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REVIEW ARTICLE

EXPERIMENTAL STUDY ON DATA COLLECTION TECHNIQUES FOR ROCK ART IN HUASHAN, ZUOJIANG, GUANGXI

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ABSTRACT

Zuojiang Huashan rock art in Guangxi is the most important part of the world cultural heritage -Zuojiang Huashan Rock Art Cultural Landscape. It is known for its grand scale, numerous images, unique system of linguistic expressions and rich connotations. As with rock art heritage around the world, the Zuojiang Huashan rock art also faces a series of conservation challenges. It is significant to completely record these rock art painted on the cliff and the information of their surrounding cultural relics in atechnically feasible and economically viable way. The experiment took Longzhou Chenxiangjiao rock art, Chaochuantou rock art, Mianjiang Huashan rock art and Ningming Huashan rock art as research objects, used oblique photography technique, object photogrammetry technique, panoramic technique and hyperspectral technique to conduct experimental research on data acquisition of the above rock art on the basis of different environments and parameters, and obtained a large amount of experimental data. The comparative analysis shows that the object photogrammetry is the most suitable data acquisition technique for Zuojiang Huashan rock art at present.

KEYWORDS:

Zuojiang Huashan Rock Art, Data Acquisition, Object Photogrammetry

1. INTRODUCTION

Zuojiang Huashan rock art in Guangxi is the most important part of the world cultural heritage -Zuojiang Huashan Rock Art Cultural Landscape.

Figure 1: Partial of Zuojiang Ningming Huashan Rock Art

It is known for its grand scale, numerous images, unique system of linguistic expressions and rich connotations (Figure 1). As with rock art heritage around the world, the Zuojiang Huashan rock art of also faces a series of natural and man-made factors that affect its permanent preservation. In addition to continuously strengthening the science and technology to mitigate the impact of the natural environment on the rock art and to protect the rock art itself and the cliffs to which it is attached, it is also an urgent task to use the existing technology to make an omnibearing true record of the rock art and its surrounding information. Since there are many techniques used for information acquisition, researchers are often at a loss when choosing which technique to use for rock art information acquisition, much less how to set different parameters to obtain the best data, and therefore the results are often unsatisfactory. In order to solve the problem of data acquisition of Zuojiang Huashan rock art under unique geographical environment, we selected one of them, namely, Chenxiangjiao Huashan rock art, Chaochuantou Huashan rock art, Mianjiang Huashan rock art and Ningming Huashan rock art, as the research object, and searched for the most suitable digital acquisition technique of Zuojiang Huashan rock art through the comparison test and analysis of various techniques such as oblique photography technique, object photogrammetry technique, panoramic technique and hyperspectral technique. Finally a large batch of experimental data was obtained, and the experiment achieved good

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results.

2.OBLIQUE PHOTOGRAPHY TECHNOLOGY EXPERIMENT

Oblique photography is an emerging mapping technology that uses several sensors sharing the same aircraft to collect images from five different angles, including one vertical and four tilts. In this experiment, we mainly used the Mianjiang Huashan rock art as the object for data collection.

2.1 Data Acquisition

For this data acquisition we chose the DJI Phantom 4 RTK UAV aerial mapping system as the main filming device. For the Mianjiang rock art survey area, we set the heading overlap rate and side overlap rate, lens tilt angle, and course height to obtain the original image. After checking the equipment and determining that the weather and surrounding environment meet the flight conditions, the pre-planned route data is uploaded and the drone automatically flies according to the route to complete the task. After the flight is completed, download flight data, photos, on-board POS and GPS data, and check data quality and integrity in the field.

2.2 Interior Processing and Results

After the external photography operation is completed, the data will be exported in time and transferred to the modeling software for Interior processing. The Interior processing includes: checking the flight quality and the quality of the captured images, such as the actual image overlap, image inclination and rotation angle, the curvature of the route, the uptake coverage, the clarity of the image, the displacement of the image point, etc. For the places that do not meet the requirements, it needs to make up the flight or re-fly in local area; using the beam method area network joint leveling method for data processing (air three encryption); establishing a real-world three-dimensional model. Based on the original images and the results of Air 3, 3D model data were generated by processing software such as DJI Terra (Figure 2a, 2b).

When completing Real scene 3D modeling, the quality inspection of the results should be carefully done. Quality inspection includes coordinate system (whether the plane datum is China Geodetic Coordinate System 2000, the elevation datum is 1985 national elevation benchmarks), unit of model (whether the ratio is 1:1 in meters), format of model (whether the 3D model storage format is osgb/obj), effective coverage area (whether the area covered by the 3D model contains the geographical information of the cultural relics), resolution (whether the model texture resolution ≤ 5 cm), accuracy (whether the relative accuracy of the model space point position ≤ 5 cm), texture details (whether the 3D model restores the current state of the rock art, whether the texture details are clear), etc.

2.3 Analysis Comparison

Based on experiments and studies, we found that the main factors affecting the inclined 3D photogrammetry include flight altitude, overlap rate (heading, side direction), inclination angle (30 degrees, 45 degrees, 60 degrees, flight time), etc.

2.3.1 Flight Altitude

When the route height is 200 meters, the heading overlap rate is 80%, the side overlap rate is 70%, and the gimbal tilt angle is 45 degrees, the model resolution is 7.75 cm (Figure 3a, 3b), and the accuracy error is between 1 cm and 5 cm.

When the route height is 300 meters, the heading overlap rate is 80%, the side overlap rate is 70%, and the gimbal tilt angle is 45 degrees, the model resolution is 8.22 cm (Figure 4a, 4b), and the accuracy error is between 2 cm and 5 cm.

When the route height is 350 meters, the heading overlap rate is 80%, the side overlap rate is 70%, and the gimbal tilt angle is 45 degrees, the model resolution is 9.59 cm (Figure 5a, 5b), and the accuracy error is between 2 cm and 5 cm.

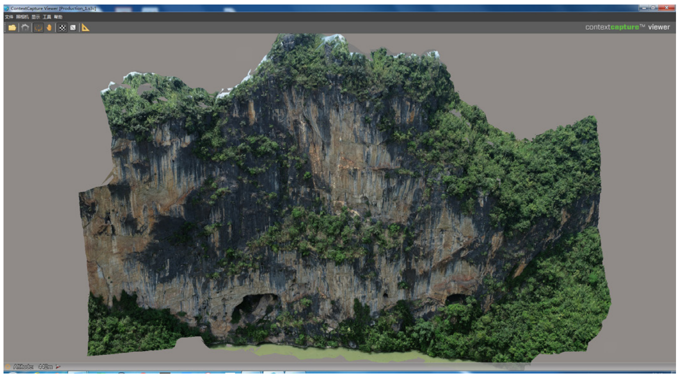
2.3.2 Overlap Rate

When the route height is 300 meters, the heading overlap rate is 40%, the side overlap rate is 30%, and the gimbal tilt angle is 45 degrees, the flight time is 40 minutes, the model resolution is 8.22 cm, the accuracy

