

Detection of Man-Made Objects Along the High-Speed Railway Based on High Resolution Remote Sensing Images

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Abstract: The condition along the high-speed railway is very important for the safe operation. In the paper, man-made objects along the high-speed railway are used as detecting targets. The paper analyses the existing forms of hidden dangers which are caused by man-made objects along the high-speed railway and what harms they could bring to operation of the high-speed railway. The method of detecting man-made objects along the high-speed railway based on high resolution remote sensing images is studied using remote sensing image classification. According to the established method which is suitable for detecting man-made objects along the high-speed railway, firstly detecting and extracting man-made objects along the high-speed railway, and improving classification accuracy by GIS vector data. Then, using the method to detect man-made objects along the Xuzhou section of Beijing-Shanghai high-speed railway based on GF-3. The results show that there is hidden danger of the plastic house, which proves the effectiveness and practical significance of the method.

1. Introduction

The high-speed railway of China is developing rapidly in recent years. It has made our national economy obviously increasing. But it has also brought some harms to ours while it improves our economic benefits. Because of the fast running, the condition along the high-speed railway is asked for higher requirements. Meanwhile, the scope of detecting work along two sides of the high-speed railway extends to 1000 meters, which proposes a new challenge to the quality and efficiency of manual detection ^[1]. The car and track have a direct impact on the safe operation of the high-speed railway, while the surrounding condition of the high-speed railway has hidden dangers. The hidden dangers of surrounding condition cannot be found in time so that causing accidents of the high-speed railway. At the same time, the external conditional hidden dangers of railway have always been one of the major hazards to the safety of railway transportation ^[2]. The most of the external conditional hidden dangers are caused by some man-made objects. Thus, it is very important to keep abreast of man-made objects and its changes along the high-speed railway in ensuring the safe operation of the high-speed railway, which can assist staff to quickly eliminate hidden dangers along the high-speed railway and improve their efficiency. Remote sensing has high spatial resolution, high spectral resolution and high temporal resolution ^[3]. The paper studies the method of detecting man-made objects along the high-speed railway based on remote sensing images because remote sensing images have short period and high resolution, and its theory of detecting targets and classification has been very mature.

2. The Situation of Detecting man-made objects along the High-speed Railway

2.1 Traditional methods

(1) Manual investigation

In the early stage of constructing the high-speed railway, the primitive method is to organize staff to survey man-made objects along the high-speed railway according to the pre-selected high-speed rail lines on the spot. Each of teams records the findings. Then they report to the relevant departments after reorganizing. Finally, the superiors determine the houses that should be demolished.

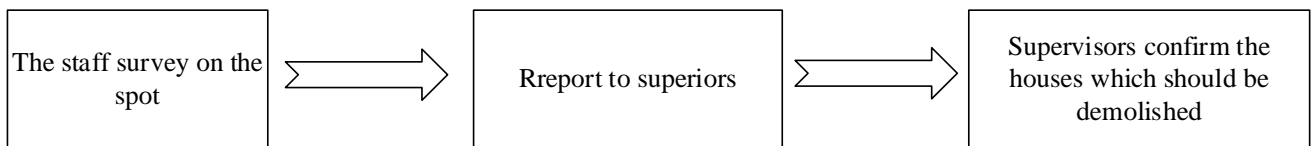


Fig. 1 Manual method for surveying man-made objects along the high-speed railway.

Although the method of manual investigation is effective for detecting man-made objects along the high-speed railway, it is time-consuming and laborious. Especially the both two sides of the high-speed railway have wider operations and the high-speed rail lines are becoming longer and longer now. When detecting man-made objects along the high-speed railway on a large scale, its efficiency is very low, and miss the place where people cannot reach. Therefore, the method of manual field survey is not only inefficient but also incomplete.

(2) Using maps of land use

People sometimes look at the relevant maps of land use to save time and convenience. This method also is useful for detecting man-made objects along the high-speed railway. However, most of the existing maps of land use are historical maps, which only reflect the situation of man-made objects along the high-speed railway in the past time.

2.2 Remote sensing images detection method

Some scholars have studied the method of detecting hidden dangers along the high-speed railway using remote sensing images. Qu Ya applies the high resolution remote sensing images change detection method to detect hidden dangers along the high-speed railway, and proposes a new change detection method using GIS data to improve the detection accuracy^[4]. Zhao Tingting does experiments to prove that the method of object-oriented change detection methods based on GIS data has a certain use value in the application of change detection along high-speed railway and updating high speed railway database, and provide reference to further follow-up researches^[5]. Fang Canming extracts the hidden dangers along the high-speed railway based on the middle level semantic features, the middle and high-level semantic features and the deep level features respectively in the framework of interpretation of scenes^[1]. In addition, there are some methods which use remote sensing images to extract buildings. Wang Hong, et al. advanced one analytic method of image-per-units target to complete the extraction of building automatically^[6]. Zhou Shaoguang, et al. present a new approach to extract the outlines of buildings since the building profile obtained by segmentation or other methods has the disadvantages of inaccuracy or irregularity^[7]. Liu Wentao, et al. designed a Deep Convolution Neural Network (DCNN) for building roof extraction, the proposed network has a cascaded structure with fully convolutional layers, with strategies for features reuse and enhancement in the design of DCNN, it is expected to accurately extract building roof^[8]. Therefore, the paper studies the method of detecting man-made objects along the high-speed railway based on high resolution remote sensing images by using previous methods which are used for detecting objects along the high-speed railway based on remote sensing images.

