Application of High-Resolution Remote Sensing Images in Urban Greening Rate Extraction

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Abstract. The urban greening rate is the ratio of the metropolitan green space area to the city's total area, and it is an essential indicator for measuring the level of urban greening. High-resolution remote sensing images can provide detailed surface information, enabling people to monitor and understand the urban greening situation from a long distance, on a large scale and in real time. This paper investigates the performance and application of high-resolution remote sensing imagery in urban greening rate extraction. This paper concludes that selecting high-resolution remote sensing images, preprocessing the images, and adopting the visual interpretation method combined with automatic computer classification and field survey can improve the accuracy of greening rate extraction. Future research can improve extraction accuracy by combining different data sources and improving the classification method. This paper can provide some references for future research on urban greening rate extraction and enhancing the level and efficiency of urban greening management.

Keywords: High-resolution remote sensing imagery, Urban Greening Rate, vegetation index.

1. Introduction

With the acceleration of urbanisation, people are increasingly concerned about urban greening. Urban greening can reduce urban temperatures, improve urban air quality, provide recreational space, and help to maintain urban ecological balance. However, there is a problem of land resource constraints in cities, and to reasonably allocate green areas, it is necessary to grasp the changes in urban greening accurately. Holding the greening information helps to optimise the layout and structure of urban green space, provides a reference for the urban ecological compensation mechanism, and helps to promote the sustainable development of the urban ecological environment. Therefore, accurate extraction of urban greening information is significant for urban planning and management.

The traditional method of greening rate survey is field measurement, which is not only heavy and inefficient but also has poor data traceability and the quality of the results is difficult to ensure. In recent years, with the high-speed development of remote sensing technology, the role of remote sensing technology in greening rate extraction has become increasingly significant, saving many workforce costs, improving efficiency, and providing vital support for urban greening management and planning. High-resolution remote sensing images have high spatial and spectral resolution, which can provide more detailed and accurate urban greening information. With the development and popularisation of remote sensing technology, more and more researchers use high resolution remote sensing images to extract urban greening rates. Based on high-resolution remote sensing images, Huiting Xu et al. discussed the feasibility of various vegetation indices in removing urban landscape greening coverage [1]. Kangbing Zhao studied how to improve the extraction accuracy of urban green space information using high-resolution remote sensing images [2]. Xu Jianhui et al. found a suitable green space extraction method for small and medium-sized cities using high-resolution remote sensing data [3]. However, in practical application, remote sensing technology also has some limitations, such as complex image processing and more significant influence by weather. Therefore, when using remote sensing technology to extract the urban greening rate, it is necessary to combine methods such as denoising and correction to process the data and combine them with field surveys to improve the accuracy and reliability of the results.

This paper presents a comparative analysis of the application of high-resolution remote sensing imagery for greening rate extraction. Firstly, this paper introduces the basis for selecting remote sensing image data sources and data preprocessing methods in greening rate extraction. Then, this paper summarises some existing research methods, mainly related to visual interpretation, automatic computer classification, and field survey. Finally, this paper evaluates the advantages and disadvantages of different research methods in extrating urban greening rate and puts forward the views on the future research direction. This paper aims to provide a reference for the future improvement of the method of extracting the greening rate, to provide a scientific basis for urban greening managers and decision makers, and promote the improvement of urban greening level and sustainable development.

2. Analysis of Data Sources for Greening Rate Extraction

2.1. Selection of Remote Sensing Images

When conducting urban greening rate extraction studies based on high-resolution remote sensing images, selecting of appropriate remote sensing image data is crucial for the accuracy and validity of the results. Common types of remote sensing data include optical remote sensing images, radar remote sensing images and hyperspectral remote sensing images. Optical remote sensing uses solar radiation or other light sources to illuminate the ground and obtains information on ground objects through atmospheric scattering, reflection and other phenomena. Visual remote sensing images have high resolution and are rich in visible and infrared wavelengths, making them suitable for ground cover classification and vegetation monitoring applications. Still, but they are greatly affected by weather, with clouds, haze and so on affecting the acquisition of data, and data can only be acquired during the day. Radar remote sensing uses radar to transmit microwave signals and receive signals reflected back from ground targets to obtain information on features. Radar remote sensing is not affected by weather and can acquire data in bad weather such as rain, sleet and snow. Its penetrating power makes it suitable for terrain mapping and ocean monitoring applications. However, the resolution is relatively low, and it is difficult and costly to distinguish the detailed information of features. Hyperspectral remote sensing acquires spectral information of ground objects in dozens or even hundreds of consecutive bands, which can provide richer spectral information and facilitate material identification and classification. However, hyperspectral remote sensing data processing is relatively complex, requires a high level of technology and is relatively costly.

High-resolution remote sensing imagery refers to remotely sensed image data with high spatial resolution. Common data sources include commercial satellites such as WorldView, QuickBird, SuperView-1, and Pleiades and SPOT. In addition, aerial photogrammetric surveys can be carried out with payloads such as aerial photographers to obtain high-resolution images. High-resolution remote sensing images provide high-precision feature information and are capable of capturing fine feature characteristics. They enable the rapid acquisition of large-scale image data, providing all-round, multi-angle observations. They also allow for multi-temporal and multi-angle monitoring, which is conducive to observing and analyzing of dynamic changes.