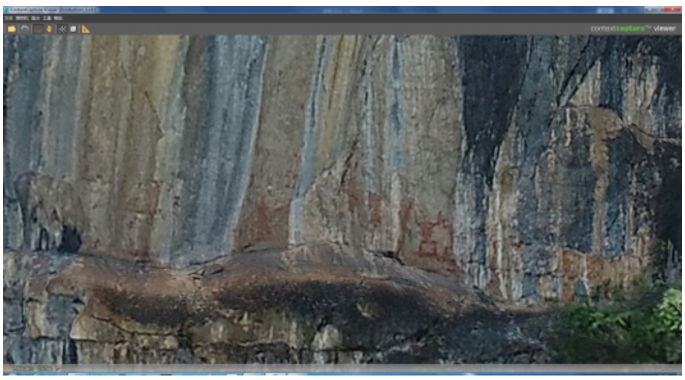
a: Rock mass

b: Details of rock art

Figure 2: 3D model of Mianjiang rock art scene

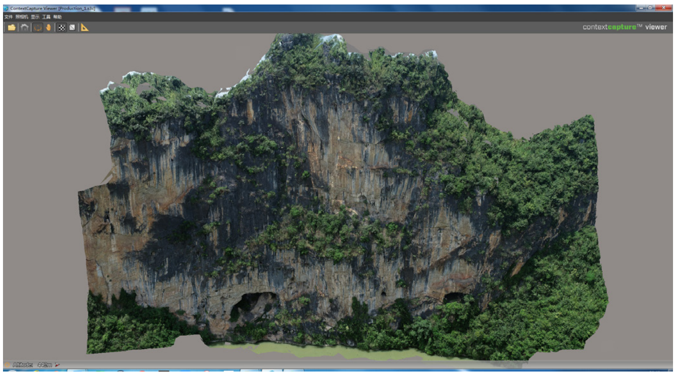


a



b

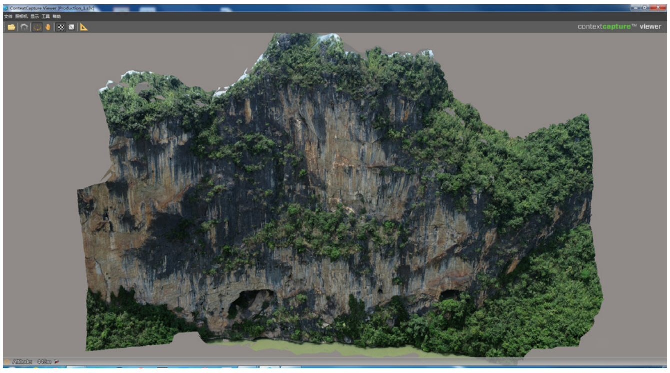
Figure 3: 3D model of Mianjiang Huashan rock art scene (H=200 m)



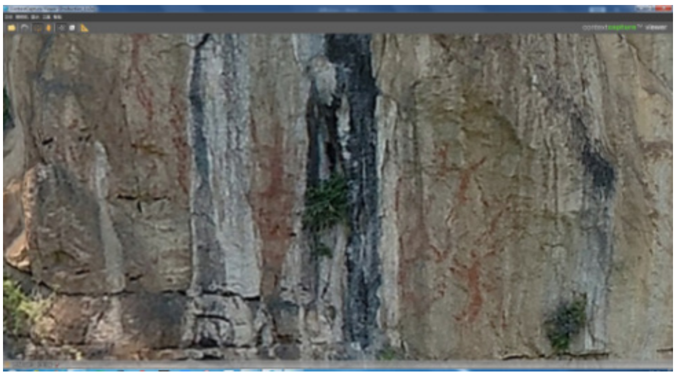
a

b

Figure 4: 3D model of Mianjiang Huashan rock art scene (H=300 m)



a

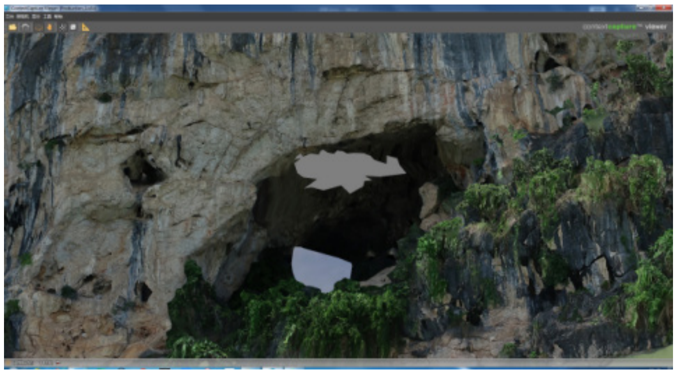


b

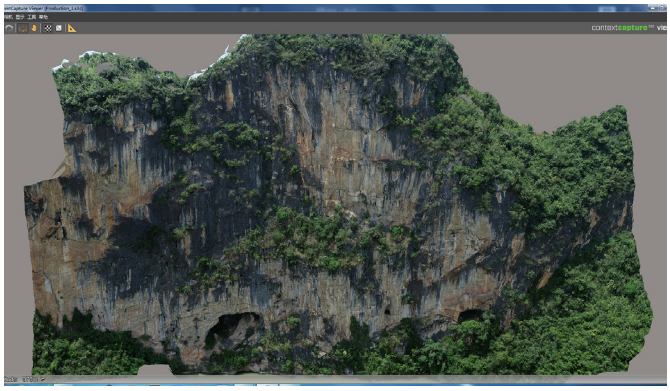
Figure 5: 3D model of Mianjiang Huashan rock art scene (H=350 m)

error is between 1cm and 5 cm, the modeling is incomplete and there are holes in some places (Figure 6a).

When the route height is 300 meters, the heading overlap rate is 60%, the side overlap rate is 50%, and the gimbal tilt angle is 45 degrees, the flight time is 60 minutes, the model resolution is 8.22 cm (Figure 6b),



a



b

Figure 6: 3D model of Mianjiang Huashan rock art scene

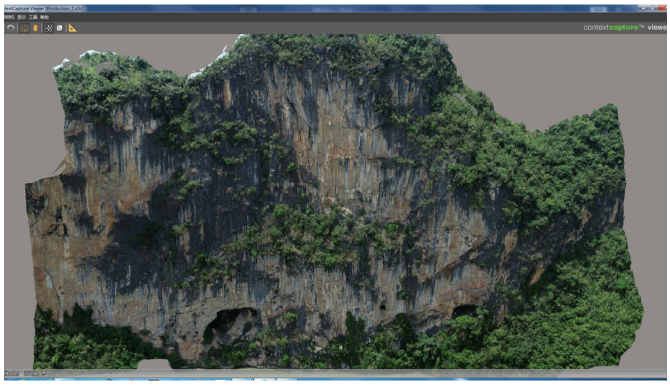


Figure 7: 3D model of Mianjiang Huashan rock art scene

and the accuracy error is between 1 cm and 5 cm.

