

Water Extraction Based on Landsat Remote Sensing Image

Dan Wu^{1,2,3,4}, Liangyan Yang^{1,2,3,4}

¹Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an 710075, China

²Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an 710075, China

³Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of natural Resources, Xi'an 710075, China

⁴Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710075, China

Abstract: With the rapid development of remote sensing information technology, the types of Earth observation products are increasingly diverse, and the spatial and temporal resolution of remote sensing images are greatly improved. In recent years, how to extract useful information from massive remote sensing data products is a hot issue in remote sensing geoscience research, among which the extraction of water information can be widely used in agricultural production, water resources protection and monitoring, disaster prevention and reduction and other applications. Based on the characteristics of remote sensing information extraction, this paper analyzes the water information extraction of remote sensing images from shallow to deep. Threshold method and normalized water index method are respectively used for water extraction, and comparative analysis is conducted. The results show that both threshold method and normalized water index method can effectively extract water, but the threshold method requires several experiments to determine the threshold value. It is impossible to determine the most suitable threshold for water extraction. Normalized water index can extract water well, and it is realized by the operation between bands, and the operation is simple and convenient.

Keywords: Water extraction, Threshold value method, NDWI.

1. Introduction

Remote sensing is a science and technology that detects the target ground objects far away from the target and non-contact target objects by means of instruments sensitive to electromagnetic waves such as remote sensors, and obtains electromagnetic wave information reflected, radiated or scattered by the objects (such as electric field, magnetic field, electromagnetic wave, seismic wave, etc.), and then extracts, determines, processes, analyzes and applies them [1,2]. The use of remote sensing image data for water extraction, macro monitoring of water resources and assessment of flood inundation scope has been widely studied in recent 20 years. The accurate determination of surface water area is of great practical significance for water resource quantity assessment, flood storage calculation, flood inundation size and loss estimation and water resource planning. However, accurate identification of the boundary between the water body and the surrounding land is a prerequisite for determining the area of the water body. However, in general, the true boundary of the water body is actually difficult to identify from the remote sensing image [3]. Remote sensing image is a comprehensive reflection of ground features. Remote sensing image is obtained by satellite sensor, and then through a series of technical means such as computer processing, effective information is extracted from the image and applied into the analysis and decision of all walks of life.

At present, the automatic extraction of water by satellite remote sensing data has been widely studied. From statistical classification to the classification method of neural network which simulates the law of human vision, from the expert system which introduces the knowledge of geoscience experts to the remote sensing image understanding system which uses the reasoning pattern recognition technology, they have improved the accuracy from different degrees and different

methods. Various methods have been proposed successively and have been well applied [4,5]. Liu Jianbo et al. used the density segmentation method to extract the distribution positions of water bodies from images [6]. Du Jinkang et al. used decision tree method to extract water information from SPOT4 images, and effectively removed the shadow [7]. In order to realize the automation and precision of water extraction, classification method and index model method are effective methods [9]. According to the characteristics of remote sensing information extraction, this paper analyzes the water information extraction of remote sensing images from shallow to deep, and compares several remote sensing image water extraction methods.

2. Data Introduction and Image Feature Analysis

2.1. Data Overview

NASA's Landsat program (Landsat) has launched 8 satellites since 1972. Landsat TM data has added short-wave infrared band and blue band on the basis of increasing channels and narrowing wave bands. The spatial resolution of Landsat1-3 was 80m. In terms of temporal resolution, the coverage period of Landsat1-3 was 18 days and that of Landsat 4-7 was 16 days. LandsatTM's radiation resolution is of the order of 256.

2.2. Image Features

Through the analysis of TM 7 band data, the following meaningful eigenvalues can be obtained:

(1) Brightness. Visible light band is the main component of brightness. The brightness of blue, green and red light in visible light respectively correspond to the gray values of TM 1-3, and the brightness mainly reflects the radiation level of ground objects.

Greenness, TM 4 is the main factor of greenness due to its high reflectance to plants, while TM 3 has low reflectance to plants, which is the opposite of TM 4. The combination of the two reflects the contrast between the intensity of infrared and red radiation.

(2) Humidity, TM5, 7 are the main components of humidity, the most intense response to humidity.

(3) Transmittance, TM1, 2 are the main components of transmittance.

