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Research on Urban Land Use based on Remote Sensing Technology

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Abstract:

The advancement of urbanization has brought urban land use change into the spotlight of research. Remote sensing technology, as the primary means of capturing this change, provides valuable data for research. The main research object of this paper is the four classification methods of land use in cities based on remote sensing technology, and it outlines the main roles and applications of these four classification methods. This paper concludes that the visual interpretation method is less efficient but widely used. In addition, the accuracy of supervised classification and deep learning methods for classification is low. Unsupervised classification is simple, but the results differ greatly from reality. The above commonly used land classification methods have their advantages and disadvantages, and their combined use ensures that remote sensing technology provides real-time, effective, and comprehensive land use information for urban planning and management. Finally, this paper looks forward to the combination of remote sensing technology and modern technology, such as artificial intelligence. The integrated technology can provide more accurate and efficient technical support for future urban development.

Keywords: Land use; classification methods; remote sensing.

1. Introduction

Nowadays, the urban population is in the stage of rapid expansion, the rapid expansion of urban land, and the urbanization process continues to promote all aspects of the city have an impact[1]. For example, urbanization has significant adverse impacts on the natural environment, mainly in the form of land-use change and destruction of ecosystems. Urbanization has also resulted in large areas of land surface being covered with concrete and asphalt, reducing soil permeability and increasing the risk of urban flooding. Land use/land cover change is an important cause affecting urban planning and management, waste disposal, water resource management, etc. Therefore, the study of land use has become an important element in urban planning and management.

Due to the rapid development of science and technology, the national economy, and the advancement of urbanization, China's land use pattern has changed dramatically, and a large amount of land has been used to build residential, commercial, and industrial land, leading to the depletion and destruction of land resources, and the changes in land use have profoundly affected the service function of urban planning and management[2]. Remote sensing, as a detection technology for sensing targets or natural phenomena at a distance without direct contact, can accurately and rapidly obtain relevant information on construction and development in land and cities. Moreover, with the vertical integration and integration of RS, GIS, and GPS, the 3s technology has gradually evolved from groping research to widely applied practice. This also highlights the advantages of remote sensing technology with multi-angle, multi-dimension, multi-point acquisition, high capture rate, etc[3]. Therefore, it is very good to use remote sensing technology to research aspects of land use.

Based on remote sensing technology, survey and dynamic monitoring of land-use management, territorial surveys, natural resource management, etc., have major advantages[4]. Xu Liangliang and Ma Kaisen et al. [5] used the full-band, true-color, three false-color datasets based on GF-2 remote sensing imagery and the Potsdam Open dataset to verify the effectiveness of the improved model in classifying urban green spaces and the generality of the model itself, taking Yuhua District, Changsha City, as an example. Lunming Qin and Xuehai Ling[6] combined the U-Net and Swin Transformer model to achieve the optimal extraction results among the current deep learning methods on the task of segmenting high-resolution cultivated land remote sensing images. The applied research of He Rui and Wang Run[7] showed that the U-Net model combined with Gaofen-2 satellite image data can effectively extract the land damage information of open-pit mines in key mining concentration areas in Hubei Province, which improves the efficiency of information extraction

on the basis of the previous human-computer interaction interpretation. As can be seen from the examples, remote sensing technology is universal in land management and integrated remote sensing monitoring technology for land has been widely applied in such areas as urban green space classification, arable land, land desertification, extraction of effective information on damaged land, and environmental emergency response. The further promotion and application of integrated remote sensing monitoring technology will provide a scientific database and service support for the medium- and long-term planning of land resources, ecological and environmental protection, early warning of natural disasters, and public security[8].

The purpose of this paper is to explore the application methods of remote sensing technology in urban land-use scenarios and to analyze the current status of the application of remote sensing technology in land-use dynamic monitoring. Through the study of application methods and the current situation, it then explores the key role of remote sensing technology in urban planning and management. According to today's scientific and technological progress in the development of remote sensing technology in the future, to make prospects, the proposal can be to enhance remote sensing science and technology to be integrated with other advanced intelligent facilities for development. Through the research of this paper, we hope that the integrated development of remote sensing technology can provide a more rigorous scientific basis and more complete technical support for the sustainable development of urban land use.

