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A Digital Mapping Modeling Method Applied to Imperial Garden Rockery

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Abstract: Rockery is the most important and unique skill in Chinese traditional gardening. Because of its complex form, rockery has been difficult to accurately survey. In this paper, we apply for three-dimensional laser scanning technology and show this method through experimental research. We select the Yingluo Rock which is the representative stone in bluestones for surveying and mapping, and the process of Surveying and mapping is introduced, including experimental data acquisition, data reconstruction, texture mapping and two-dimensional image generation. The results of the experiment are displayed and analyzed. Then we get the advantages and limitations of 3D laser scanning technology in the modeling and mapping of bluestone.
Keywords: Bluestone; rockery; digital modeling; 3D laser scanning technology.

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1. INTRODUCTION

Rockery is the most important and unique link in the traditional Chinese gardening. As the important achievement of Rockery, rockery is manually piled by materials such as soil and stone [1]. Rockery has always been difficult to measure accurately due to the complicated and inconstant shape. In ancient times, stone can only be expressed in the form of painting while the development of artificial surveying and mapping techniques in modern times has made the surveying and mapping of rockery possible; many surveying and mapping achievements have emerged [2]-[3]. However, most of the results of rockery surveying and mapping are attached to buildings as the recapitulative outline in two dimensions, the complicated three-dimensional relationship of rockery remains difficult to express [4].

The three-dimensional laser measuring technique and oblique photography measuring technique have developed rapidly and been widely applied in cultural relics research and archeology works in the recent years [5]-[12]. According to the current research, the measurement and performance of rockery need to be further explored. Therefore, in this paper, the bluestone mockery in imperial garden of Beijing is selected as the research object to make discussion on the modelling methods for its digital surveying and mapping.

Fig 1. Real scene of Yingluo Rock in Jingyi Garden, the Fragrant Hill

2. SURVEYING AND MAPPING EXPERIMENT ON ROCKERY WITH THE THREE-DIMENSIONAL LASER SCANNING TECHNIQUE

The common digital mapping technique currently used can be divided into the three-dimensional laser scanning technique and oblique photography measuring technique. In which the three-dimensional laser scanning technique obtains the observation distance by calculating the time difference according to the principle of laser ranging. The oblique photography measuring technique determines the three-dimensional relationship of the space by calculating the different coordinate positions of the same feature point in the digital photo of the measured object to obtain the three-dimensional model of the measured object.

2.1 Research object of experiment

The materials of imperial garden rockeries represented by three mountains and five gardens are mainly composed of Bluestone and Fangshan Stone. The most famous bluestone rockery is the Yingluo Rock in Jingyi Garden of the Fragrant Hill. Yingluo Rock is semicircular rockery piled up by a group of bluestones. The entire rockery group consists of three parts, the main mountain is located deep in green, the secondary mountain is in front of the waterfalls and blind platform and the accessory mountain is an independent peak on the southeast of the main mountain. There stands old tress in great numbers in the surrounding area while there are buildings such as pool and Qing in Pavilion in front of the rockery.

2.2 Experimental device

The main device for the experiment is FARO Focus3DX 330. Table 1 shows the device parameters.

2.3 Experimental procedure

The scanning plan is formulated according to the shape characteristics of the Yingluo Rock and the existing conditions in combination with the results of field scanning for constant adjustment. It mainly includes three steps: data acquisition, data reconstruction, and two-dimensional image generation.

Table 1. Major parameters of FARO Focus3DX 330

title	content
type	FARO Focus3DX 330
weight	5.2kg
dimension	240×200×100
range	0.6m to 330mm
speed	976,000 p/s
laser grade	Grade 1
wavelength	1550nm
range error	±2mm
pixel of integrated color camera	70,000,000

3. EXPERIMENTAL PROCESS

3.1 Data procurement

Scanner station setting and data procurement. A scanner station shall be installed first according to the height of rockery and Set the scanner station according to the height and turning of the rockery. In addition to ensuring the integrity of point cloud data of rockery for the dead angle-free scanning, there must be certain degree of overlapping among the point cloud data above 15%. In this experiment, 14 stations are set around the Yingluo Rock. During jointing the stations, the standard spherical target provided by FARO shall be adopted for measurement. In this experiment, 6-8 targets are set at each station. The laser intensity is set by default, the scanning resolution is set as 1/4 of the accuracy. In this experiment, camera with 600×1200dpi resolution built in the FARO scanner is adopted for shooting.

