Research on Remote Sensing Feature Selection and Information Extraction of Urban Construction Waste Based on Jilin-1 Image

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Abstract. Construction waste generally refers to the waste generated by man-made or natural factors such as new construction, demolition, and repair. It has many characteristics such as discrete distribution, various types, and frequent changes. Conventional survey methods are difficult to obtain construction waste location information quickly and accurately, while information extraction methods based on high-resolution remote sensing images can efficiently acquire construction waste information in a large area. Therefore, this paper uses the domestic Jilin-1 satellite (JL-101A) remote sensing image, based on multi-scale segmentation, and through the method of object-oriented remote sensing feature recognition. This paper regards the Qianxinzhuang Village in Daxing District, Beijing as the study area. And it takes research on information extraction of construction waste in cities. The results show that the optimal segmentation scale of the study area is 74; the overall accuracy of the object-oriented knowledge rule classification method is 88.0%, and the Kappa coefficient is 83.6%. The results show that the object-oriented method based on the domestic Jilin-1 satellite is feasible for information extraction of construction waste, and it has certain significance for the management of construction waste.

1. Introduction

According to the "Regulations on the Management of Urban Construction Waste and Engineering Waste (Revised Draft)" promulgated by the Ministry of Construction in June 2003, construction waste refers to the lithosols, residual mud and other waste produced by the construction unit or individual, with the process of construction, demolition or renovation [1]. The acceleration of urbanization in my country has intensified the production of construction waste, and the annual amount of construction waste has accounted for 80% to 90% of the total amount of urban waste. The continuous increase of urban construction waste has also brought negative impacts on the living environment of human beings, such as occupying a large amount of land and harming the surrounding air environment. In order to improve the quality of urban environment, it is necessary to rationally plan urban land use resources, identify and effectively manage construction waste.

Traditional construction waste identification and management methods are generally on-site surveys or measurements, but construction waste has persistent hazards to the surroundings. Therefore, this method was not enough to meet the needs of nowadays identification. Remote sensing image data has obvious advantages in immediacy, objectivity, and macroscopicity. It is an advanced method for identifying construction waste. The continuous enrichment of high spatial resolution and high temporal resolution remote sensing data also provides a good data source for remote sensing identification. So
far, many scholars have made some attempts and achieved good results in the application of identifying and extracting the urban construction waste by using remote sensing image data. Bagheri used aerial remote sensing photos and used visual interpretation to identify the urban solid waste piles distributed in Italy [2]. Zhao Jing and others used aerial remote sensing photos combined with field surveys to conduct preliminary interpretation of the target, and confirm the location of urban garbage [3]. Liu Yalan used domestic small satellite Beijing-1 image data to establish interpretation signs to identify changes [4]. Qin Haichun and others used domestic GF-1 image data, introduced the soil adjustment vegetation index SAVI, and used the post-classification change detection method to analyse the dynamic changes of the Qizishan landfill [5]. Luo Liqun combined Quickbird images and Hyperion hyperspectral images to extract urban solid waste [6]. The extraction of urban construction waste mostly uses pixel-based analysis methods, and the extraction accuracy is relatively low. It is difficult to solve the problem of confusion between construction waste and surrounding features.

This study intends to use domestic high-resolution Jilin-1 satellite images and take the demolition area of Qianxinzhuang Village, Daxing District, Beijing as the research area. Through the analysis of multiple characteristics of construction waste, using the object-oriented classification method to extract remote sensing information of construction waste.

2. Materials and methodology

2.1. Study area

The study area is a demolition area where located in Qianxinzhuang, Daxing District, Beijing. It is found that it was originally a dense residential area where has been demolishing began in 2018. The area was covered with a large quantity of construction waste. This is a typical research area for construction waste information extraction. It can be seen from the images that the main types of surface coverage in the study area are construction waste, buildings, roads, bare soil, and vegetation.
2.2. Data
The image from Jilin-1 satellite (JL-101A) was used in this study. The data of JL-101A has high spatial and time resolution. It can acquire 2.88m multi-spectrum (blue 450-520 nm, green 520-600nm, red 630-690nm, simulated NIR 700nm-800nm) and 0.72m panchromatic image. For that the 2.88m multispectral image has good quality and rich information. And the revisit period is only 3.3 days.

The Jilin-1 satellite image has been widely used in forest resource investigation, flood disaster evaluation, urban heat island research, etc. It has the advantages of high efficiency, low cost and high precision to identifying the construction waste.

The image used in this study included the panchromatic and multispectral bands which was produced on October 19, 2018. Before the identification and extraction of construction waste, the necessary pre-processing was performed on the image. And the target area was acquired according to the region of interest based on the fusion image.

2.3. Methodology

2.3.1. Optimal segmentation scale.
The pixel-based analysis method cannot effectively distinguish construction waste from surrounding features. Therefore, this study adopts an object-oriented classification method and uses a multi-scale segmentation algorithm to obtain image objects. The selection of scale is vital to the effect of image segmentation. Segmentation parameters generally include scale parameters and homogeneity parameters [8]. The homogeneity condition parameters include shape factor and spectral factor. The sum of them is 1.

ESP2 (estimation of scale parameter 2) is a scale parameter evaluation tool. The result graph shows the variation of local variance and rate of change with scale. The peak of the ROC curve guides the possible optimal segmentation scale [9]. This study uses ESP2 tools to access the most optimum segmentation scales initially.

