of images should be corrected firstly. Accuracy of colour is the basis for later use, such as image monitoring. The author uses the colour evaluation software to evaluate the colour restoration degree of the image, and obtains the index, CIDIE2000 < 5, then the author calculates the data by using 3D reconstruction software. Firstly, the coordinate input software of control points is used to control the size and precision of the 3D reconstruction model. When the spatial triangle relationship established by the image meets the precision requirement which is less than 0.2mm, the reconstruction of the 3D texture model of the stone tablet is completed. e.g. Figure 7-8.

Figure 7. Processed image

Figure 8. Digital model with colour and texture

3.1.6 Achievements: The author has made a series of achievements such as high-precision three-dimensional texture model, orthophoto map and vector line drawing of the stone tablet, which provide the basis for preventive conservation work of the stone tablets.

3.2 Applicability Conclusion

In the collection efficiency, the use of digital camera can quickly complete the field collection, the collection efficiency is high; In terms of cost, the equipment only needs ordinary surveying and mapping instruments, ordinary cameras and related accessories. Compared to the use of 3D scanning technology alone, the cost is lower.

In the subsequent digitization of other cultural relics, different methods should be selected according to the specific needs of the project, the use of the results and the site conditions. From the perspective of practice, each of the three technologies has its own advantages and disadvantages. The organic combination of

the three methods and proper use of the advantages of different methods is the most cost-effective way of digitization at present. e.g. Figure 9.
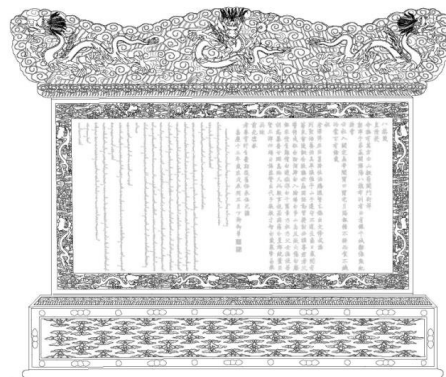

Figure 9. CAD line diagram

4. CONCLUSIONS

According to the author, the research of this paper has the following shortcomings, which can also be used as the research direction in the future.

With the same research method, the research results may be quite different when facing different research objects. The most important characteristic of cultural heritage is its coexistence and diversity. Therefore, different collection strategies should be formulated according to its characteristics.

Digitization involves many majors. This paper mainly conducts directional research in the acquisition stage and strives to do the best technical research in the processing stage. The fusion of different data sources is one of the difficulties in the current digitization, and the technical details in the later utilization still need more professional people to study.

The deficiency of the industry is directly related to the lack of standards, so it is urgent to develop digital standards for cultural heritage, and the results of strategy research have reference significance for the formulation of standards.

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