In a study on the feasibility of urban landscape coverage extraction using high-resolution remote sensing imagery, Huiting Xu et al. found that an increase in the spatial resolution of remote sensing imagery can effectively reduce the misclassification of features in the extraction result [1]. The study proves that high-resolution remote sensing images can provide more detailed spatial detail information, which helps to extract the urban greening rate more accurately. In addition, selecting remote sensing data at appropriate time periods can reflect the changes in urban greening rate in different seasons and time periods [2]. In actual research, selecting appropriate remote sensing data according to specific needs is conducive to improving the accuracy and effectiveness of research results. Overall, when selecting remote sensing data, it is necessary to consider various factors, such as data type, resolution and acquisition period, to obtain comprehensive information on the change of urban greening rate.

2.2. Data Preprocessing

During the acquisition process, remote sensing images are affected by various factors such as sensor noise, atmospheric interference, cloud cover, and vegetation cover. Sensor noise and atmospheric interference may lead to impaired or distorted signals in the image, making it difficult to accurately extract detailed information. Cloud cover and vegetation cover can lead to missing image information in some areas, affecting the observation and analysis of the whole area. Therefore, remote sensing images need to be processed accordingly. Before carrying out urban greening rate extraction based on high-resolution remote sensing images, data preprocessing is usually required to improve the data's quality and usability and the extraction results' accuracy. Typical remote sensing image preprocessing methods include denoising, cropping and fusion. Using denoising methods such as smoothing filters and wavelet transform can effectively remove or reduce these noises and thus improve the accuracy of urban greening rate extraction. Extracting the urban greening rate usually focuses on a specific area, and cropping the image according to the study area can reduce the interference of the irrelevant regions, reduce the amount of computation, and improve the processing efficiency. By fusing multiple remote sensing image sources using methods such as image fusion and data fusion, higher quality images and more comprehensive information can be obtained. In addition, preprocessing operations such as radiometric calibration, atmospheric correction, geometric correction, etc. can be performed as needed. Radiometric calibration converts the original DN value to the radiant brightness value, which can eliminate the error caused by the sensor itself and obtain the accurate radiant value at the sensor inlet. Atmospheric calibration converts the radiant brightness or surface reflectance to the actual reflectance of the ground surface, eliminating the errors caused by atmospheric absorption, reflection and scattering. Geometric correction mainly consists of systematic geometric correction, projection distortion correction and geometric fine correction, which can reduce or eliminate the geometric distortion on the image so that the image can correspond accurately with the field in the spatial position relationship. Fig. 1 illustrates part of the data preprocessing method flow, which can be adjusted as needed in practical applications.

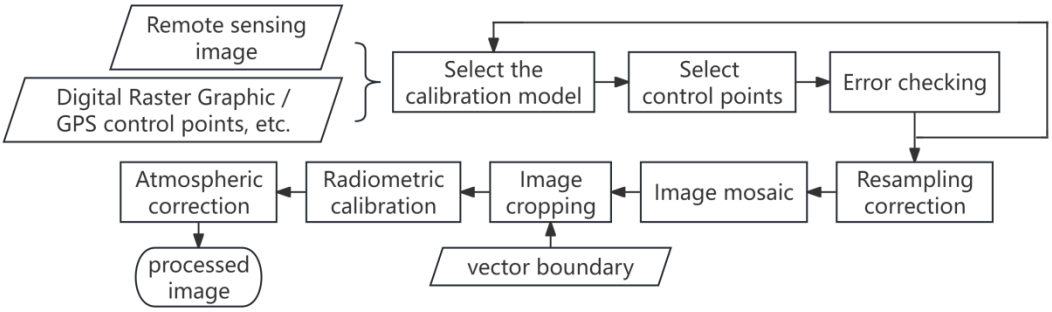

Figure 1. Data preprocessing flowchart

3. Current Status of the Application of Remote Sensing Technology in Greening Rate Extraction

In the current study, the researcher mainly selects high-resolution remote sensing images such as WorldView, QuickBird and SuperView-1 as the data source for greening rate extraction and green space information extraction. Greening rate can be extracted using automatic computer classification, such as remote sensing image classification techniques, which classify features into different categories based on spectral characteristics. The main acquired land use types include green space, buildings, water bodies, etc. The greening rate is then estimated by calculating the proportion of green space. The greening rate is estimated by calculating the vegetation cover using vegetation index and land cover index. In addition, visual interpretation of remote sensing images to delineate green and non-green areas by combining expert experience and on-site surveys is also a reliable method for calculating the greening rate. Combining of visual interpretation and automatic computer classification can improve efficiency while ensuring extraction accuracy. Finally, it is necessary to

combine remote sensing images with ground field surveys to obtain real data such as green space coverage, which is used to verify the accuracy of remote sensing extraction results. Comprehensive use of high-resolution remote sensing images, vegetation index data and ground truth survey data, combined with image classification, index calculation and other methods, can be a relatively accurate extraction of urban greening rate.