2. Application Methods

Land is the carrier of human activities, and the use of arable land, forest land, residential land, water systems, roads, etc., is the main manifestation of land use. The use of remote sensing technology can not only investigate the current status of land use on a large scale but also monitor and obtain information on land use changes. The more widely used land use classification methods mainly include visual interpretation, supervised classification, unsupervised classification, deep learning methods, and so on[9].

2.1 Visual Interpretation

Visual interpretation is a kind of remote sensing image interpretation, which is a process that requires professionals to obtain specific target feature information on remote sensing images through direct observation or with the help of auxiliary interpretation instruments, and obtaining thematic information from remotely sensed images is rich in content, high in efficiency, and has a wide range of applicability, and it is a basic skill for geological research and remote sensing applications in the information society[10]. However, this approach is qualitative and preliminary, as it remains at the level of physical and mathematical modeling, so it has no way of being automated and real-time. Visual interpretation is an analytical study that provides valuable aspects of an intriguing local area, which is then quantitatively automated and modeled so that human knowledge and human experience can be combined with our quantitative modeling theory of remote sensing.

2.2 Oversight Classification

Supervised classification requires professional analysts to select known category features as training samples for the classification system to learn to train a model based on the understanding of image region features and discriminate all the image elements to be classified according to certain classification principles. Supervised classification includes methods such as decision tree classification algorithms, maximum likelihood classification, support vector machine classification, random forest algorithms, and so on[9]. A decision tree classification algorithm can deal with multiple sources of unrelated data and make decisions under risky conditions. Its classification accuracy depends on whether a good decision tree model is established. The support vector machine classification method mainly solves the problem of nonlinear classification, and there is difficulty in multi-classification. This method has better classification effects and higher accuracy. Random forest algorithms can not only deal with very high dimensional data and do not have to do feature selection but also can solve the error caused by unbalanced datasets. However, the use of certain noisy classifications is prone to overfitting phenomenon, and the accuracy of using this method depends on the feature preference. In 2016, Li Biao et al. proposed a hyperspectral remote sensing image classification method based on random forests, which makes full use of spectral and spatial structural information of hyperspectral images and improves the accuracy of remote sensing image classification[11].

2.3 Non-supervisory Classification

Unsupervised classification, also known as cluster analysis, involves the processing of data into different categories by the computer itself without the need for human-assisted intervention. Still, the attributes of the classification results cannot be determined. A common unsupervised classification algorithm is the Iterative Self-Organising Data (ISODATA) analysis algorithm. This new method is very effective in the identification of spatial target materials related to hyperspectral imagery, which is widely used in the classification of information in remotely sensed

imagery[9]. The improved ISODATA clustering algorithm proposed by HONG P et al. combines the spectral and spatial information of hyperspectral images. It uses a weighting matrix to compute the similarity between 2 pixels separately to determine more accurately whether they belong to the same class or not[11].

2.4 Classification Of Deep Learning Methods

The deep learning method classification uses neural networks for information recognition through the use of a large number of training samples, looking for sample data intrinsic laws to get the optimal training model. Then, the data is to be processed into the training model to get the optimal classification process, which can effectively improve the correctness of change detection. With the continuous development and in-depth research in this field, this method will have a broad development prospect and important application value in remote sensing image processing and play an increasingly important role[11]. Its method classification mainly includes the BP neural network classification algorithm, the classification algorithm of space-spectrum combination, and so on[9].

3. Applications

In China, satellite remote sensing data could also be used as supplementary information for land-use surveys and managed in conjunction with land monitoring of aerial remote sensing technology for sampling. Hyperspectral remote sensing technology can identify different kinds of vegetation by analyzing the reflectance in different bands. By establishing mathematical models between the reflectance of plants in different bands and the moisture content of vegetation, a rapid and accurate estimation of the moisture content of vegetation can be achieved[12]. Therefore, hyperspectral remote sensing can identify and monitor different types of land cover, such as cropland, forests, watersheds, buildings, and so on.

Accurate identification of land cover types can be achieved through spectral analysis of hyperspectral remote sensing data and the application of classification algorithms. Remote sensing technology can also be combined with topography, texture, and other data to improve the accuracy of land cover identification. Its excellent temporal and spatial resolution can capture subtle land use changes.

