REMOTE SENSING CHANGE DETECTION STUDY OF THE GRAND CANAL AND ENVIRONS ---A CASE STUDY IN THE YANGZHOU SECTION, JIANGSU, CHINA

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ABSTRACT:

The Grand Canal of China is the longest ancient canal in the world. In terms of improving communications between the north and south, promoting economic and cultural exchanges and strengthening the unification of the country, the canal is an astonishingly huge project in the history of Chinese civilization. However, at present, some sections of the Grand Canal have already dried up. We are faced with difficult challenges posed by the modernization of the urban areas, and the urbanization of the countryside. Remote sensing survey provides chance for us to know more about the past and present of canal. The aero photographs and satellite images from different date were true reaction of upper sight at that phase, which recorded the Grand Canal's distribution and circumjacent environment. In this study, we employ aero photographs taken in 1954 and SPOT5 images taken on 18 November 2002 as data resources. We integrates Wallis filter, data fusion, visual interpret, buffer analysis and other GIS technologies involved with the shape information. In this way, we get the change information about canal and its environs, which reflects that there is great correlation between the canal and environs.

1. INTRODUCTION

The Grand Canal extends from Hangzhou, Zhejiang Province, in the south, to Tongxian, part of the Municipality of Beijing, in the north, which passes through six provinces and connects five major rivers. The Great Wall guarded the frontier whereas the Grand Canal served as an economic lifeline across the five major rivers systems over centuries. It has been hailed as "a long corridor of ancient culture" and "a show room of folk customs", and the new mission assigned by the current epoch is diversion of the South to the North. We have already reached a critical juncture in both the rescue and the protection of the Grand Canal and the promotion of its sustainable development. It's necessary for us to know more about the past and present of the Grand Canal.

Remote sensing survey is one of the most cost-effective methods for the archaeological survey. It reflects industry, agriculture and environment's distribution and change with the cities around the canal. Increasingly remote sensing, and time series remote sensing in particular, is being utilized for archaeological resource management. The anomalies in the images can help us to detect the changes, which can tell people more information about the archaeological resource. Up to date, there are many effective methods for change detection, which can provide us with more opportunities to learn about the past and present of the Grand Canal.

Due to the great spatio-temporal span of the Grand Canal, many cities found fame because of the Grand Canal. To demonstrate the utility of remote sensing, an exemplary section of the Grand Canal is presented. As one of the most important port cities at that time, Yang Zhou enjoyed unparalleled prosperity and fame. The canal was first cut near Yang Zhou, which means that, to some extent, Yang Zhou and the canal were born at the same time.

This paper tries to seek a remote sensing archaeological means based on old aero photographs and SPOT5 that is fit for the reality of the Grand Canal. In fact it provided a better understanding of the past and present of the canal and help the future conservation and management. The old aero photographs refer to aerial photographs gained before 1958.

2. CANAL CHANGE DETECTION

Here we employ old aero photographs and new remote sensing image as data sources. Our object is to detect the change of canal which has a long history; hence, many other auxiliary data such as the historical records and topographic maps, can help us detect the changes and determine the range of research.

2.1 Study Area

This article studies the Yang Zhou city which is the ancient canal's Birthplace. Yang Zhou is a city of general history where Fu Chai, the Duke of Wu, started to excavate ancient canal of Hangou in 486 BC. It is fated to describe a period of Chinese history, namely, a history of ancient canal, from the beginning of excavation of Hangou. Although the riverway of ancient canal has changed many times, the center position of Yang Zhou never changes in the long years following. The original purpose of excavation of canal is for the military affairs, however, it plays a very important role in economy in the following changes. Ancient canal, the mother river of Yang Zhou, helps develop the city of Yang Zhou, extend the terrain of Yang Zhou and pattern the streets of Yang Zhou, which makes vital contributions to the development and prosperity of Yang Zhou culture.