When the route height is 300 meters, the heading overlap rate is 80%, the side overlap rate is 80%, and the gimbal tilt angle is 45 degrees, the flight time is 90 minutes, the model resolution is 8.22 cm (Figure 7), the accuracy error is between 1 cm and 5cm.

2.3.3 Inclination Angle

When the route height is 300 meters, the heading overlap rate is 80%, the side overlap rate is 80%, and the gimbal tilt angle is 30 degrees, the flight time is 95 minutes, the model resolution is 8.22 cm (Figure 8a), the accuracy error is between 1 cm and 5 cm.

When the route height is 300 meters, the heading overlap rate is 80%, the side overlap rate is 80%, and the gimbal tilt angle is 45 degrees, the flight time is 90 minutes, the model resolution is 8.22 cm (Figure 8b), the accuracy error is between 1 cm and 5cm.

When the route height is 300 meters, the heading overlap rate is 80%, the side overlap rate is 80%, and the gimbal tilt angle is 60 degrees, the

a

b

Figure 8: 3D model of Mianjiang Huashan rock art scene

Figure 9: 3D model of Mianjiang Huashan rock art scene

flight time is 85 minutes, the model resolution is 8.22 cm (Figure 9), and the accuracy error is between 1 cm and 5 cm.

2.4 Summary

The 3D model of rock art generated by the drone oblique photography with different flight heights, overlap rates, gimbal tilt angles, the surrounding geographic information of it is fully visible, and the accuracy error is within 10cm; The lower the flight altitude, the higher the image resolution, and the model appears holes when the heading overlap is less than 60% and the side overlap is less than 50%; There is not much difference between models with different tilt angles of the gimbal. Since the rock art in Zuojiang Huashan is on the outdoor rock, the details of rock art, rock and trees are blurred in the data results obtained by the tilt camera. We hold the view that oblique photography live 3D modeling can only satisfy the collection of data on the general scope of rock art and the surrounding environment, but cannot satisfy the study of local details of rock art by cultural relic experts.

3. OBJECT PHOTOGRAMMETRY TECHNIQUE EXPERIMENT

The object photogrammetry, through a reasonable choice of photographic instruments, photographic methods and layout control, can photograph multiple points in an instant and obtain the three-dimensional spatial coordinates of point groups on the target object without harming the object being measured. We used Mianjiang rock art, Chaochuantou rock art, and Chenxiangjiao rock art in Huashan as the objects for the data acquisition experiments of the close-view photogrammetry technique, respectively.

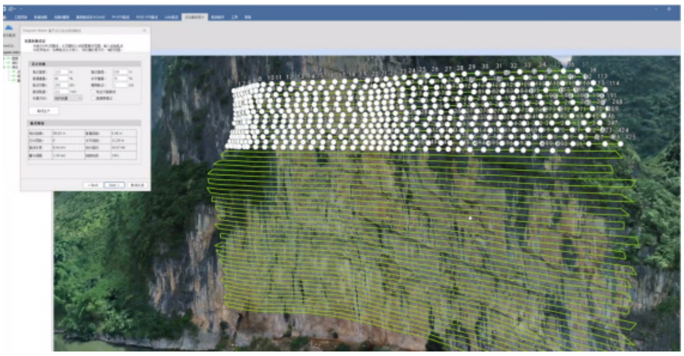
3.1 Data Acquisition

We choose DJI M300RTK+P1 UAV aerial mapping system as the filming equipment. Firstly, rough mode acquisition was carried out. After the pre-flight inspection of the drone was completed and the weather and surrounding environment were determined to meet the flight conditions, the drone was flown manually to shoot. After the flight was completed, the flight data, photos, on-board POS and GPS data were downloaded and imported into the DJI Terra to establish the rough model (Figure 10), and then fine route planning (software: WPM Waypoint Master) was performed. The technician set the heading overlap rate and side overlap rate, lens tilt angle, route height, elevation distance and other different variable parameters to obtain the original image (Figure 11a, 11b). The third step was to take object photography. According to the data, the location of the rock art in the rock was first marked on the rough model, and then the DJI M300 RTK drone was used to take pictures about 8 meters away from the rock art elevation under the premise of ensuring flight safety. After the flight was completed, the flight data, photos, on-board POS and GPS data were downloaded, and the data quality and integrity were checked at the site (Figure 12a, 12b).

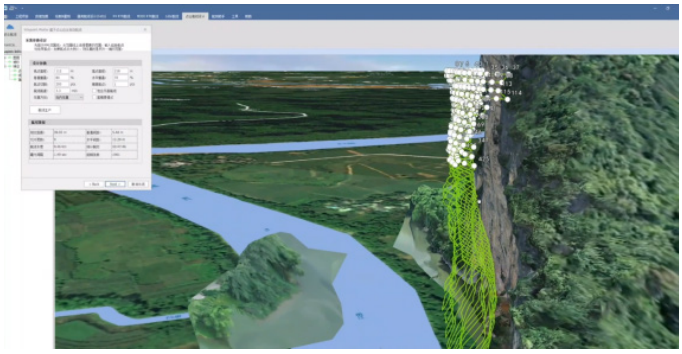
3.2 Data Processing and Result

After the outdoor photography operation was completed, the data were

Figure 10: Rough model (Chenxiangjiao)



a



b

Figure 11: Object photogrammetry route planning (Chenxiangjiao)

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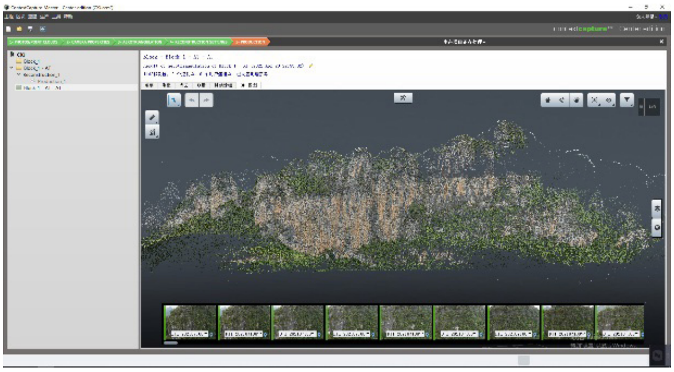
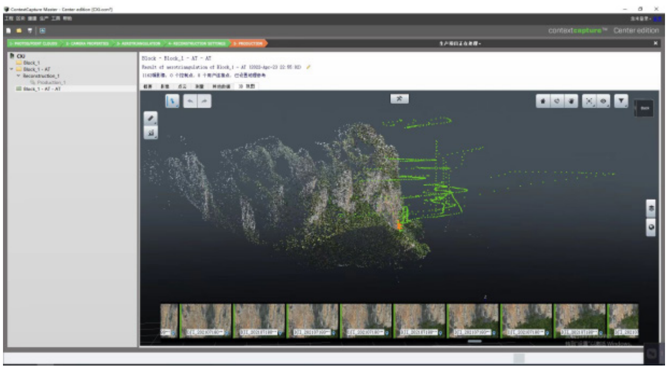
a b

Figure 12: Object shooting site operations of drones (Chenxiangjiao)



a



b

Figure 13: Air 3 encryption results (Chenxiangjiao)

exported in time and transferred to modeling software such as DJI Terra or Context Capture Center for interior processing. The content of the internal processing includes: data inspection (the inspection content is basically the same as the oblique photography technique); processing the internal data of UAV object photogrammetry by using the method of joint leveling of the beam method area network (Figure 13a, 13b); establishing a refined 3D model, and using the internal processing software such as DJI Terra and context Capture Center to generate 3D model data based on the original images and the results of the Air 3. The 3D model data were generated based on the original images and the results of Air 3, and the 3D model data were generated by using the internal processing software such as DJI Terra and Context Capture Center (Figure 14 – Figure 19).