2.3.2. ReliefF feature selection algorithm
The ReliefF algorithm was modified algorithm originated in Relief algorithm which was submitted by Kononenko in 1994. It can extend the research object from two categories to multi-classes. When the weight calculated by ReliefF algorithm is larger, the function of this feature on classification is more obvious. The specific calculation formula is as follows:

\[
W(A) = W(A) - \sum_{j=1}^{k} \frac{\text{diff}(A,R_{j})}{m \times k} + \sum_{c \neq \text{class}(x)} \frac{\sum_{j=1}^{k} \text{diff}(A,R_{j}(c))}{m \times k}
\]

Among them, \(M\) is the number of iterations; \(K\) is the number of nearest samples; \(\text{diff}()\) is the distance between samples; \(H_{j}\) is the nearest sample of random sample \(R\) among similar samples; \(M_{j}\) (C) is the nearest sample random sample \(R\) among heterogeneous samples.

2.3.3. Object-oriented classification
Object-oriented classification is superior to the traditional pixel-based classification method. It no longer uses pixels as the smallest unit, but divides the image into objects, and comprehensively uses the spectral and spatial characteristics of each object for classification [9]. Object-oriented classification can make better use of the unique advantages of high-resolution images, and is more suitable for information extraction and recognition of high-resolution images.

The rule-based classification method is to analyse the spectral, shape, and texture characteristics of construction waste through segmented image objects and then construct a knowledge base for extracting construction waste.
3. Result and discussions

3.1. Determine the optimal segmentation scale
The appropriate shape factor and compactness factor were determined through multiple experiments, which were 0.3 and 0.6 respectively. When they were fixed, the multi-scale segmentation has been operated. The segmentation results were obtained by using ESP2 tools. It shows that 33, 74, 126 are the most suitable segmentation scales.

In order to obtain the optimal segmentation scale, the three number were used in experiments. The segmentation results show that when the scale is 33, the segmentation of massive vegetation and construction waste area were too fragmented to be calculated; When the segmentation scale is 126, some small areas cannot be well segmented; and when the scale is 74, it is closer to the real outline of the construction waste dumps in the study area. The effect is shown in Figure 2. Therefore, when the shape factor is 0.3 and the compactness factor is 0.6, 74 is determined as the optimal segmentation scale of the study area.

3.2. Feature selection of urban construction waste based on ReliefF algorithm
By using the ReliefF algorithm to optimize the initial feature, a large number of irrelevant features were removed. The ReliefF algorithm was implemented through Python3.7. In this experiment, 14 spectral features, 10 shape features and 32 texture features were select to construct the initial feature space. The ReliefF algorithm selected the follow 18 features shown in the figure, the 5 features with the largest weight were finally selected to build a rule set for feature extraction. They are NDVI and Brightness in spectral features, GLCM Homogenetiy (all dir.) and GLCM Stv (all dir.) in texture features, as well as L/W in geometric features.

(a) 33,0.3,0.6 (b) 74,0.3,0.6 (b)126,0.3,0.6

Figure 2. Comparison of several optimal parameter segmentation effects
3.3. Establish a rule set of construction waste extraction
Due to the complex composition and hazy boundaries of construction waste, it was difficult to directly extract construction waste dumps. Therefore, this paper used an indirect method that extracts other types of ground objects which had distinct features based on object-oriented classification. Finally, the remaining areas were construction waste dumps.

In the eCognition 9.0 software, the thresholds for separating different features were obtained by selecting samples and analysing data. The suitable rule set to extract construction waste from the Jilin-1 satellite image is obtained by setting the appropriate thresholds. The final outcome of extraction is shown in Figure 4.

3.4. Accuracy evaluation
This paper mainly evaluated the accuracy of the extraction results through the overall accuracy (OA) and Kappa coefficient. Overall Accuracy (OA) is used to indicate the accuracy of the entire experiment. Kappa coefficient (Kappa Coefficient) reflects the overall recognition accuracy by using all of the information in the error matrix [10].
In this paper, a number of sample points were generated randomly with the support of ArcGIS 10.3. According to the real ground data in the same period, the category attributes of sample points were defined by manual interpretation. And the accuracy of the experimental result was evaluated by the error matrix. The result showed that bare soil was significantly different from construction waste in spectrum and texture, so the recognition accuracy was high; a large amount of construction waste in the study area were covered with green dust-proof nets, hence there were more misclassifications with vegetation, which had an effect on final extraction results. The ultimately overall accuracy of the rule-based classification method reached 88.0%.

| Classification data | Verification data |
|---------------------|-------------------|
|  | vegetation | Buildings and roads | Bare soil | Construction waste | Total |
| Vegetation | 44 | 4 | 1 | 14 | 63 |
| Buildings and roads | 2 | 108 | 0 | 7 | 117 |
| Bare soil | 6 | 2 | 63 | 2 | 73 |
| Construction waste | 1 | 4 | 0 | 101 | 106 |
| Total | 53 | 118 | 64 | 124 | 88.0% |

4. Conclusions
In summary, this paper establishes corresponding rule sets for different land types to extract various features based on the multi-scale segmentation of high-resolution remote sensing images, and integrates all the extracted features to obtain the construction waste extraction results in the experimental area. Its accuracy achieves 88%. It can be seen that it is feasible to use the Jilin-1 satellite to extract the construction waste by object-oriented remote sensing technology.

What can be summed up that identifying the construction waste dumps by means of remote sensing technology has achieved good results. A new attempt has been made in the application of remote sensing data sources to extract information from construction waste, which explores a practical approach for urban environmental construction.

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