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Recognition and Extraction of High-Resolution Satellite Remote Sensing Image Buildings Based on Deep Learning

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Abstract: As the technology applications continue to emerge and create innovations, building identification and extraction by high-resolution satellite remote sensing image technology has been a challenge for scholars to overcome. And many scholars have achieved some success in this field. Space information is clear, shadows are disorderly and details are not obvious in satellite remote sensing image technology. The current remote sensing processing technology usually can not meet the requirements of high-resolution remote sensing image detail processing. This paper uses an object-oriented analysis technology based on deep learning to solve this problem. It can make full use of some characteristics of the image. Compared with the current remote sensing image processing technology, its most important feature is that it can process the smallest unit, which is composed of some similar attributes, rather than a single pixel. Finally, the identification and extraction of buildings are detected. In this paper, we compare the multi-scale segmentation algorithm and mean shift segmentation algorithm. These two methods can obtain more accurate object outlines derived at high resolution from the remote sensing satellite pictures. Results of experiments show this paper that the proposed method has better effect on the recognition as well as detection and extraction of buildings. The accuracy of recognizing as well as selecting buildings from the high definition remote sensing satellite pictures is 89.7%.

1. Introduction

With the rapid economic development, high-rise buildings have risen in the city. The spatial geographic information of the city must also be constantly updated. It is difficult to meet the needs of scholars if it still relies on traditional manual detection. Deep learning is widely used in positioning and detection. The technology of remotely sensed satellite images is a technique to detect buildings without touching them. It can quickly and accurately obtain information about buildings in the city. For rapidly changing cities, remote sensing technology can quickly obtain ground information by observing all the time. Because it can obtain the basic information of the city more clearly, and can update the city in real time, the development of high-resolution satellite remote sensing image technology is becoming more and more rapid, which also provides strong technical support for urban information automation technology.

Foreign countries use a high definition approach of remote control by satellite to study cities based on the interpretation of aerial photographs and the collection of basic geographic information about cities. Recognizing buildings from remote sensing images and extracting their effective information is not only a problem that the field of remote sensing focuses on. It is also a key direction for computers to move towards artificial intelligence. Some scholars have proposed a new method to automatically extract the 3D reconstruction of buildings. The extraction of buildings from a long photo is slowly replaced by the creation of clues such as three-dimensional data and digital models from multiple images with overlapping degrees. Tskhay Ko recommends combining line segments with gray and geometric information, and creating blocks according to compatibility conditions, and finally integrating the relationship between the blocks and the exported shadows to determine whether the block is a building [1]. Pavol Mar ák proposed a method of using fusion information to identify man-made features to accurately interpret buildings and other landscapes [2].

There are also some research results in China on satellite remote sensing imaging technology. The successful launch of China-Pakistan Resources No. 1 satellite marks that China's remote sensing applications have entered the stage of independent development and development. completely freeing us from the dependence on foreign technology, enabling us to receive data and information from our country and some neighboring countries at any time. At present, China is still vigorously developing and launching the latest high-resolution remote sensing satellites. Ji S created and published a multi-source dataset to be used in construction inspection, assessed improvements in precision achieved in a more recent study of this dataset, demonstrated the use of the proposed dataset, and proposed a connected full deconvolutional model of the network that yielded improved segments with improved precision.[3]. Li C proposed a strategy for automatic extraction of high-rise buildings from high-resolution aerial projection images [4]. Gudius P presented a fully deconvolutional network (FCN) architecture optimized with respect to precise as well as fast identification of objects within polyspectral laser images. The FCN proved to outperform humans, achieving a cutting edge of 97.67% accuracy for multiple sensors.[5].

This paper exercises the shadow calculation system through deep learning, and uses high-resolution satellite remote sensing image technology to obtain the image that needs to be processed initially. There are 3700 training samples and 40,000 test samples. The model is judged by calculating the standardized mean square error. The accuracy is evaluated. The classification accuracy of different spectral data sets for shadows is as high as 99%, and the accuracy of model judgment is relatively accurate. Through further classification, the accuracy of classifying the shaded part into the building has reached more than 80%. The unsatisfactory accuracy this time is due to the problem of the building construction materials. Some buildings have metal roofs, so the accuracy value is not Very high. Therefore, the model has certain feasibility.

