Research on the Water Area Extraction in Suzhou Based on Remote Sensing

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Research on the Water Area Extraction in Suzhou Based on Remote Sensing

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Abstract. In order to accurately obtain the information and calculate the area of water, the traditional visual interpretation method was used to extract the information of water in Suzhou with the high-resolution remote sensing image. By on-the-spot sampling measurement verification, the precision of visual interpretation was proved to meet the practical requirements. The research in experimental area indicate that the visual interpretation method is operable. The water area of Suzhou was obtained as 3205 square kilometers, and the area is 994 square kilometers except for the area of Taihu lake and the Yangtze river.

1. Introduction
With the rapid development of space information technology, it is possible to acquire remote sensing images with multi temporal, high resolution and accuracy [1]. The extraction of water information has been a basic work in the field of remote sensing information extraction [2], and the 3S technology plays a more and more important role in building base database and monitoring illegal activities such as occupying water area illegally. There are two methods for extracting water information from high-resolution remote sensing images. One is visual interpretation, the other is semi-automatic or automatic information extraction. The accuracy of visual interpretation is relatively high, which depends on subjective judgment of human beings, but the efficiency is low. The kinds of semi-automatic or automatic information extraction methods are various, Li Changyou [3] used ETM to extract the water of Ulanusuhai Lake by multi-band combination algorithm and multi-spectral mixture analysis method, but the accuracy of the semi-automated method can’t be verified quantitatively, and the band combination can’t be excluded only in specific water conditions. Although the automatic or semi-automated extraction method improves the efficiency to a certain extent, it lacks the universality of the application, most of which only adapt to the specific research area. There is no unified standard for the evaluation method of precision for the specific resolution of remote sensing images, and the extracted target is basically water, and it can’t be effectively extracted. Therefore, such research does not form a relatively complete and mature theoretical system. In view of the large scope of the researching area and the complex distribution of rivers and lakes, and the need to calculate water area, the accuracy of water area is higher. In order to minimize the influence of errors, the visual-interpretation method is used for extracting information of water in Suzhou city.

2. The Basic Situation of Researching Area and Data Source
Suzhou is located in the downstream of Yangtze River and Taihu Lake, and its territory is flat. The river ports and lakes are crisscrossed and scattered, and there are more than 20 000 rivers, 300 lakes in it. Water has played a huge role in flood control, drainage, irrigation, water supply, shipping, ecological landscape and water culture in Suzhou. In order to investigate the total area and distribution
of water areas in Suzhou accurately, obtaining high-precision water extraction information, as well as using aerial images of different phase to monitor the change of them and getting information of water-occupied behaviour, we need to use the high-resolution aerial images combined with large-scale topographic maps to finish the survey in same condition.

In this research, the basic images used for interpretation were taken in 2011 and 2013, and all of them are colourful aerial images with resolution of 0.1-0.3 m. Which have been processed by orthophoto correction and band fusion. At the same time, what were regarded as auxiliary information for interpretation included topographic map of Suzhou with 1:1000 scale, topographic map of Jiangsu Province with 1:10000 scale, and electronic map of Suzhou City.

3. Extraction of Background Information in Water Area

3.1. Technology Roadmap

The roadmap for extraction of background information in water area is shown as figure 1.

![Figure 1. The roadmap for extraction of background information in water area](image)

3.1.1. Definition for water area. In principle, the definition of water area is based on two basic conditions: hard coastline and no-hard coastline: (1) Hard coastlines include embankment, hard revetment, revetment, retaining walls and roads. Generally, it appears white stripes on aerial images. When there is a rigid coastline or house within 5 meters outside the water surface, the boundary of the water is directly drawn along the edge of the rigid shoreline or the side of the water side of the building, as shown in Figure 2. (2) When there are no artificial structures along the coastal waters, we draw water boundary along the water and land trace lines on the base of waterfront of the water area combined with high-resolution aerial images at different periods, just as shown in Figure 3.
Figure 2. Sketch map of waterfront area with hard slope protection, revetment and retaining wall along the coast

Figure 3. Sketch map of the water area of a riverway with no hard coastline along the coast

3.1.2. **Definition of river channel range of entry and exit.** According to the "Suggestions on strengthening management and protection of lakes" and actual situation, the principle of defining the scope of the lake channel is formulated: (1) The water range of lakes and rivers should be bounded by the structural centerline that controls the vertical flow of buildings, when there are sluices and other controlled buildings in the estuaries.(2) If there are no sluices and other controlled buildings in the estuaries but the lake is managed by municipal government, we should trace to 500 meters of the lake for the boundary, as shown in Figure 4.(3) If there are no sluices and other controlled buildings in the estuaries and the lake is not managed by municipal government, or the lake is managed by municipal government and the river is a catchment river, the area of rivers and lakes is directly bounded by the entrance and exit of rivers and lakes.(4) When the length of the river between two cities is less than 1000 m, the water area of the lake is bounded by half the length of the river.