2.2 Data Process And Change Detection

After having acquired the data, the first step is to preprocess the images. There are some basic steps in this method (Figure 1).
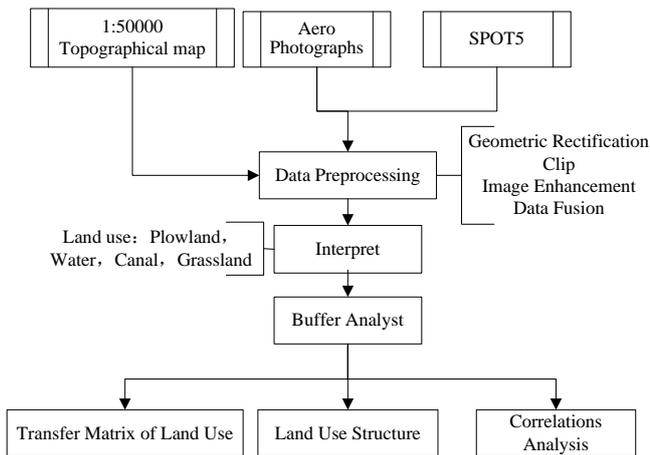
Figure 1 The flow chart of the study

2.2.1 Data Preprocessing

First of all, the images were georectified to the Yang Zhou topographic map (1:50000). On this basis, we can get the aero photographical mosaics of Yang Zhou. Because there is no flight parameters, we should adjust the hue and contrast of the aero photographs, and then apply the Wallis filter which enhances image contrast and suppresses noise at the same time. Wallis filter is a generalization of the so-called statistical differencing operator; it aims at projecting image gray mean and variance to appointed values. In fact, it is a local image transform that makes gray mean and variance of different part approximate. Namely, it increases gray contrast of parts where contrast is small and decreases gray contrarily. Because of smooth operator introduced when computing gray mean and variance, Wallis filter enhances useful information and suppresses noise simultaneously. As a result, it improves SNR.The enhanced image is forced to a form with desired first order and second order moments. It is increased in amplitude with respect to the original at pixels that deviate significantly from their neighbors, and decreased in relative amplitude elsewhere. The result is as follows(Figure 2).
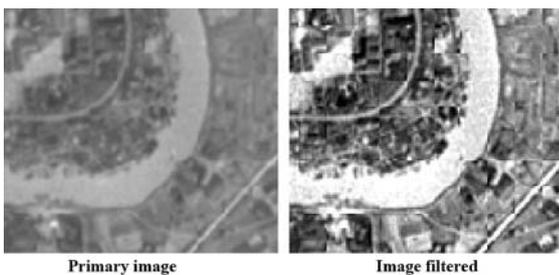

Figure 2 Wallis filter

After rectification, SPOT5 multi-spectral and panchromatic data are fused in order to improve the spatial resolution of multi-spectral images while reduce spectral distortions. It can utilize the multiresolution data in an efficient manner without deteriorating data quality, both for visual interpretation, and for image analysis and change detection. In the case of SPOT-5, the multispectral bands 1-3 are imaged with 10m IFOV while the SWIR-band has 20m IFOV. All bands in the SPOT-5 multispectral products have 10 m pixel size. In parallel with the multispectral data, SPOT-5 is capable of simultaneously acquiring panchromatic data with 2.5 m or 5 m resolution. Here we used the pansharp methods. The Pansharp merging

technique gives the best results without changing at all the statistical parameters of the original images (Figure 3).

Figure 3 Pansharp

2.2.2 Interpret

After the above processes, visual interpretation can be carried out on the processed image. Poor classification accuracy in change detection leads to inaccurate information on land use change. Overestimation of land use change has been reported due to poor accuracy of classification. One way to avoid the overestimation of change and other inadequacies is to interpret visually. The interpretation can show the original images which will provide useful information in identifying change classes.