2. Building Recognition Based on Deep Learning for Remote Sensing Images

2.1 Deep Learning

Deep learning studies the underlying patterns and levels of representation of huge data samples and combines the underlying simple features with more abstract and complex complex features to achieve a distributed representation of data features. Dominant neural networks are representative of deep artificial intelligence principles in neuroscience. As a powerful technical tool for deep learning, it is an important component of deep learning algorithms in the wave of artificial intelligence [6-7]. Deep learning is the process of learning features. The principle is to learn the inherent features and abstractions of the original data and to determine the features of the model by fine-tuning the test data.

Since the concept of deep learning was introduced, various models have emerged, including deep belief networks, convolutional neural networks, and recurrent neural networks.

(1) Deep belief neural network.

Deep belief networks are probabilistic generation models. Compared to traditional neural networks, their models differ in that they generate training data with maximum probability by observing the joint distribution of data and labels.DBNs can be used for feature selection and classification as well as data generation [8-9]. Figure 1 shows the structure of a more general DBN neural network.

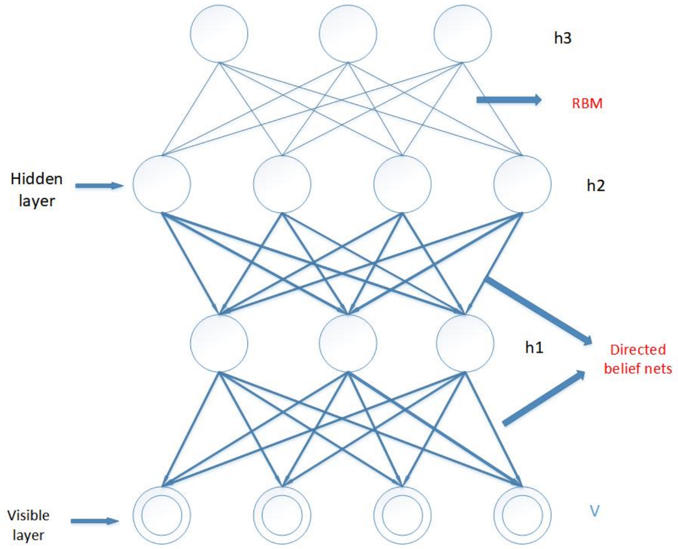


Figure 1: DBN structure diagram

The DBN neural network structure shown in Figure 1 has linkages among the interneurons of top and bottom levels, but no connection between them within a single layer.

(2) A convolutional Neural Web

A convolutional nerve neck is a feed-forward neural network that uses convolutional kernel operations instead of the more common matrix multiplication operations. It is characterized by having sparse interacting as well as argument shared. The weights are connected to achieve sparse interaction properties [10-11].

Due to the incremental nature of their web construct, extraction with regard to image characters progressively shifts of simple grain characters at the lower levels towards sophisticated structural signals at the higher levels, with the final combination being given as a characteristic diagram [12].

2.2 Image Identification

(1) Digital image processing techniques

Compared with the aforementioned displacement meters, GPS, electronic total stations, and laser interferometers, displacement measurement using digital image processing is a low-cost method for non-contact displacement tracking [13].

Methods of correlation of digital pictures: It is one of the important methods for monitoring deformation in the field of digital image processing. Its underlying concept consists of taking the structure spot pictures around the time of deformation and dividing the spot image in front of defined shape by dividing it into smaller sub-regions. If subregions are quite minor, every subregion could potentially be considered a rigid body moving. Then, the amount of division can be achieved for each subregion through a specific choice of related functional to calculate and find out the area with the highest correlation coefficient to that of subregions in the deformed image as the location for the new deformed subregion with Shift [14-15]. If the displacement of the whole domain needs to be calculated, the degree of relevance may be calculated for all subregions.