Splicing and registration of point cloud data. After the point scanning is completed, the data shall be imported into the dedicated software SCENE that matches the FARO scanner, and the point cloud data are jointed and registered in SCENE to optimize the and the data of the jointed point cloud project, afterwards the point cloud model in the format of xyz will be exported.

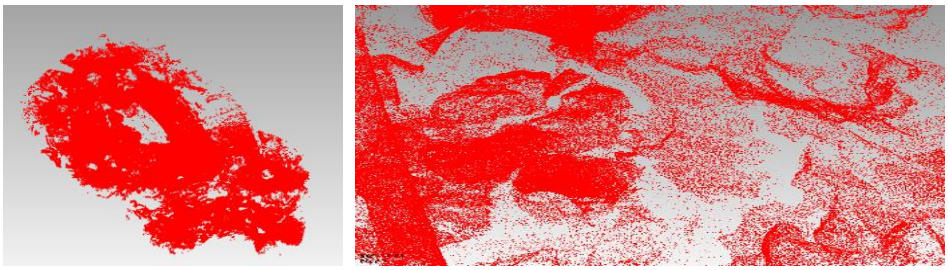

Fig 2. Complete and local point cloud model

The procedures of the three-dimensional construction of rockery are mainly point cloud reconstruction, three-dimensional model construction and texture mapping etc.

Point cloud reconstruction. In this experiment, Germanic studio is adopted to export the data into a file with the extension. Xyz via the SCENE software and open it for processing. To ensure the accuracy of rockery contour, the extraction of point cloud is controlled at 50%.

During the extraction, data not participating in three-dimensional construction will be deleted and delousing processing on the point cloud will be performed to eliminate some interferences, thereby improving the accuracy of three-dimensional model construction.

Three-dimensional model construction. As the three-dimensional point cloud model only contains the spatial coordinate information of the measuring points, the point cloud model shall be reconstructed through gridding to generate a corresponding three-dimensional geometric model. The procedures of which include cover, hole-filling, data compaction and model reconstruction.

The processed point cloud model is covered and encapsulated into a triangular grid model. There will be some errors and unclosed surfaces of the covered model in comparison with the actual model due to the complicated rockery shape. Holes shall be filled manually to restore the defective surfaces as far as possible according to the actual situation. This is the most important and tedious part of the three-dimensional model construction. After the whole filling, the three-dimensional model and the point cloud model are compared to conduct the reconstruction and data compaction after controlling the error.

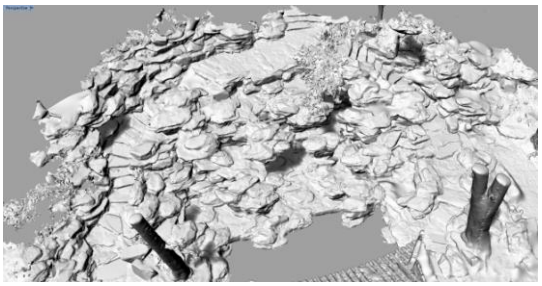

Fig 2. Three-dimensional model construction of Yingluo Rock

Texture mapping. Texture mapping is to form a material model by establishing the correspondence between various vertices of the model and the pixels of the image. To be specific, we adjust the model into the viewpoint corresponding to the photo and then importing the photo, the photo will be automatically mapped onto the model by the software. There will be textures on the model that are roughly the same with patterns of the original materials.

Fig.4 shows the comparison of the model after texture mapping and the real scene, the left is model and the right is real scene.