For different applications and research objects, the meaningful eigenvalues are different, among which the transmission, humidity and brightness have the greatest influence on water extraction.

2.3. Water extraction index

In remote sensing images, there are three metrics that are relatively large for water image extraction:

(1) Influence of spatial resolution on water extraction

Spatial resolution is the shortest distance between two objects that can be recognized in an image, and pixel is the smallest unit that can be recognized in an image. Therefore, the spatial resolution directly determines the image quality. The higher the spatial resolution, the more obvious the distinction between water and ground objects in the target image. The better the water extraction.

(2) The influence of spectral resolution on water extraction

Spectral resolution refers to the number of image bands obtained by the sensor, the wavelength position of each band and the size of the interval between wavelengths. The higher the spectral resolution, the smaller the wavelength interval, that is, the bandwidth, and the finer the spectrum division. However, the spectral resolution should be within a certain range, beyond the fixed range, the greater the correlation between bands, resulting in increased data redundancy.

(3) The influence of time resolution on water extraction

Time resolution refers to the size of the time interval between sensors to acquire the same position. The satellite sensor collects data repeatedly according to a certain time period, and the minimum time interval for repeated observation is called temporal resolution. Temporal resolution has great influence on water information extraction [5].

3. Research Methods and Results Analysis

In this paper, part of the image of Lanzhou City was captured for analysis, and the image in the study area was obtained by atmospheric radiometric correction, geometric correction and image segmentation, as shown in Figure 1.



Figure 1. Pre-processed image in the study area

3.1. Single-band threshold method

The reflectance of water body is greatly reduced in several bands with longer wavelength, which is the biggest indicator of difference from non-water features. The single band threshold method uses this feature to extract water information. In the near infrared band, water bodies have strong absorbability. On the contrary, vegetation and dry soil and other non-water features have strong reflectance in this band. Therefore, appropriate thresholds can be set to distinguish water bodies from ground features. The reflectance difference between water body and other non-water body is obvious in near infrared band, so it is very feasible to extract water body with an appropriate threshold value. The biggest factor that determines the effect is the determination of the threshold, which determines the degree accuracy of information extraction [10].

Single-band threshold method means that the spectral response curve of water body and other ground objects in a certain band is obviously different, and appropriate threshold value is set for a single band to extract the water body. The single-band threshold method mainly uses the fifth band (mid-infrared band) of TM image that reflects the water-land boundary well. According to the gray feature of the image, the threshold is determined by data sampling for water extraction.

3.2. Normalized water body index method

The basic principle of water index method is to enhance the contrast between some features through the ratio calculation between bands. Considering that the spectral characteristics of water body are strong transmittance in TM2 and TM5 is in the absorption zone of water, which reflects the sensitivity of water content, the difference between the values of TM2 band and TM5 band and the ratio of the sum of the values of the two bands are used as the normalized water body index (NDWI). When $NDWI > C$ is satisfied, the extracted ground objects are water bodies. The calculation formula of normalized water body index is shown in Equation (1) :

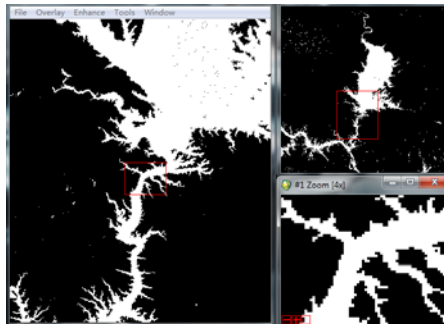
$$NDWI = (TM2 - TM5) / (TM2 + TM5) \quad (1)$$

3.3. Comparison of results

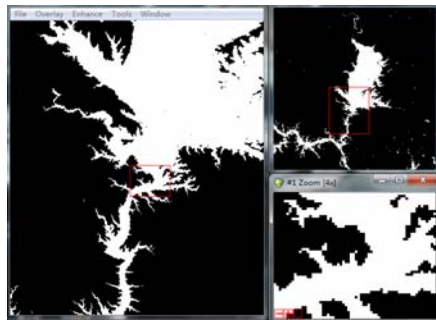
The key of threshold method is the determination of threshold value, which has been a difficult problem so far. The optimal threshold value is obtained through repeated trials [11]. ENVI remote sensing image processing software was used to examine the extraction effect of water body image and false color composite image by link function. It is concluded that the single band threshold method can extract almost all the shadows in addition to the water. At the same time, the width of the extracted water body is smaller than the actual, and there is a significant difference between the water body and non-water body in the fifth band. However, due to the influence of mountain shadow, the reflection energy of the middle infrared on the negative slope is particularly low, which results in the obvious dark tone of mountain shadow on the image. The confusion between water body and shadow makes it difficult to extract water body by the threshold method on the single band.