For example, Qin Lunming, Ling Xuehai, et al. use a combination of U-Net and Swin Transformer models to achieve the optimal extraction results among the current deep learning methods on the task of segmenting high-resolution cropland remote sensing images. This method is simpler in data acquisition, and the extraction accuracy of cropland areas is improved relative to previous methods. They believe that the deep learning method, as an emerging technology, has a large development space in the extraction of arable land area from remote sensing images. However, the technique still needs to be further improved, such as the pixel-level classification achieved by semantic segmentation, which leads to the appearance of more noise, finding a more efficient method to remove noise, and the difficulty of recognizing small pieces of cultivated land. Subsequent research will be conducted on related issues to improve the existing methods to enhance the extraction of cropland area from high-resolution remote sensing images in terms of speed and accuracy[6].

He Rui and Wang Run et al. use the U-Net model combined with the Gaofen-2 satellite image data to effectively extract the land damage information of open-pit mines in key mining concentration areas in Hubei Province. They think that the information extraction effect of each backbone model of the U-Net model is quite different. The overfitting phenomenon occurs when the number of layers of the backbone model is too deep, which reduces the accuracy of the information extraction results. The information extraction effect is relatively better when the backbone model is set to ResNet34. At the same time, if the computer hardware conditions allow, the larger the sample size in the data sample set, the better the model learning effect and the better the information extraction effect[7].

For land use classification in sparsely populated desert areas in countries such as Canada and Australia, researchers use SRSM (Satellite Remote Sensing) monitoring mode, while in densely populated large cities, ARSM (Aerial Remote Sensing) monitoring mode is used. In Japan, Corsica, Sardinia, and other small island countries in Western Europe, which are backward in terms of economic development, since land information is relatively complete, the general credit operation procedures (including regular aerial photography) can be used to grasp and satisfy the demand for various kinds of information in the land management work without the need to use remote sensing technical information. Many developed countries are focusing on the application of satellite remote sensing technology in land use and monitoring and have made important breakthroughs. The results of such forward-looking research will provide support for expanding the use of remote sensing technology[3].

4. General Discussion

Synthesizing the descriptions of the application methods in the previous section, it is possible to derive the characteristics of the crossover between them:

(1) The two methods of land use classification, visual interpretation and supervised classification, mainly still

need to rely on the assistance of professionals in order to complete the analysis and interpretation of remotely sensed images, which is relatively inefficient and cannot deal with larger data. Still, the application scope of these two methods is relatively wide.

(2) Supervised classification and deep learning classification methods require a lot of complex training of the classification model before classification, and many of the model methods after training rely too much on the training samples to appear as an overfitting phenomenon, leading to a decline in classification accuracy[9].

(3) unsupervised classification does not pre-training, can deal with massive data, the processing process is mainly data features categorization, relatively simple, but its classification results and the actual category gap is large, the accuracy is not high, the results need to be manually pattern matching[9].

Remote sensing technology is the most important data source for exploring urban development and supporting urban planning and management. With the increasing resolution of remote sensing images in recent years, more high-resolution satellites have appeared, and the development of its image-processing technology has ensured a variety of ways to extract information[13].

In urban land development and urban planning and management, the close integration of remote sensing technology with GIS and other scientific and intelligent means has achieved the relevant analysis and processing of land resource attribute data and spatial data. This integrated analysis has greatly improved the inadequacy of remote sensing technology in land use classification, and the visual display of abstract data through a variety of maps has made it possible to apply and compare the data flexibly, thus improving the efficiency and capacity of urban land use resource management[14].

In addition, remote sensing technology can accurately extract information on urban land use change and can effectively monitor urban land use dynamics. Remote sensing technology, with its characteristics of rich information, all-weather, short information acquisition cycle, and multiple sources of data acquisition, plays an important role in improving the efficiency of urban planning and promoting sustainable development and provides technical support and services for the construction of smart cities[15]. With the continuous advanced development of artificial intelligence technology, the development of a logical remote sensing image analysis system with better comprehensive analysis capability is also an important direction for the future development of remote sensing images in land use classification[16].