When 3D realistic modeling is carried out, quality control is also conducted for coordinate system (whether the plane datum is China Geodetic Coordinate System 2000, the elevation datum is 1985 national elevation benchmarks), model units (whether the ratio is 1:1 in meters),

Figure 14: Rock mass of Huashan Chenxiangjiao rock art

Figure 15: Detail size of Huashan Chenxiangjiao rock art

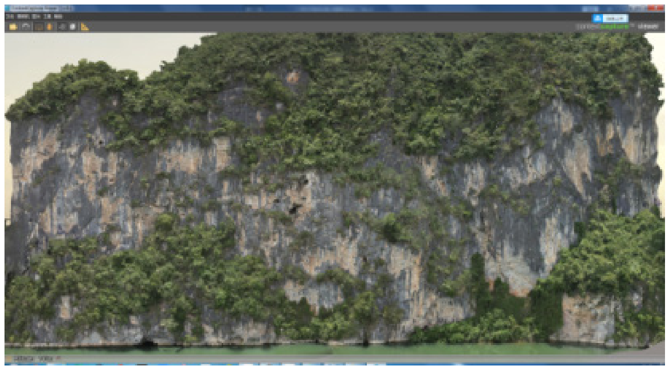


Figure 16: Rock mass of Chaochuantou rock art

Figure 17: Detail size of Huashan Chaochuantou rock art

model format (whether the 3D model storage format is osgb/obj), effective coverage area (whether the area covered by the 3D model contains the geographical information of the cultural relics), resolution (whether the model texture resolution ≤ 5 cm), accuracy (whether the relative accuracy of the model space point position ≤ 5 cm), texture details, etc.

3.3 Analysis Comparison

Figure 18: Rock mass of Huashan Mianjiang rock art

Figure 19: Detail size of Huashan Mianjiang rock art

Figure 20: Backlight rock art (Chenxiangjiao)

Figure 21: Front light rock art (Chenxiangjiao)

Based on the research and experiments, we found that the main factors affecting the results of 3D modeling of rock art by object photography include lighting, distance, overlap rate, etc.

3.3.1 Lighting

When the object photography distance is 8 meters, the heading overlap rate is 90%, the side overlap rate is 90%, the model resolution is 0.07 cm, and the accuracy error is between 0.2 cm and 0.5 cm. The quality of rock art close-up photographic model results is greatly influenced by different weather lighting (Figure 20, Figure 21).

3.3.2 Distance

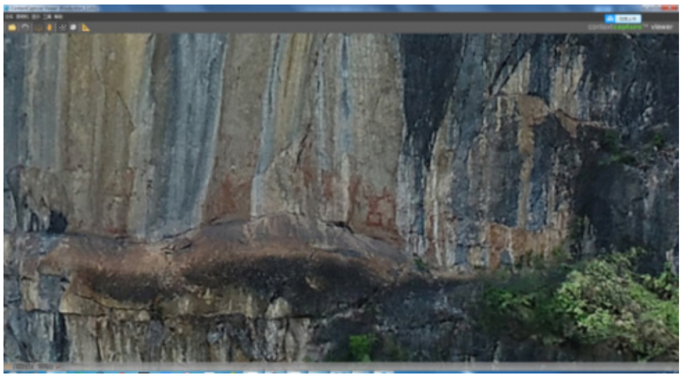


Figure 22: Huashan Mianjiang rock art

Figure 23: Huashan Mianjiang rock art

Figure 24: Huashan Chaochuantou rock art

When photographing on a sunny day, horizontal overlap is 90%, vertical overlap is 90%, and the object photography distance of rock art is 20 meters, model resolution is 0.31 cm, accuracy error is 0.2 cm-0.5 cm (Figure 22).

When photographing on a sunny day, horizontal overlap is 90%, vertical overlap is 90%, and the object photography distance of rock art is 12 meters, model resolution is 0.15 cm, accuracy error is 0.2 cm-0.5 cm (Figure 23).

When photographing on a sunny day, horizontal overlap is 90%, vertical overlap is 90%, and the object photography distance of rock art is 8 meters, model resolution is 0.07cm, accuracy error is 0.1 cm-0.5 cm (Figure 24).

3.3.3 Overlap Rate

When photographing on sunny days, with 40% horizontal overlap rate and 40% vertical overlap rate, the distance of close rock art photography is 8 meters, and the close photography is not involved in 3D reconstruction, and the model resolution is poor (Figure 25a).

When photographing on sunny days with 70% horizontal overlap rate and 70% vertical overlap rate, the model resolution was 0.07 cm with an

a

b

Figure 25: Huashan Mianjiang rock art

Figure 26: Huashan Mianjiang rock art

accuracy error of 0.1 cm-0.5 cm at a distance of 8m close to the rock art (Figure 25b).

When photographing on sunny days, with 90% horizontal overlap rate and 90% vertical overlap rate, the model resolution was 0.07 cm with an accuracy error of 0.1 cm-0.5 cm at a distance of 8 m close to the rock art (Figure 26).

3.4 Summary

With the above analysis and comparison, we believe that the object photogrammetry technology has obvious advantages for data acquisition technology of mural painting class immovable cultural relics, with higher efficiency and lower cost, and the generated digital 3D model has high resolution, high precision and realistic texture, which can meet the geographic information acquisition around rock art, and also meet the requirements of experts for digital archiving and long-term research of rock art class immovable cultural relics.

4. PANORAMIC IMAGE TECHNOLOGY EXPERIMENT

Panoramic photography is a technique of photographing by uniformly rotating a movie camera on a horizontal plane or a vertical plane, and the technique is rather simple. We conducted experiments of panoramic photography data acquisition with rock art of Chenxiangjiao, Chaochuantou and Mianjiang in Huashan as objects respectively.