$$C_{ZNCC} = \sum_{i=-M}^{M} \sum_{j=-M}^{M} [\frac{\{f(x_i, y_i) - f_m\}\{g(x_i, y_i) - g_m\}}{\Delta f \Delta g}] \tag{1}$$

$$C_{ZNSSD} = \sum_{i=-M}^{M} \sum_{j=-M}^{M} [\frac{f(x_i, y_i) - f_m}{\Delta f} - \frac{g(x_i, y_i) - g_m}{\Delta g}]^2 \tag{2}$$

Among them,f() with g() representing the grayscale position value at every single location of the pixel respectively in pre and post deformation. f_m, g_m, Δf and Δg the concept and mathematical formula:

$$f_m = \frac{1}{(2M+1)^2} \sum_{i=-M}^{M} \sum_{j=-M}^{M} f(x_i, y_i) \tag{3}$$

$$g_m = \frac{1}{(2M+1)^2} \sum_{i=-M}^{M} \sum_{j=-M}^{M} g(x_i, y_i) \tag{4}$$

$$\Delta f = \sqrt{\sum_{i=-M}^{M} \sum_{j=-M}^{M} [f(x_i, y_i) - f_m]^2} \tag{5}$$

$$\Delta g = \sqrt{\sum_{i=-M}^{M} \sum_{j=-M}^{M} [g(x_i, y_i) - g_m]^2} \tag{6}$$

The digital picture linkage approach has the advantages of simple and simple algorithms, easy implementation and a wide horizon, non-contact deformation tracking method and high tracking accuracy. The drawback of the numerical picture related approach is that it is inherently computationally intensive and iterative.

Method of concrete object following: Target tracking, by its name, locates one particular object from every single frame of the picture and forms a target trajectory. To compensate for offset, a calibration plate is placed over the measured object. By sampling a calibration plate's displacement using that digital still image camera, this point's distance is displayed. Tracking a shift in this way is target tracking [16-17].

Such a goal tracking technique would be more appropriate than the digital imaging technique for tracking structural motion. The currently weaknesses of such techniques are reflected in the unreasonable monitoring of target values [18], but they are not only demanding on surveillance settings, they are also very influential towards the context.

(2) Simulation Handling

Simulated picture handling involves lens processing for optics, camera work and TV production, all in parallel and in time. The speed of processing is high and can run at parallel. Analog image handling can reach the speed of light in theory. The shortcomings of this are low resolution, flexible control, few crime functions, as well as linear handling[19].

2.3 satellite remote sensing technology for high resolution images

As shown in Figure 2, remote sensing satellite images can monitor agriculture, forestry, ocean, etc. Some remote sensing satellite images of high resolution can already be used to measure new topographic maps and to modify them. and it is of great significance and good application prospects to perform change detection to achieve rapid and automatic update of the map database[20]. According to the existing technical conditions, the high-resolution remote sensing satellite image change detection update map database can be divided into four steps, namely preprocessing, classification, feature extraction and change detection.

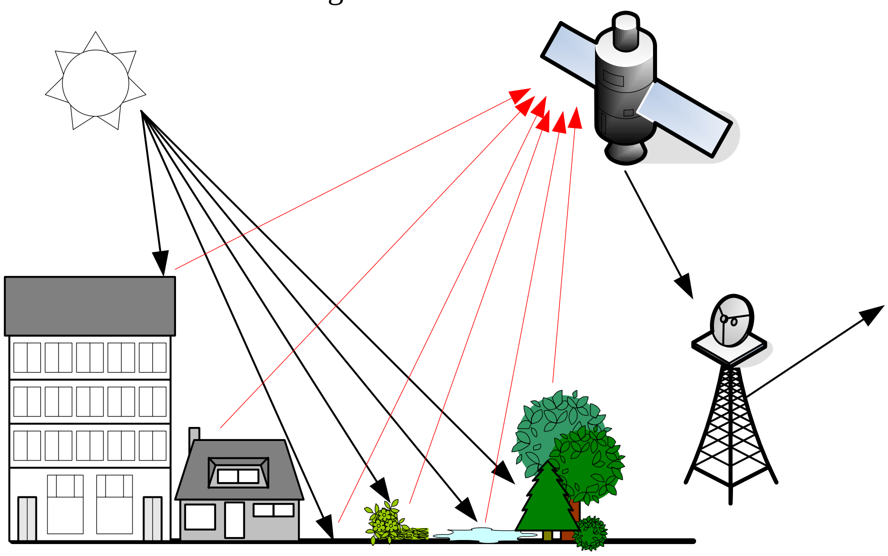


Figure 2: Schematic diagram of the application scope of satellite remote sensing technology

