

# RECOGNITION AND EXTRACTION OF THE ANCIENT SITES COVERED BY THICK VEGETATION IN HAINAN PROVINCE OF CHINA

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## 1. INTRODUCTION

China has a vast territory and is the only ancient civilization in the world which has a continuous history of over 5,000 years' development, with many cultural heritages distributed throughout the country, especially those primary sites which have great impact on China's politics, society, military and foreign relations, e.g. the Silk Road was opened up for spreading Chinese civilization to the world by land and sea in the 2nd century BC. Therefore, it is of great significance for the study of China and the whole history of human development to be fully aware of all kinds of information existing in cultural heritages. However, some cultural heritages have been destructed or are experiencing destruction caused by natural and human factors; even their remains and clues are also disappearing.

As a study of the history of human development, archaeology came into the world in the western country during the early 19th century and was introduced into China in the early 20th century. With the development of natural science, from the originally single subject, archaeology has developed into a multi-disciplinary system consisted of environmental archaeology, underwater archaeology, remote sensing archaeology, etc.

Remote Sensing technique used to be used for researches on atmosphere, ocean, land cover and use, forest, etc. With technical improvement and combination with other spatial information techniques such as GIS and GPS, remote sensing has greatly extended the scale and depth in archaeological researches and become an important tool that helps us understand the temporal and spatial distribution pattern of cultural heritages, to reconstruct the development history of ancient civilization, to establish the cultural heritage information management system, and to realize a virtually recovering of ancient civilization.

This research was the first time in China to apply remote sensing to recognize and survey the ancient city sites covered by thick vegetation, which were inaccessible due to complex relief and severe obstruction. It was difficult, even impossible, to use traditional survey methods in this kind of environment, so there were still not any accurate parameter about these ancient sites in addition to the record in Hainan ancient chorography. Few similar jobs were done in the world except Maya Site in Guatemala and Angkor Wat in Cambodia, especially in China. Therefore, this research was an innovative application of remote sensing technique.

## **2. STUDY AREA**

Hainan Island (Province) is the second largest island in China and located on the southernmost land separated from the mainland by Qiongzhou Strait, traversing tropics and subtropics. The area of the island is 33,920 square kilometers, the 51 percent of which is covered by natural tropical forests. Up to now, there have been 27 cultural sites of ancient city found around the whole island and 16 of them are located in tropical forests.

## **3. DATA ACQUISITION & PROCESSING**

We collected corrected 15-meter Landsat images taken during 1999 to 2001, 10-meter multi-spectral ALOS images and 2.5-meter panchromatic ALOS images taken on 31st Jan 2009, and 0.5-meter black-and-white aerial photos taken in 2007. Firstly, we corrected the multi-spectral ALOS images with the Landsat images, and then corrected the panchromatic ALOS images with the corrected multi-spectral ALOS images, and conducted Brovey image fusion between them to produce the multi-spectral ALOS images with 2.5-meter resolution. In the end we corrected the aerial photos with 2.5-meter resolution ALOS images.

## **4. PRINCIPLE**

During the field survey we found that most plants rooted on the rammed earth piles (the remains of city walls) were taller and more flourishing than the ones rooted on the surrounding ground. Due to unknown time when they began to grow, we analyzed two factors below: sunshine and nutrient; then we got the conclusion that (1) the advantage in height made the plants on the piles receive the largest intensity of the sunshine every day, which reversely maintained the advantage in height of higher plants; (2) most part of the roots of the plants on the piles were buried in the shallow soil layer (near the ground) with more nutrients, which made the plants more flourishing.

These two factors made the boundary of ancient city sites recognizable on the air photos, according to the vegetation mark and shadow mark. In the end we chose Qiongzhou, Zhuyaling, Dayapo and Nanjianzhou Ancient City as typical examples to demonstrate the important roles remote sensing played in recognizing the border of ancient city sites and calculated the perimeter and area of each ancient city site.

## **5. INTERPRETATION**

### **5.1. Recognize the Disappeared City**

Qiongzhou Ancient City was established as the government of Qiongzhou in 631. It was abandoned and the government was moved to the location of the current capital, Haikou City, in 971. This ancient city has disappeared. According to the local record, we only knew the approximate location of the four city corners, but there was no evidence attained during the past field investigations. However, after color stretching, from the aerial

angle we could see the outline of a city surrounded by vegetation (red color) on the 2.5-meter ALOS and 0.5-meter aerial photo. We conducted three kinds of filter algorithms, each with different windows ( $3\times 3$ ,  $7\times 7$ ,  $11\times 11$ ,  $15\times 15$ ), for the aerial photo, i.e. High Pass Filter Algorithm, Erode Algorithm and Dilate Algorithm. By comparison, the image processed by Erode Algorithm produced the best effect, so we chose this algorithm to extract the boundary of this ancient city site. Through the calculation in GIS software, the perimeter was 1,475 meters; the area was 135,382 square meters.

## **5.2. Recognize the Inaccessible City**

Zhuyaling Ancient City was the earliest city found in Hainan Province until now. It was estimated that this ancient city was established in Han Dynasty. Only the location of the north wall was known through excavation validation. However, we could recognize the boundary according to surrounding relief and shadow mark, and then extract it by High Pass Filter Algorithm. The perimeter of the city was 750.5 meters; the area was 35,347 square meters.