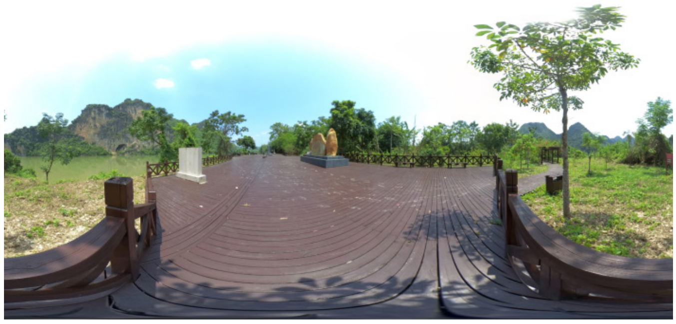


Figure 27: Ground panorama of Huashan Mianjiang rock art

Figure 28: Aerial panorama of Huashan Chenxiangjiao rock art

4.1 Data Acquisition

It includes ground panoramic photography and air panoramic photography. Ground panoramic photography uses insta360 one r dual-lens panoramic camera for one-touch photography and automatic stitching imaging (Figure 27). Air panoramic photography is often done with the help of drones for panoramic photos.

4.2 Data Processing and Results

The data processing mainly includes three contents: panorama stitching, Photoshop-based panorama image repair, and panorama uploading.

The panoramic photos were stitched by PTGui. Firstly, we imported 40 photos taken at one shooting location into the software, and then clicked on the alignment image. The software would automatically configure its lens parameters and stitch the panoramic pictures. Next, fuse the panoramic sky picture with the panoramic picture made by PTGui through Photoshop to produce the final panoramic picture. Finally, we upload the created panoramic pictures to 720 Cloud Panorama website, which can be logged in through WeChat account.

Through data collection and data processing, we obtained the panoramic image results of the rock art of Chenxiangjiao, Chaochuantou, Mianjiang in Huashan (Figure 28-Figure 32).

In the data processing, we also focus on resolution (whether the resolution is ≥ 75 dpi), image color (whether the image color is homogenous and there is no obvious color difference), image format (whether the image storage format is JPG), authenticity (whether the image real scene shooting is real and there is no fiction), interactivity (whether the stitching results can be connected with Flash technology, whether the mouse or keyboard can control the direction of the circular view, and whether the up and down, left and right, front and back range of roaming browsing), and whether the panoramic range (whether the panoramic range covers the geographic environment around the rock art and the internal environment), etc. All these aspects were checked.

4.3 Analysis and Comparison

Figure 29: Aerial panorama of Huashan Chaochuantou rock art

Figure 30: Ground panorama of Huashan Chaochuantou rock art

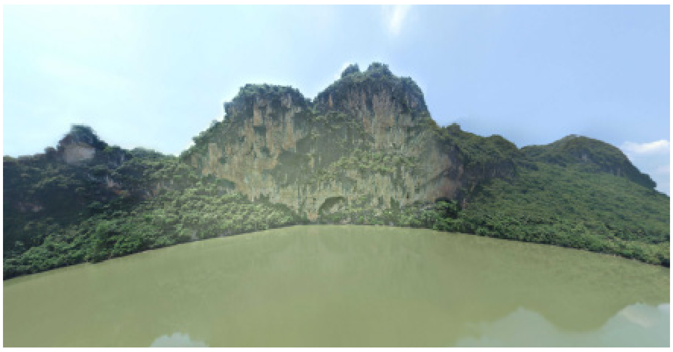


Figure 31: Aerial panorama of Huashan Mianjiang rock art

Figure 32: Ground panorama of Huashan Mianjiang rock art

Based on experiments and research, we found that the main factors affecting the quality of the panorama of rock art include weather, camera shutter speed, ISO, flight height, etc. (Figure 33 - Figure 36).

4.4 Summary

The quality of rock art panoramic imaging varies in different weather, shutter speed, ISO, and height, and can give a three-dimensional sense of realistic 360-degree images, with all surrounding geographical information visible in full, maximizing the authenticity of the scene and making the viewer feel like he or she is there, which can meet the requirements of heritage conservation, promotion, and online browsing.

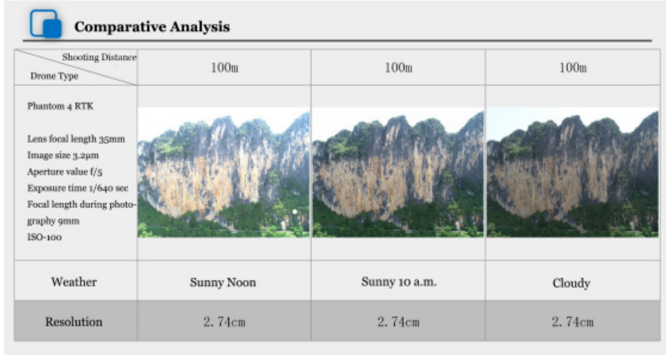


Figure 33: Results under different weather (Chenxiangjiao)

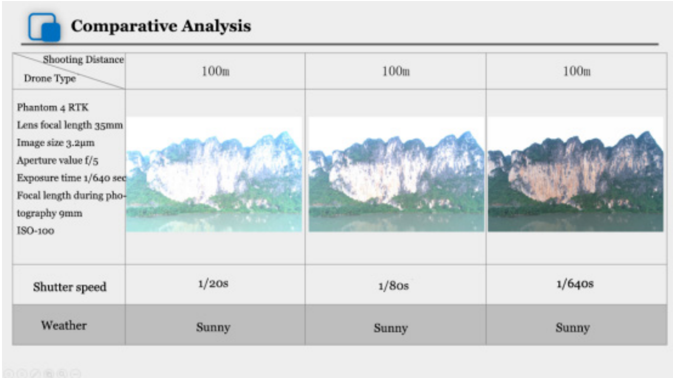


Figure 34: Results under different shutter speed (Chenxiangjiao)

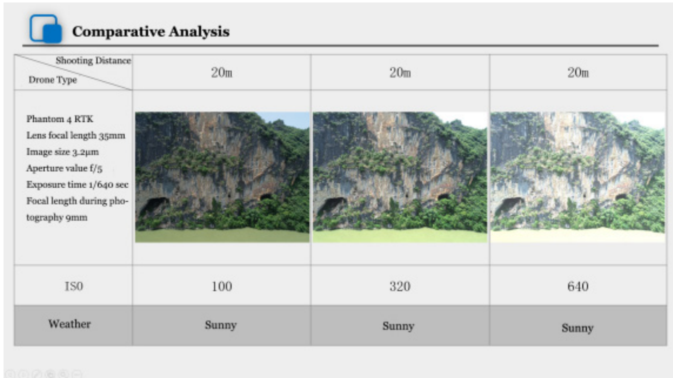


Figure 35: Results under different ISO (Mianjiang)

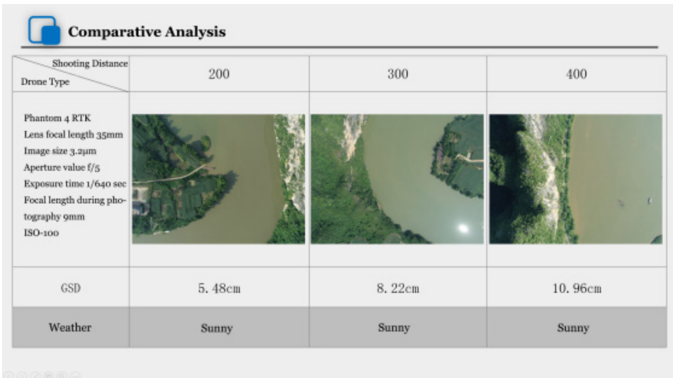


Figure 36: Results under different height (Chaochuantou)

However, the resolution of rock art details is not enough, and can only meet the needs of experts and scholars to understand the rock art environment, inconvenient to conduct further research on rock art.