2.2.3 Buffer Analysis

The final step is to analyst the result with GIS methods, then a spatial analysis can be undertaken. The process involves generating a buffer around existing geographic features and then identifying or selecting features based on whether they fall inside or outside the boundary of the buffer. So, we should build a buffer of 2km around canal, and then buffer analysis is used for identifying areas surrounding the canal.

2.3 Results And Discussion

2.3.1 Canal Change

From the result of interpretation, we can see that there is a new canal section in 2000's images. The reason is that the new Yang Zhou section is excavated after 1954. In 1958, Yang Zhou experienced canal cutoff, and this work finished in 1962. From then on, the new canal became the vital ship channel instead of the old canal that loses its function of transportation.

According to the statistic calculation，the length of canal in Yang Zhou is 1.41682km2 in 1950s, while the length is 3.18716km2 in 2000s. The most important factor is the canal cutoff which resulted in the increase of area.

Here, we employ the shape index which can be used as an important index to judge the shape. The general form of shape index is $I_{shp} = \sqrt{s} / p$, where s is the area of the object; p is the perimeter. The shape index in 2000's is 0.02604, less than 0.030493, which is in 1950's. But the trend of canal changed little from 1950s to 2000s (Figure 4).
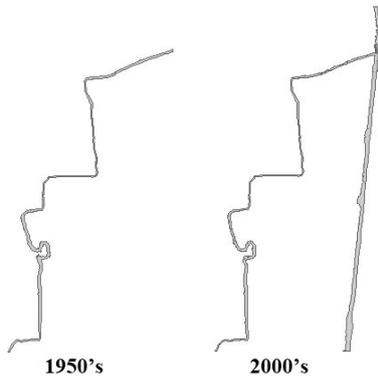
1950's   **2000's**

Figure 4 The canal of two date

2.3.2 Land Use Structure

According to the result of buffer analysis, we can get the area of various land use pattern (Figure 5). It's obvious that the land use structure has changed greatly since 1954. In 1950s, the leading land use pattern is the cultivated land, with the proportion of 78.67%. On the contrary, in 2000s, the cultivated and the construction land account for nearly 90%.

Especially, the cultivated land changed from 88.48km2 to 50.40km2, with the most decrease in area. The area of communication land increased to 3.06264km2, with the highest increase rate. Besides these, the construction land has a great increment of 33.54km2. Compared with the above land use pattern, the water changed little. There is no wander that the canal can accelerate urbanization. The most direct evidence is that the area of construction land increased obviously.
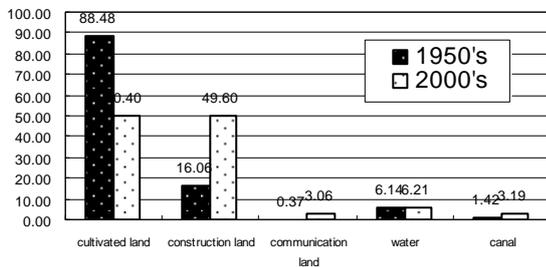

Figure 5 Comparison of Land use structure

2.3.3 Transfer matrix of land use change

Based on the multi-temporal remote sensing image date, the paper analyzed and studied the land use change around canal in Yang Zhou on approximately 60a. By overlaying the image date to get the transfer matrix of land use change, the feature of spacial distribution of land use change is revealed. The following figure is the transfer map of land use pattern around canal (Figure 6).