2.3 Hidden dangers of man-made objects along the high-speed railway

The man-made objects along the high-speed railway may be harmful to safe operation of high-speed railway, such as simple houses, temporary shed, illegal sites, etc. The simple houses or

temporary shed along the high-speed railway may be constructed by some light and simple materials, such as color steel plate, plastic film or dust gauze. The houses or shed built by these materials are not strong enough. In windy weather, they are likely to be blown away and fall into high-speed railway's catenary, track or impact on vehicles, and affect the safety of the high-speed railway seriously. There may also be some illegal sites for storing or producing flammable and explosive dangerous goods along the high-speed railway. They will seriously affect the normal operation of high-speed railway if dangerous goods explode or cause fire. Therefore, it is very necessary to detect man-made objects along the high-speed railway.

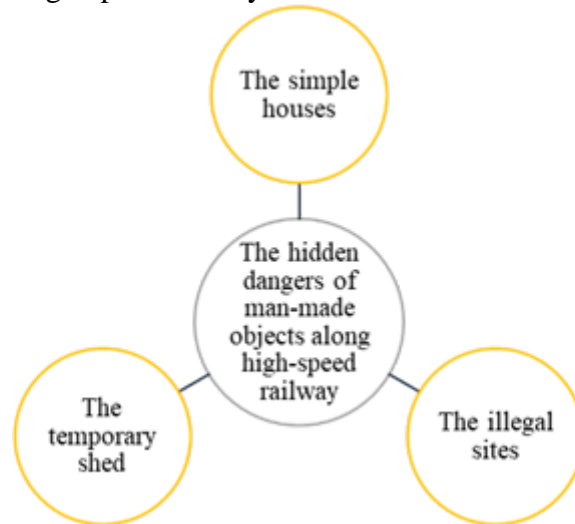


Fig. 2 The Hidden dangers of man-made objects along the high-speed railway.

3. The methods of remote sensing images classification

3.1 Pixel-oriented method

Pixel-oriented remote sensing images classification include two methods: supervised classification and unsupervised classification. The objects are classified according to their spectral information when classifying.

Table 1 The Difference between supervised classification and unsupervised classification

Pixel-oriented classification	Characteristics	Models	Advantages	Disadvantages
Supervised classification	Need prior knowledge	Minimum distance, Mahalanobis distance, maximum likelihood, neural network, support vector machine, etc.	The method can identify attributes of different categories because of having priori knowledge.	People must select training samples as prior knowledge, and the classification accuracy is influenced by training samples.
Unsupervised classification	No need prior knowledge	K-Means、ISODATA	No need manual selection of training samples, and its accuracy is not affected by human.	Classification can only distinguish different categories, but cannot determine the attributes of categories; the process of classification needs iteration, so the computation is large.

3.2 Object-oriented method

Object-oriented method of remote sensing images classification which is a classification method for high resolution remote sensing images regards objects as units. And it need set standard parameters according to the spectral information, shape, size, texture and contextual information of the classification objects. The classification of images is accomplished by segmenting remote sensing images. The common algorithm of image segmentation is multi-scale segmentation. It starts from a pixel object and carries out a bottom-up region merging technology, and small image objects can be merged into larger objects. In aggregation processing, the adjacent objects are merged if they conform to the set of heterogeneous minimum criteria. The merging process ends if the minimum expansion exceeds the threshold range defined by the scale parameter. The selection of segmentation parameters is very important if we want satisfactory results of segmentation ^[9].

3.3 Intelligent classification algorithms based on Remote Sensing Images

People have been seeking ways that computers can classify remote sensing images automatically. Therefore, they have studied many intelligent classification algorithms. These algorithms can not only reduce people's workload greatly, but also make use of deeper information of the images to improve the classification accuracy. Intelligent classification algorithms based on remote sensing image include: support vector machine classification, neural network classification, ant colony intelligent classification, image segmentation and classification, and hyperspectral classification and so on.

With the gradual emergence of artificial intelligence, artificial neural network technology has been widely applied in remote sensing image classification, and has had good results in detecting objects. Neural network classification can make certain rules or priori knowledge through making computer itself training in massive amounts of data, so as to no need people. Using the idea of simplicity to complexity, first understanding low-level information and then understanding high-level information in the process of autonomous learning. At present, the models of neural network include convolution neural network and BP neural network.