5. HYPERSPECTRAL TECHNOLOGY EXPERIMENT

Hyperspectral imaging technology is a technique based on numerous narrow-band image data, which combines imaging technology with spectral technology to detect the two-dimensional geometric space

Table 1: Fixed parameters

Scanning time	May 15, 2021, 11:00 - 12:00
Scanning frame rate	40PFS
Weather	Sunny
Scanning distance	10 m
Scanning location	Ningming Huashan Rock Art No. 1 mission site

Table 2: Variable parameters

Scanning method	Horizontal scanning and vertical scanning

Table 3: Fixed parameters

Scanning method	Horizontal scanning
Scanning frame rate	40PFS
Weather	Sunny
Scanning distance	10 m
Scanning location	Ningming Huashan Rock Art No. 1 mission site

Table 4: Variable parameters

Scanning time	May 14-15, 2021 in the morning, noon and afternoon

and one-dimensional spectral information of the target and acquire continuous, narrow-band image data with high spectral resolution. We conducted data acquisition experiments of hyperspectral imaging technology with Ningming Huashan rock arts as the object.

5.1 Data Acquisition

In this experiment, we adopted X-brand hyperspectral equipment to collect data on the rock art of Huashan in Ningming with different parameters of three variable groups, respectively. The three sets of variable parameters were: scanning mode, scanning time, and scanning flatness.

5.1.1 Scanning Mode

Select a determined task point, set different scanning modes in the same time, and check the hyperspectral image data quality in spatial dimension (RGB pseudo-color display) and spectral dimension (spectral curve) by comparing the effect of different scanning modes on the hyperspectral image data of the same area, and compare to get the best scanning mode. (See Table 1, Table 2).

5.1.2 Scanning Time

Due to the topographic and orientation characteristics of the mission area, different scanning operation time set correspond to different ambient light conditions, and the variation of light conditions has a great impact on the hyperspectral imaging. By comparing the hyperspectral image data scanned at different times for the same area, the quality of hyperspectral image data in spatial dimension (RGB pseudo-color display) and spectral dimension (spectral profile) is viewed. The information of the three sets of data scanning operations is as follows. (See Table 3, Table 4).

5.1.3 Scanning Flatness

Due to the concavity of the mountain, the surface of the mountain is uneven, and the rock art is drawn on the flat rock surface of part of the area, while the rock art is drawn on the undulating rock surface of part of the area. The hyperspectral image data of rock art in different flatness areas were collected at the same distance at the same time using the transverse scan mode, and the influence of flatness on the hyperspectral image data of rock art was judged by analyzing the spatial and spectral dimensional data quality of hyperspectral data of rock art in different flatness areas. (See Table 5, Table 6).

Table 5: Fixed parameters

Scanning method	Horizontal scanning
Scanning frame rate	40PFS
Weather	Sunny
Scanning distance	10 m
Scanning time	May 15, 2021, morning

Table 6: Variable parameters

Scanning location	Ningming Huashan Rock Art No. 1 mission site (flatter areas) and No. 3 mission site (undulating areas)

5.2 Data Processing

Image enhancement: emphasizing the data features and enhancing the image effect by adapting the density or hue of the image. This includes color enhancement, edge enhancement, contrast enhancement, density segmentation, ratio calculation, deblurring, etc. (Liu, 2012).

Information extraction: using special digital image processing system to process the enhanced images and extract effective remote sensing information. It includes automatic identification and classification by various statistical analysis, cluster analysis, spectral analysis, etc. (Wu, 2009).

5.3 Data Outcome

5.3.1 Scanning Method

Set up a scanning station at Ningming Huashan Rock Art No. 1 mission site, use the same duration, scanning frame frequency and scanning distance to collect the same area with different scanning methods, and compare the data quality of the two groups as follows.

(1) Spatial dimension data quality

Figure 37: Horizontal scanning spatial dimensional images of Ningming Huashan Rock Art No. 1

The two sets of hyperspectral image data were shown in pseudo-color according to RGB (650 nm, 550 nm and 450 nm), and the spatial dimensional effects of the images of the two scanning methods are shown below (Figure 37, Figure 38).

By comparing the hyperspectral image data acquired by different scanning modes at Ningming Huashan rock art site 1 at the same time, it can be seen that there is no obvious quality difference between the hyperspectral image data acquired by different scanning modes in the spatial dimension, that is, the scanning operation mode of the hyperspectral imager has no obvious effect on the quality of the hyperspectral image data in the spatial dimension.

(2) Spectral dimension data quality

The hyperspectral image of the rock art in the same area within Ningming Huashan Rock art No. 1 mission site was selected to view the spectral curves of the hyperspectral images in different scanning modes at the same location, and the area was selected as a rock art figure with a concentric circle at the left leg in the image, and the spectral curves of the figure in different time periods are as follows (Figure 39, Figure 40).

Comparing the spectral curves of the hyperspectral images acquired by different scanning modes, it can be seen that the spectral curves in different scanning modes have consistent trends and very close reflection peaks and troughs, indicating that different scanning modes have no obvious effect on the spectral dimension of the hyperspectral images.

5.3.2 Scanning Time

The scanning station was set up at Ningming Huashan Rock Art No. 1 mission site, and the same scanning method, scanning frame frequency and scanning distance were used to scan the same area at different time, and the data quality of the three groups were compared as follows.

(1) Spatial dimension data quality

The three sets of hyperspectral image data were pseudo-colored according to RGB (650 nm, 550 nm and 450 nm), and the spatial dimensional effects of the images in each time are shown below (Figure 41a, 41b, 41c).