The water index method uses different bands to calculate the reflectance and spectral characteristics of ground objects, and uses the calculation between bands to achieve the effect

of enhancing the features of a certain ground objects. In this paper, NDWI is used for water extraction, and it is found that NDWI has a good effect on water extraction in this study area.



(a) Single band threshold method



(b) NDWI

Figure 2. Water extraction results

By comparing the single-band threshold method and the normalized water body index, it is found that the normalized water body index has a higher accuracy for water body extraction. The single-band threshold method not only requires constantly setting different thresholds for experiments, which is time-consuming and laborious, but also the water body extracted after obtaining the optimal threshold is greatly affected by noise and there are a large number of non-water fine pixels. But the normalized water body index method extracted water body boundary is clear, almost unaffected by noise.

4. Conclusion

Water body information extraction, as a branch of remote sensing image information extraction, has great practical application value in disaster prevention and reduction, lake and river monitoring. For water body information extraction of massive remote sensing data, relying on manual interpretation requires huge human and financial resources, and cannot meet the demand for water body information extraction in a short time. Therefore, a high performance water extraction method is needed to reduce the error of water

extraction. The research content of this paper can well meet the requirements of the above application scenarios. Through the analysis and comparison of different experimental results, good water extraction effect has been achieved, but there are still some problems, such as low data resolution and relatively single extraction method. In future studies, The integration of various remote sensing data and the combination of remote sensing data and ground synchronous monitoring data will be strengthened to improve the accuracy of original data.

Acknowledgment

This paper was supported by Shanxi Province Land Enginaeering Construction Group Project DJNY2022-28.

References

- [1] Guo Dazhi, Jin Xuelin. Remote sensing -- an advanced comprehensive detection technology [J]. *Mine Survey*, 1991 (3):4.
- [2] HE Q Q. Study on reflectance hyperspectral characteristics of mixed pixels of dead leaves and soil [D]. Northeast Normal University, 2013.
- [3] Huang Chunlong, Xing Lixin, Han Dong. Water system information extraction based on texture feature [J]. *Journal of Jilin University*, 2008,38(suppl.): 276-278.
- [4] Yang Zhiwen, Chen Jinyun, Zhang Zhiyuan. Research on automatic reservoir extraction method based on network information and remote sensing image [J]. *Water Resources Informatization*, 2022(000-003).
- [5] Li Fei, Sang Guoqing, Sun Ying, et al. Research on complex water information extraction method based on Gaofen-1 satellite remote sensing data [J]. *Journal of University of Jinan (Natural Science Edition)*, 2021, 035(006):572-579.
- [6] Liu Jianbo, Dai Changda. Application of TM image in monitoring and management of large reservoir situation [J]. *Environmental Remote Sensing*, 1996, 11(1):6.
- [7] Du Jinkang, Huang Yongsheng, Feng Xuezhi, Wang Zhoulong. Study on extraction method and classification of water body from SPOT satellite image [J]. *Journal of Remote Sensing*, 2001,5(3):214-219. (in Chinese)
- [8] Yu Huan, Zhang Shuqing, Li Xiaofeng, Na Xiaodong, Kong Bo. Remote Sensing Technology and Application, 2008, 23(3): 310-315. [J].
- [9] Study on extraction method of water by ETM+ image [J]. *Computer Engineering and Design*, 2009,30(4): 993-996. (in Chinese)
- [10] LIU Wei. Research on Mass Remote Sensing image data storage Technology [D]. Changsha: National University of Defense Technology, 2007.
- [11] Li Ke, Wang Yiyong. Research on improved automatic extraction model of TM image water [J]. *Journal of Water Resources and Water Engineering*, 2007,18 (6): 20-22. (in Chinese)