Tranfer of Land Use Pattern around canal in Yangzhou 1950s-2000s

Legend

- canal-canal
- canal-communication land
- canal-construction land
- canal-cultivated land
- canal-water
- communication land-canal
- communication land-communication land
- communication land-construction land
- communication land-cultivated land
- communication land-water
- construction land-canal
- construction land-communication land
- construction land-construction land
- construction land-cultivated land
- construction land-water
- cultivated land-canal
- cultivated land-communication land
- cultivated land-construction land
- cultivated land-cultivated land
- cultivated land-water
- water-canal
- water-communication land
- water-construction land
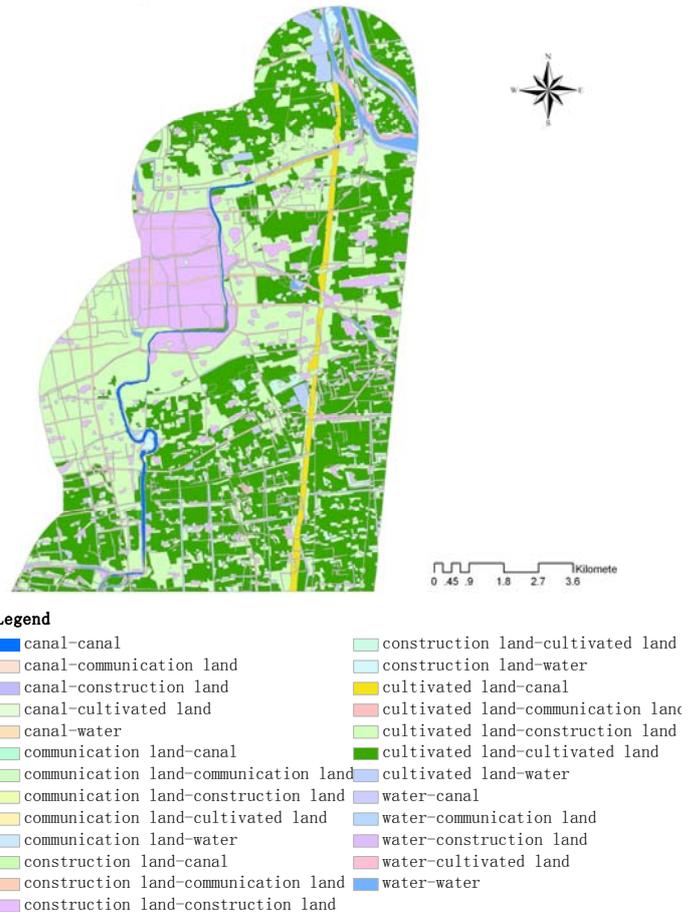- water-cultivated land
- water-water

Figure 6 Transfer map of land use pattern

50.78% of the cultivated land didn't change, while 40.55% transferred to construction from 1950s to 2000s, which reflects a fact that the excavation of the canal not only strengthened the unification of the country, but also promoted economic of Yang Zhou. Furthermore, most of the changes took place along the canal. It demonstrates that canal promoted process of civilization and more land changed to construction land for the development of city. At the same time, there is 18.13% of the construction land that transferred to cultivated land.

There is no difficulty to find that the communication land increased by 3.06264km2 and most of the new communication land located around canal. This reveals that the affinitive correlation between the canal and environs.

Another visible feature is that there is 2.17% (nearly 1.93185km2) of the cultivated land changed to canal, which can be explained by the historical records. According to the records, government dredged, repaired, and modernized the system between 1958 and 1964. So many cultivated lands were excavated to be canal.

3. CONCLUSIONS

Via the analyst of the photos and images, we conclude that the canal can promote process of civilization obviously. Based on the result, the old canal going through the Yang Zhou changes

little in the aspect of shape information; meanwhile, the canal situated eastern of Yang Zhou is dredged up after 1954, which can't be found in the aero photographs. The environs of Yang Zhou changed greatly and the city expanded obviously. The method employed can provide the useful information about the canal and the city around, with which we can summarize the change law of riverway and city. This can help us comprehend the canal and try to make the Grand Canal display one thousand years' brilliance again.

According to this paper, we can come to the conclusion that integration is the key. The remote sensing images can be readily combined with other datasets. The archaeology will work effective if a suite of interdisciplinary technique such as RS and GIS can be employed, which tailored to the specific needs of each site. The integration can give us better understanding to the applications of remote sensing in archaeology on the theories, methods and techniques.

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