By comparing and checking the spatial dimensional data of hyperspectral images of Ningming Huashan Rock Art No. 1 mission site at different time, it can be seen that the data collected in the morning time has clearer

Figure 38: Vertical scanning spatial dimensional images of Ningming Huashan Rock Art No. 1

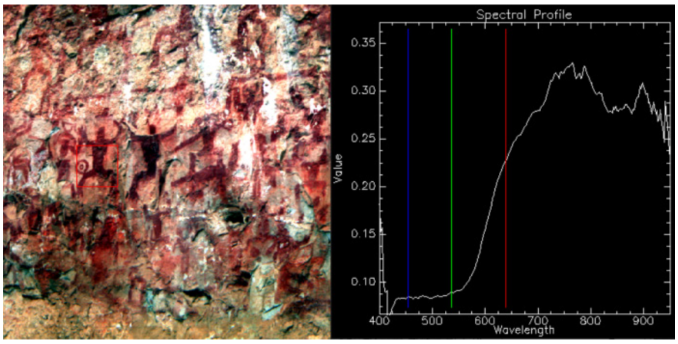


Figure 39: Horizontal scanning spectral curves of Ningming Huashan Rock Art No. 1

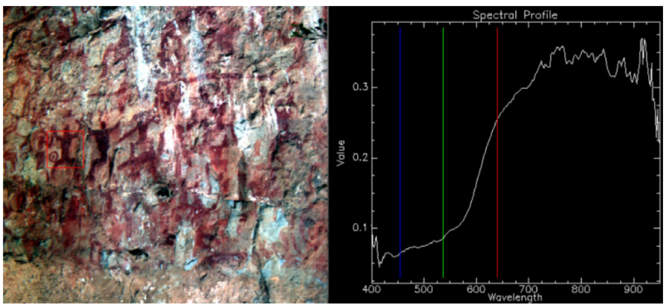


Figure 40: Vertical scanning spectral curves of Ningming Huashan Rock Art No. 1

a: In the morning

b: In the noon

c: In the afternoon

Figure 41: Horizontal scanning spatial dimensional images of Ningming Huashan Rock Art No. 1

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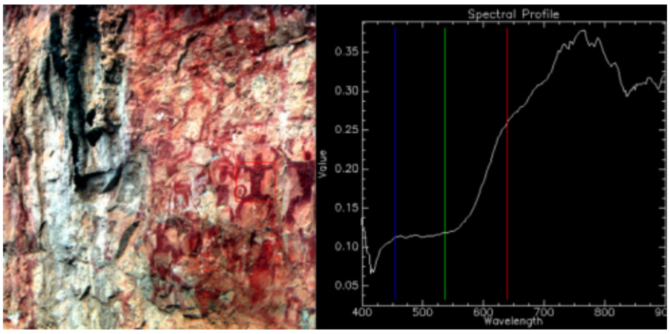
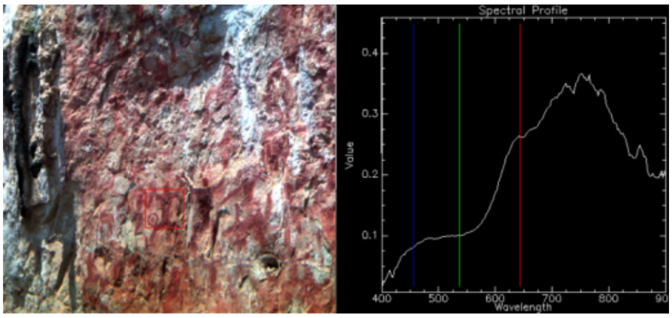
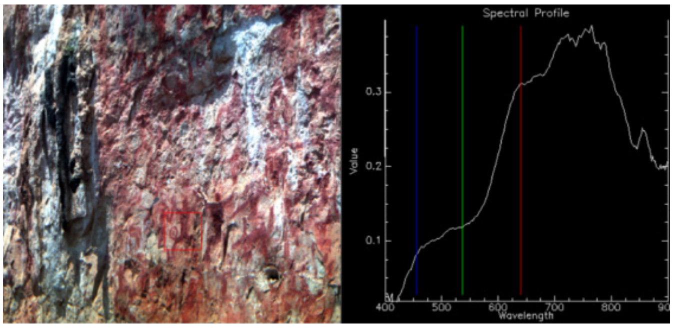


a: In the morning



b: In the noon



c: In the afternoon

Figure 42: Image spectral curve of Ningming Huashan Rock Art No. 1

texture and the contrast between rock art and surrounding rocks is clearer, which is more favorable to the interpretation, extraction and analysis of rock art.

(2) Spectral dimensional data quality

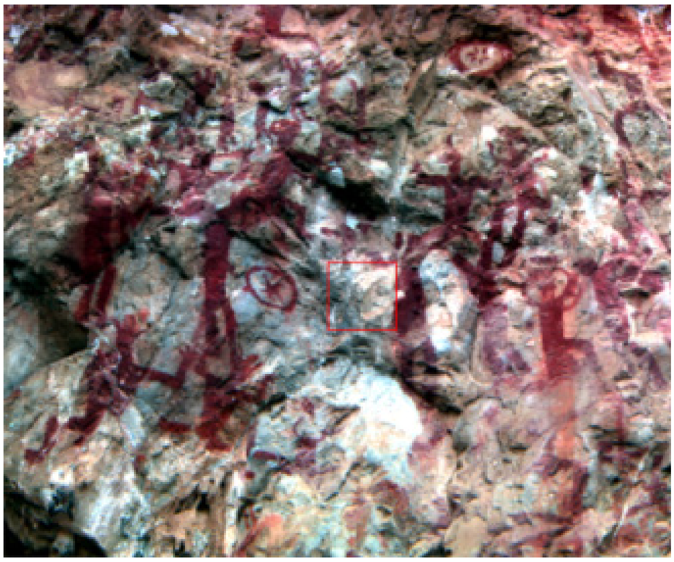
The hyperspectral image of rock art in the same area of Ningming Huashan Rock Art No. 1 mission site was selected to check the spectral curves of hyperspectral images at the same location at different times, and the area was selected as a rock art figure with a concentric circle at the left leg in the image, and the spectral curves of the figure in different time were as follows (Figure 42a, 42b, 42c).

Comparing the spectral curves of hyperspectral images at different times, it can be seen that the spectral curves of rock art have richer details of peaks and valleys, and the spectral curves at different times and different positions have consistent trends, and the peak of rock art reflection and peak value of reflection are very close to each other, indicating that the hyperspectral images collected in different time have good quality in spectral dimension.

5.3.3 Scanning Flatness

The hyperspectral imager was set up at Ningming Huashan rock art site 1 and site 3 respectively, and the same scanning mode, scanning frame frequency and scanning distance were used to collect hyperspectral image data at the same time, and the two sets of hyperspectral image data were compared as follows.

a: Flatter areas



b: Undulating areas

Figure 43: Spatial dimension of hyperspectral images of Ningming Huashan Rock Art No. 1

(1) Spatial dimension data quality

The two sets of hyperspectral image data were displayed in pseudo-color according to RGB (650 nm, 550 nm and 450 nm), and the spatial dimensional effects of the images of the two scanning modes are shown below (Figure 43a, 43b).

By comparing the hyperspectral image spatial dimension data of rock art in different flatness areas, it can be seen that in the undulating area, the shadow of the protruding part of the rock body has more influence on the spatial dimension display of the image, causing interference to the interpretation of the rock art, which is not conducive to viewing and extracting the rock art part, while in the flatter area, the contrast is higher, which is more convenient for the interpretation of the rock art part.