## **5.3. Discover the Remains**

Dayapo Ancient City was established in 1582. Only the remains of the east wall, north wall and west wall have been found during the past field work. However, after recognizing them all on the image by Filter Algorithm, we found that the east wall and west wall were nearly parallel, and both the northwest corner and northeast corner of the city were rectangular. In addition, the length of each wall measured in GIS software was nearly equal. Therefore, based on the assumption that the shape of the city was square, we tried to draw the fourth wall on the aerial photo and conduct the field validation according to the geographical coordinates attained from the image. In the end, we found the remains of the south wall in the region covered by thick vegetation, which was just 1.5-meter-long. The perimeter of the city was 1,242 meters; the area was 98,423 square meters.

## **5.4. Survey the Irregular Border**

Nanjianzhou Ancient City was established in 1329 and was abandoned in 1368. In addition to complex relief and severe obstruction by the tropical forests growing along the border, the shape of the boundary was so irregular that there were no traditional methods that could be used to measure the perimeter of the city, not to mention the area. However, we could recognize the entire boundary of the city by virtue of the vegetation mark on the image (Fig. 1) and extract it by High Pass Filter with a  $15\times 15$  window (Fig. 2), then calculate its perimeter and area in GIS software. The perimeter was 2,681 meters; the area was 178,394 square meters.

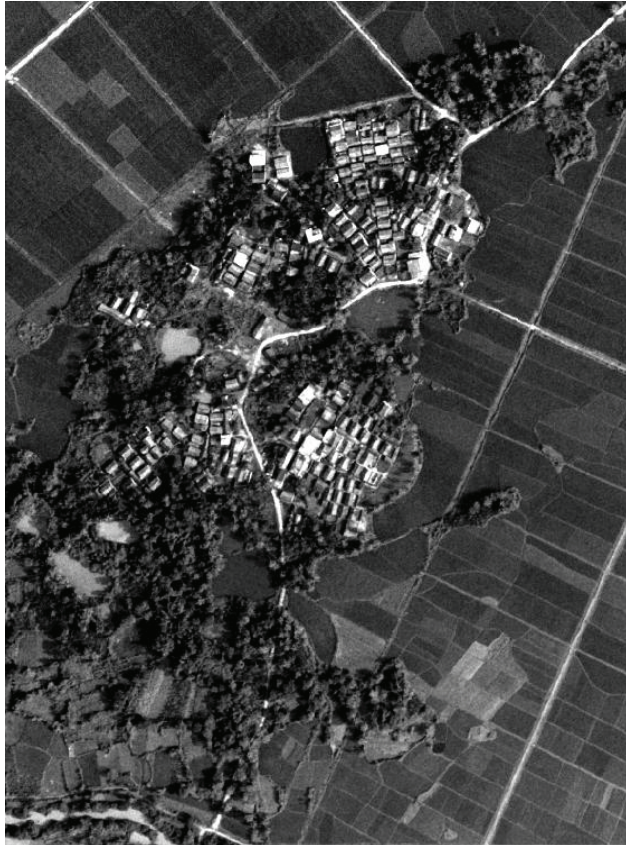


Fig. 1 Original Image

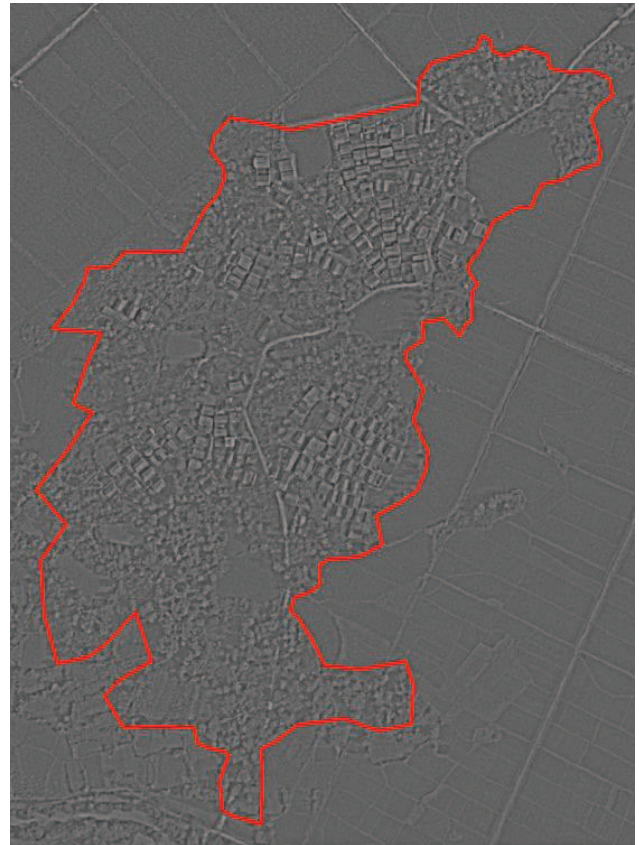


Fig. 2 Image after High Pass Filter (15×15 window)

## 6. CONCLUSION

At last we calculated the perimeter and area of each ancient site by the GIS software and got the same results as the record of Hainan ancient chorography. We also used our new results to revise the results of previous National Cultural Relics General Survey, which were attained in traditional ways.

This was a successful attempt, leaving valuable experience for the relevant researches in future. Through this research, we can see that, based on the high imaging altitude, remote sensing can be applied in archaeological researches to recognize and survey the boundary of ancient city sites covered by thick vegetation without any obstruction, which was not realized by traditional methods.

## REFERENCES

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