Table 2 Comparison of remote sensing image classification

The remote sensing image classification	Advantages	Disadvantages
Pixel-oriented method	The method is simple and suitable for classification of low-resolution remote sensing images.	The classification accuracy is limited by almost no information of geometric structure and texture of the classes. And it is not suitable for classification of high-resolution images.
Object-oriented method	The spectral, shape and texture features of objects and the context information of images are synthetically used to make obvious differences between categories so that improving classification accuracy when classifying.	The scale of image segmentation has great influence on the results of image classification.
Intelligent classification algorithms	The method is more intelligent, greatly reduces the workload of people, and can excavate many potential information of data, thus improving classification accuracy.	The theory of algorithms is complex and difficult to understand.

4. The Method System of Detecting Man-made Objects along the High-speed railway Based on Remote Sensing Images

4.1 Detection method system

This paper is studied for applying the classification algorithm of remote sensing image to detect man-made objects along the high-speed railway under the previous classification methods of remote sensing images. Using supervised classification algorithm to classify remote sensing images based on gray and texture features of image, and improving classification accuracy by superposing with GIS vector data. The figure 3 is the method system of detecting man-made objects along the high-speed railway based on remote sensing images.

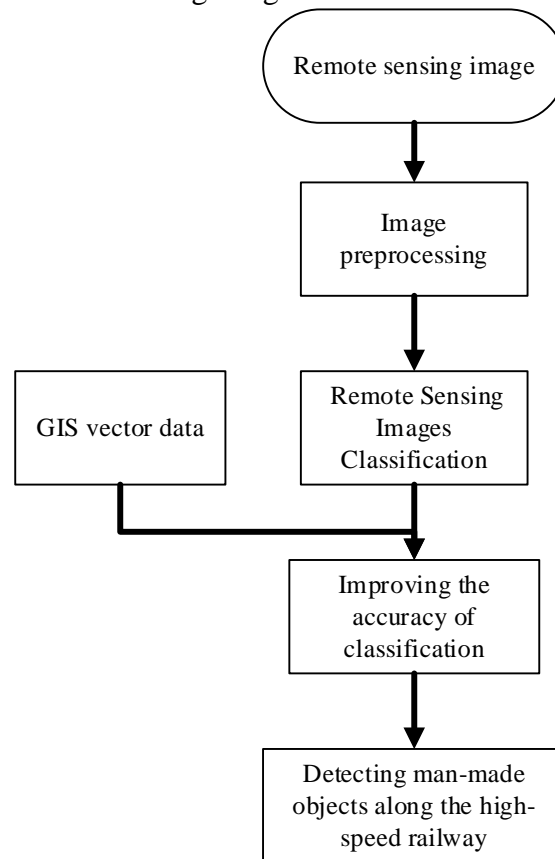


Fig. 3 The Method system of detecting man-made objects along the high-speed railway based on remote sensing images.

4.2 Experimental

The method proposed in this paper is used to detect man-made objects along the Xuzhou section of Beijing-Shanghai high-speed railway. It uses GF-3 satellite data with a resolution of 2 m. The man-made objects was extracted by processing the GF-3 remote sensing images of September 2016, January 2017 and April 2017. And then analyzing and comparing the results of three times. The result shows that there are hidden dangers of plastic houses, and the number of plastic houses increased from September 2016 to January 2017, and plastic houses increased again from January 2017 to April 2017, as shown in Figure 4. The existence and continuous increase of plastic houses may threaten the safety of the high-speed railway. So it is necessary to report to the relevant departments for investigation and control measures to avoid high-speed railway accidents.



Fig. 4 The results of detecting man-made objects along the Xuzhou section of Beijing-Shanghai high-speed railway.

5. Conclusion

The paper firstly analyzed and summarized the types of hidden dangers caused by man-made objects along the high-speed railway, and then analyzed the possible hazards to safe operation of high-speed railway. Then, introduced and summarized the remote sensing images classification. Finally, proposed the paper's method system of detecting man-made objects along the high-speed railway based on remote sensing images, and used the method to detect man-made objects along the Xuzhou section of Beijing-Shanghai high-speed railway and found that there are hidden dangers of plastic house along the high-speed railway in this area, and plastic houses have been increasing all the time. It proves that the method proposed in this paper can help railway departments to eliminate hidden dangers along the high-speed railway and improve the efficiency of researching work. So it has practical significance.

In the future work, the method proposed in this paper will be enhanced to improve the accuracy of image processing by removing or reducing the noise in remote sensing images. In addition, the intelligent classification algorithm of remote sensing will be studied to realize the automatic detection of man-made objects along the high-speed railway by computer, to avoid the influence of human factors on the detection results.

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