The current research direction mainly focuses on extracting and evaluating urban green space information, involving various remote sensing techniques and methods. Kangbing Zhao extracts green space information by improving the vegetation index by introducing the red edge factor, combined with an object-oriented decision tree classification method based on multiple features. Through human-computer interactive interpretation, the refined investigation of urban green space information is realised and the quality of the investigation results is improved [4]. Jianhui Xu et al. extracted green space information from high-resolution satellite remote sensing images using supervised classification, vegetation index classification, and visual interpretation. The results showed that the classification accuracy could be significantly improved using the vegetation index classification method, among which the normalised vegetation index (NDVI) had the highest accuracy [3]. Lingling Han et al. extracted the green space information of the built-up area of Tai'an City by choosing Quickbird, a high-resolution remote sensing image, as the data source and combining the methods of visual interpretation and automatic computer classification. The distribution status of various types of urban green space was derived through statistical analysis [5]. Using IKONOS images as data source, Qiang Xu et al. comprehensively applied mapping and remote sensing technologies, and adopted unsupervised classification, supervised classification, and visual interpretation to extract green space information in the images. Through the accuracy analysis and comparison, an ideal method for the extraction of green space information in small areas is explored [6]. Huiting Xu et al. investigated the application of remote sensing technology in vegetation cover estimation, and related studies and methods. These include the method of calculating vegetation cover based on the low-altitude visible spectrum, the method of estimating vegetation cover in mining areas based on image element dichotomy, the application of machine learning in urban greening land cover extraction, the application of UAV imagery in sugarcane growth monitoring and the estimation of cover in Daning mining areas. Some detailed information on the application of remote sensing technology in vegetation cover estimation is provided [1].

4. Conclusion

This article introduces the selection basis of remote sensing image data sources and data preprocessing methods in greening rate extraction and combs. It summarizes some existing research methods, mainly involving visual interpretation, computer automatic classification and field investigation. High-resolution remote sensing image technology has essential application value in urban greening rate extraction, which can improve the accuracy and efficiency of greening investigation and assessment. The improved vegetation index and object-oriented decision tree classification methods through the red edge factor can improve the extraction accuracy of green space information, while the supervised classification and vegetation index classification methods can improve the accuracy of green space information extraction. In addition, through the comprehensive use of surveying and mapping, remote sensing technology, and classification methods, green space information can be accurately extracted in small areas. These research results provide a practical reference for optimizing the urban greening rate survey method and improve the accuracy and practicality of the survey results.

However, current research still has some shortcomings. In the extraction of urban greening rate, there is still a problem of difficulty in accurately extracting small green areas. In object-oriented decision tree classification methods, it is necessary to improve the algorithm to improve the accuracy and efficiency of classification. In addition, the application of different vegetation indices is also controversial, and it is necessary to study how to choose a vegetation index suitable for specific

scenarios. Therefore, people need to improve existing methods and technologies further to improve the accuracy and efficiency of urban greening rate extraction. Future research directions can be conducted by combining different data sources and improving classification methods to improve extraction accuracy. First, by combining multi-source remote sensing data, ground observation data, and social media data, urban green space information can be better obtained and the accuracy and comprehensiveness of green space information can be improved. Secondly, by improving the algorithm and the accuracy and efficiency of classification, green and non-green spaces can be better identified. At the same time, advanced technologies such as machine learning and deep learning are introduced to improve the accuracy of extracting green space information. It is also essential to conduct field surveys to study the impact of ground objects' physical and chemical properties on remote sensing information. In-depth exploration of these research directions will help to better understand and grasp the development status of urban greening and provide strong support for urban planning and sustainable development.

References

[1] Xu Huiting, Zhang Xin, Xie Junfei, Et Al. Application of Vegetation Index in Urban Green Coverage Rate Census. Journal Of West China Forestry Science, 2023, 52 (04): 101-107.

[2] Zhao Kangbin. Application Of High Resolution Remote Sensing Image Technologytaking Urban Greening Investigation As An Example. Journal Of Nanjing Institute of Technology: Natural Science Edition, 2019, 17 (04): 50-56.

[3] Xu Jianhui, Su Ya. Study Of Urban Green Space Surveying Based on High Resolution Lmages of Remote Sensing. Resource Development & Market, 2010, 26 (04): 291-293+288.

[4] Li Guang. The Extraction Method of Crop Planting Structurein Irrigation District Based on Multi-Source Opticalremote Sensing Collaboration. Northwest A&F University, 2023.

[5] Han Lingling, Fei Xianyun, Tian Muge. Analysis Of Urban Greening of Tai'An City Based on Remote Sensing Lmage with High Resolution. Journal Of Anhui Agricultural Sciences, 2012, 40 (23): 11753-11756.

[6] Xu Qiang, Li Jing. A Study on the Application of High-Resolution Remote Sensing Images in the Extraction of Green Space Information in Small Areas. Theoretical Research in Urban Construction, 2012, (13).