Figure 4. The scope of the entry and exit of the lake without control buildings
3.1.3. Special situation processing
(1) When the two rivers run through, the middle line of the river channel should run through the connecting place, that is the length of the two rivers includes the range of the perforation.
(2) When the two rivers run through, if the water of the intersection doesn’t belong to each area, the water is incorporated into the rivers with higher or larger width, and the other is disconnected at the intersection.
(3) When the river is connected with other types of water, if the water area of the intersection belongs to an independent water type, when the river area is drawn, both ends of the river are disconnected at the intersection of the intersection.
(4) When the sandbank and beach in the middle of the river and lake is full of large artificial buildings, we should process them by hollow treatment, as shown in Figure 5.
(5) When the sandbars and beaches in the middle of the river and lake don’t have the above situation, they will be submerged at high water level, so they belong to the waters.

Figure 5. A schematic diagram for determination of water area (Blue line represents the water area line, and the yellow line represents the dike line)

3.2. The Result of Extracting Information of Water Area for Suzhou City in 2013
Including Taihu Lake and Yangtze River, the whole water area of Suzhou city is about 3 205.005 km², and if not including Taihu Lake and Yangtze River, the number is about 994.348 km². Including Taihu Lake and Yangtze River, the area of lakes is the most components of water area, accounting for 68.6% of the total area of the city's water. The second is rivers, the proportion is about 29.9%, and the area of ponds is the smallest, about 1.5%. If it does not contain Taihu Lake and Yangtze River, rivers’ area of Suzhou is the largest, which accounts for about 50.5% of the total water area. The second is lakes, whose proportion is about 44.6% and the area of ponds is still the smallest, that is about 4.9%.

4. Verification of the Results of Water Extraction by Actual Survey
The RTK technology is used to measure the boundary line of the water area. The error of the calculated point position is ±0.16 m, less than ±0.3 m, which is the limitation of digital mapping technology. Based on the above discussion, we can get the conclusion that the method of water area extraction based on remote sensing is accurate and reliable, and it can meet the actual demand, too.
Table 1. Information of water area for sampling

| Name of rivers | Level | Latitude and longitude       |
|---------------|-------|-------------------------------|
|               |       | Segment A | Segment B | Segment A | Segment B |
| Taipu River   | Catchment | 120.5586E, 31.0051N | 120.6185E, 30.9984N |
| Jinghang River| Catchment | 120.4793E, 31.3998N | 120.6431E, 31.0028N |
| Xitang River  | Municipal | 120.5499E, 31.3825N | 120.5881E, 31.3343N |
| Wusong River  | Municipal | 120.8546E, 31.3091N | 120.7177E, 31.1998N |
| Laoqiputang River | Municipal | 121.2099E, 31.6087N | 121.1173E, 31.5924N |
| Nanhengtao-Qigan River | County | 120.6515E, 31.8759N | 121.1139E, 31.5968N |
| Shitou River  | County | 121.1139E, 31.5968N | 121.1330E, 31.5783 N |

Table 2. Results of sampling and verifying

| Level    | Middle Error(m) | Extraction area of internal industry (m²) | Measurement area of external industry (m²) | Relative error of area | Rivers’ length of measuring (km) | Actual length of rivers (km) | Sampling ratio |
|----------|------------------|------------------------------------------|------------------------------------------|------------------------|----------------------------------|------------------------------|----------------|
| Catchment| ±0.11            | 12585383.7                               | 12596809.8                               | -0.10%                 | 82.51                            | 168.55                       | 49.0%          |
| Municipal| ±0.18            | 35221021.5                               | 35158727.6                               | 0.20%                  | 416.34                           | 764.01                       | 54.5%          |
| Country  | ±0.19            | 3899779.2                                 | 3889801.3                                | 0.30%                  | 74.10                            | 172.31                       | 43.0%          |
| Town     | ±0.20            | 1076975.9                                 | 1080126.6                                | -0.30%                 | 51.11                            | 65.49                        | 78.0%          |
| Total    | -                | 52783160.3                                | 52725465.3                               | 0.10%                  | 624.05                           | 1170.36                      | 53.3%          |

5. Conclusions
If the survey situation is complex, the range is large and resolution of images is high, the method of visual interpretation has high efficiency compared with traditional and manual inspection. At the same time, it can also take the accuracy of extraction and actual needs into account. Using remote sensing and GIS technology to establish a more accurate base library of water information, combined with high-resolution remote sensing images, we can get the basic information of the specific area clearly, intuitively and efficiently. The frequency of data renewal will be accelerated, and it can provide decision-making support for the timely investigation and investigation of illegal occupation. The upgrading of information management level is of great significance. The accuracy of visual interpretation is closely related to the experience of the interpreters, but there will inevitably be errors. In order to avoid the errors of human factors, the automatic extraction method is still the focus of future exploration.

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