Figure 3. Comparison of the model after texture mapping and the real scene

3.2 Generation of two-dimensional drawing

There are two ways to make the two-dimensional maps. The first one is to export the o orthographic images with FARO SCENE, the second one is known as line drawing for short.

Orthographic image drawing. In this experiment, the FARO SCENE is adopted to export the orthographic images. Specifically, SCENE is adopted to slice the complete point cloud model after being jointed. The obtained model slices shall be adjusted at different views for checking to select the appropriate angle to export the orthographic images. Generally, time of exporting shall be determined by the accuracy of the exported images.

The line drawing method to process the three-dimensional model-exported images with the drawing software. To export the two-dimensional images of the three-dimensional grid model on different angles and direction. To insert the exported images into the AutoCAD in the same way of inserting the grating images; the contour lines and typical lines of stones or historical buildings are described with the spline curve or polyline, after which, the images and ready outlines are put into Photoshop for amplification processing to get the final drawing.

Fig 4. Generation and drawing of two-dimensional drawing of Yingluo Rock

4. ANALYSIS ON EXPERIMENTAL RESULTS

The data and image results of Yingluo Rock in Jingyiyuan of the Fragrant Hill obtained in this experiment. Here and now, the experimental results are analyzed from accuracy, consumed time and other aspects.

Three-dimensional model. The accuracy validation and comparison validation of the point cloud model and the three-dimensional grid model are conducted in this experiment. The overall maximum error in the point cloud jointing is -2.87 mm, which is within the error range allowed by the experimental device itself.

Table 2. Data conditions after the three-dimensional grid model optimization

Model title	Number of vertices	Number of triangular meshes	Superficial area (m^2)	Volume (m^3)	Error with point cloud model (mm)
Yingluo Rock	1427701	2791550	927.5579	176.3875	1.97

During optimizing the point cloud model, the extraction and delousing of point cloud will exert certain influences on the feature points of its edge hence the accuracy of the triangular grid model due to the complexity of the rockery shape. Therefore, the accuracy of triangular grid model of the mockery may be influenced.

During surveying and mapping the rockery mass, the complexity of the rockery mass and the surrounding environment always bring forth adverse effects on surveying and mapping. These

conditions will always result in the local or detail defections. These defections exert large influences on the accuracy of rockery model.

The complexity of the rockery and the environment makes the natural light conditions that are originally changing more complex; what's more, there will be obvious changes in conditions such as exposure and color temperature during the image shooting, hence the accuracy of texture mapping will be influenced.

Two-dimensional drawing. Two drawings are obtained in this experiment, namely the positive photography drawing and line drawing. The orthographic image drawing exports the slice of model. The exported images are colorful, vivid, visual, and intuitive and lively that can reflect the appearance lines, colors and textures etc. of the measurement target and even the seasonal conditions of the plants in garden. The line drawing requires the operator's second expression after understanding the measurement goal. The automation degree of the production is lower than that of the image map, the precision is also lower than the image map due to the human influence of the operator. In addition, in terms of expression effect of the figure, the line drawing can also express the spatial level and feature characteristics of the garden.

In summary, both methods have their unique advantages and disadvantages. Which method is adopted to depict an image shall be determined by factors such as time and operator's mastering of software.

5. CONCLUSION

After making a series of experimental studies and result analysis, it is discovered that the three-dimensional scanning technique has high accuracy and the model generated through surveying and mapping is vivid and lively to greatly improve the accuracy of rockery surveying and mapping, reflect the fine texture and complex spatial structure of rockery more detailed. On the other hand, the limitations of the three-dimensional laser scanning technique can also be discovered, for example, objects obstructing one another will be difficult to find, the amount of data is huge. Still, the results of rockery surveying and mapping brought by 3D scanning technology are unprecedented in accuracy and texture. It is hoped that these limitations can be overcame by this technology in the future to simplify the data processing and make the surveying and mapping more efficient and convenient.

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