5. Conclusion

This paper focuses on the application of remote sensing technology in urban land use scenarios. The four commonly used land classification methods include the visual interpretation method, supervised classification method, unsupervised classification method, and deep learning classification method. Firstly, this paper analyses the application of remote sensing technology in urban land use scenarios and lists examples of remote sensing technology in land use, arable land, mining areas, deserts, and so on. Overall, remote sensing technology has the advantages of excellent temporal and spatial resolution in land use classification and can capture subtle land use changes. Meanwhile, this paper concludes that remote sensing technology can provide real-time effective and comprehensive land use information for urban planning and management. The future human-computer interactive interpretation of remote sensing technology is the main trend and development direction of the future development of remote sensing interpretation and other reasonable suggestions.

References

[1]Huang Wen. Discussion on the impact of urbanization on the urban ecological environment[J]. Heilongjiang Environmental Bulletin,2023,36(08):18-20.

[2]YAN Yingcun, XU Ruixiang, XIAO Jianjian et al. Remote sensing survey and driving analysis of LUCC in Bayin River Basin of Qinghai Province[J]. China Desert,2012,32(01):276-283.

[3]Cao Yangkun. Study on the current status of land use dynamic remote sensing monitoring and its technology application[J]. Residential and Real Estate,2023(Z1):153-155.

[4]Zhao Gengxing. Overview of remote sensing land use scenario and dynamic monitoring[J]. Journal of Shandong Agricultural University,1997(01):69-74.

[5]XU Liangliang, MA Kaisen, WANG Xia et al. Application of LA-UNet network model in remote sensing classification of urban green space[J/OL]. Journal of Applied Ecology:1-14[2024-03-05].https://doi.org/10.13287/j.1001-9332.202404.025.

[6]Qin LM, Ling XH, Zou YJ, et al. Segmentation of high-resolution arable land remote sensing images based on SF-Unet[J/OL]. Radio Engineering:1-9[2024-03-05].http://kns.cnki.net/kcms/detail/13.1097.tn.20240227.1125.002.html.

[7]He Rui,Wang Run,Xu Hang et al. Application of U-Net based land damage information extraction from open pit mines in Hubei Province[J]. Resource Environment and Engineering,2024,38(01):100-110.DOI:10.16536/j.cnki.issn.1671-1211.2024.01.013.

[8]E Gao-Yang, HAN Fang, QIN Bing-Xi et al. Application of remote sensing technology on comprehensive monitoring of

agricultural resources and soil environment[J/OL]. Shandong Agricultural Science:1-11[2024-03-11].http://kns.cnki.net/kcms/detail/37.1148.S.20240229.0925.002.html.
[9]Zhou Ke, Yang Yongqing, Zhang Yanna et al. A review of land use classification methods in optical remote sensing images[J]. Science, Technology and Engineering,2021,21(32):13603-13613.
[10]Chai Li-Quan. Analysis of visual interpretation methods and influencing factors of remote sensing images in urban planning[J]. Chinese and foreign architecture,2013(06):82-84.
[11]DU Runfeng, WANG Xiaopeng, ZHANG Jiahua et al. A review of hyperspectral remote sensing classification method of Gaofen-5 satellite[J]. Journal of Qingdao University (Engineering and Technology Edition),2023,38(04):83-93+100. DOI:10.13306/j.1006-9798.2023.04.013.
[12]M. Li, H.R. Luo. Application of hyperspectral remote sensing in natural resources investigation and monitoring[J]. Guangxi Water Conservancy and Hydropower,2024(01):150-154. DOI:10.16014/j.cnki.1003-1510.2024.01.033.
[13]ZHU Wei,ZHAO Renhui,ZHENG Qi. Application of urban remote sensing in digital city[J]. Value Engineering,2010,29(23):140. DOI:10.14018/j.cnki.cn13-1085/n.2010.23.049.
[14]JIANG Jinlong,LI Jian,LIANG Jun. Application of remote sensing technology in the study of urban land use evolution[J]. Anhui Agricultural Science,2007(07):2001-2003.DOI:10.13989/j.cnki.0517-6611.2007.07.064.
[15]Chen L, Zhao YY. UAV remote sensing device for smart city mapping engineering survey[J]. Smart China,2023(09):86-87.
[16]Wang Yuanyuan,Li Jing. A review of land use/cover classification methods in remote sensing imagery[J]. Remote Sensing Information,2004(01):53-59.