(2) Spectral dimensional data quality

The hyperspectral images of the same rock art figure at different locations in Ningming Huashan rock art site No. 1 and No. 3 were selected to check the spectral curves of the hyperspectral images in different flatness areas, and the spectral curves in different flatness areas are as follows (Figure 44, Figure 45).

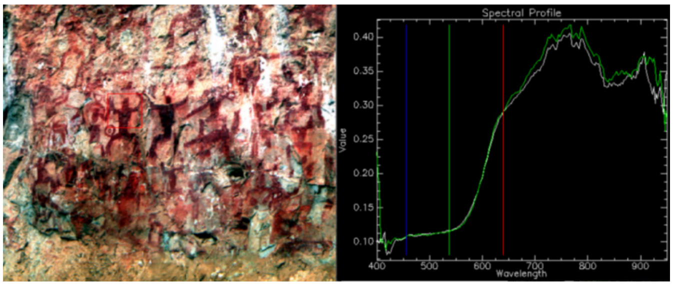


Figure 44: Hyperspectral image spectral curve of Ningming Huashan Rock Art No. 1 (flatter areas)

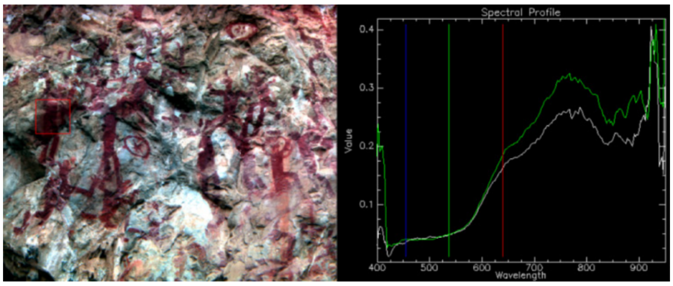


Figure 45: Hyperspectral image spectral curve of Ningming Huashan Rock Art No. 3 (undulating areas)

Comparing the spectral curves of hyperspectral image data of rock art in different flatness areas, it can be seen that the spectral curves of different parts of the same rock art figure have smaller differences in flatter areas, and in more undulating areas, the spectral curves of different parts of the same rock art figure have larger differences, which have a greater impact on the spectral analysis of rock art later.

5.4 Analysis and Comparison

5.4.1 Scanning Mode

By analyzing the hyperspectral image data acquired by two scanning modes of horizontal and vertical scanning at the same time, the hyperspectral data under different scanning modes have the same data quality in both spatial and spectral dimensions without obvious differences, which indicates that the scanning mode has no obvious influence on the acquisition of the Huashan rock art spectral data, and the scanning mode can be flexibly selected for data acquisition according to the characteristics of the operation area. The scanning mode can be flexibly selected for data acquisition according to the characteristics of the operation area.

5.4.2 Scanning Time

By analyzing the hyperspectral images acquired at different times at mission site No. 1 of the Huashan rock art in Ningming, it can be seen that data acquisition at different times has a certain effect on the spatial dimensional quality of hyperspectral images, and has no obvious effect on the spectral dimension. Among the three sets of data acquired at different times, it can be clearly seen that the data in the morning has a better spatial dimensional effect, so the best data acquisition time for the Huashan rock art is the morning.

5.4.3 Scanning Flatness

By comparing and analyzing the hyperspectral image data of Huashan rock art in Ningming collected in different flatness areas, the spatial dimensional data and spectral dimensional data quality of hyperspectral image of rock art in flatter areas are better than those in more undulating areas, so the flat areas are more favorable for hyperspectral rock art analysis and research.

5.5 Summary

This experiment applied hyperspectral data acquisition technology on Ningming Huashan rock art for several times to obtain basic data, and achieved certain results. Due to the special geographic location of the rock art, there are some areas covered with rock shedding and sediments, which leads to the confusion of rock art and background in the covered area, and the outline information of rock art cannot be directly obtained. Through the data processing work such as MNF variation and spectral difference operation, and the separation of complex background, the spatial dimension data and spectral dimension data can be better extracted. However, the limitation of hyperspectral equipment, the professionalism of data analysis and the expensive time and labor cost make it difficult to promote this technology in rock art-type data acquisition. The author only recommends it for scientific research purposes.

6. DISCUSSION AND ANALYSIS OF DATA ACQUISITION TECHNIQUES FOR ZUOJIANG HUASHAN ROCK ART

Through the experiments and research on data acquisition of Zuojiang Huashan rock art by various technical methods, we found that different techniques have different results and obvious advantages and disadvantages in collecting basic data on various aspects such as the characteristics of cultural relics, their environment and geographical information.

The advantages of using oblique photogrammetry for data acquisition of Zuojiang Huashan rock art are high efficiency, low cost, non-contact, which can reflect the real situation around the cultural relics, size information, top texture, and controllable area; the disadvantages are blurred texture of feature details, distortion of local structure, and accuracy only at the decimeter level, etc.

The advantages of using nap-of-the-object photogrammetry technology for data acquisition of Zuojiang Huashan rock art are high efficiency, low cost, non-contact, which can reflect the real situation of structure and texture around and inside the cultural relics, with accuracy up to centimeter level, clear texture of internal details, small amount of collected data, and can realize network release; the disadvantage is that the effect is general for the model of moving objects or features with fewer points.

The advantages of using panoramic technology for data collection of Zuojiang Huashan rock art are high efficiency, low cost, strong sense of reality, good interactivity, no need for separate plug-ins, and roaming browsing in up and down, left and right, front and back ranges, etc.; the disadvantages are that the dimensional information of cultural relics cannot be measured, the resolution is poor at a long distance, and the perspective dead angle is easily produced, etc.

The advantage of using hyperspectral technology for data collection of Zuojiang Huashan rock art is that hyperspectral can clearly process the collected murals, but the data processing and analysis of materials, pigments and spectra are highly specialized, and the applicable equipment is less, so it is only at the stage of scientific research in the conservation of cultural relics.

In the data collection for Zuojiang Huashan rock art, we did not use 3D laser scanning technology for the experiment. We found that the technology works efficiently and saves labor and material resources when collecting data on rock carvings; it can well obtain the detailed features of complex objects in a large area with high precision in one measurement; the point cloud results have absolute geographic information parameters and high precision; the collection can reduce the damage to cultural relics by human factors and better protect them through non-contact scanning. Likewise, the technology should have the same advantages in the collection of Zuojiang Huashan rock art data. However, at this stage, 3D scanning equipment is expensive and the data processing software is highly specialized and difficult to handle. Combining the data acquisition research content and acquisition cost, under the condition of high data accuracy requirement and sufficient cost, we can recommend the use of 3D laser scanning method for Zuojiang Huashan rock art data acquisition to meet the requirements of cultural relics experts for high precision digital content archiving of rock art and related scholars for research on cultural relics.

In the light of the above analysis and comparison, we believe that the object photogrammetry technique is the most suitable technique for data acquisition of Zuojiang Huashan rock art at this stage.

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