(1) Pretreatment technology

Radiation treatment: Remote sensing images are affected by the sun's altitude angle, atmospheric refraction, scattering and other factors during the imaging process, causing the image to have problems such as insufficient brightness, blur, and noise. These problems will definitely have a negative impact on the subsequent change detection work. Image processing algorithms such as histogram adjustment, Gaussian filtering, Fourier transform, etc. Radiation correction can be applied to the image to enhance its picture qualities.

Registration: This is the most important task in preprocessing, and its purpose is to ensure that the image and map are in a unified coordinate system. The registration here can be divided into two aspects, one is to register the image to the map, the other is to register the map to the image. This method has rigorous theory and high accuracy, but the calculation is complicated [21]. In addition, it is also possible to generate approximate orthophotos through methods such as polynomial models, rational function models, direct linear transformation models, etc. These models do not have a strict theoretical basis. The accuracy is limited, but the calculation is simple, and high accuracy can be achieved for some special situations.

Data fusion: Using data fusion technology can effectively synthesize multiple images to generate new images with more information, thereby improving the accuracy of change detection.

(2) Classification

Classification is to divide each pixel data into each feature subspace. The specific process is: determine the classification category, select the feature, determine the training data, measure the total statistics, and classify and verify the result [22-23].It can be classified into supervised and unsupervised classification depending on what training data is present.

(3) Feature extraction

Edge detection: The edge line is the basic element of the image shape and one of the important manifestations of the image nature. Other features of the image are also derived from the basic features of edges and regions, Therefore, detection of edges has been the primary method of extracting characters in pattern analysis as well as in image analysis[24]. In the process of edge detection, the prior knowledge brought by the old map should be added. This part of the prior knowledge mainly refers to the geometric features of the old map.

Regional segmentation: Image segmentation is a technique and process that divides an image into meaningful areas according to certain characteristics and extracts objects of interest. Within these regions, their characteristics are often the same or similar, while the characteristics of adjacent regions are different from each other, and there are boundaries between these regions. Remote sensing images are complex images with a large number of regions and rich gray levels, and more complex methods must be used for region segmentation.

Target recognition: Due to the complexity of image understanding and the limitations of technical level, there are still many difficulties in automatic target recognition on high-resolution remote sensing images. In the target recognition process, the prior knowledge brought by the old map can be considered. This part of the prior knowledge mainly refers to the relationship between the object attributes and geometric characteristics of the old map.

(4) Change detection

Generation of change result graph: Combining the classification results, the difference between the feature detection results and the old map data can be calculated. Based on the calculation results, the following three types of results can be detected according to a certain threshold: the part that has not changed, this part can be used as the background of the change result map or Directly discard; the changed part, this part can be used as the prospect of the change result map, and its attributes are determined based on the prior information analysis; the uncertain part, this part needs to be manually interpreted or other methods to determine whether it has changed[25 -26], if it changes, its attributes need to be further determined.

Post-processing: Post-processing is to further analyze the results of the third category, until all changes are divided into the first two results.

2.4 Fitting Method of Target Detection

The fitting of the shape of the features is to fit the edges of the extracted different features into a straight line segment or a closed vector polygon according to their own attributes. For the fitting of the shape of the features, take the buildings on both sides of the road as an example, use the recognized buildings as the mask, and use the object-oriented multi-scale segmentation algorithm to extract the accurate edges and shapes of the buildings: because the above edge output result is It is uneven, and then the Mean Shift segmentation algorithm is used to transform and derive the green space with rectangular characteristics [27-28]. Finally, vectorize all the extracted artificial features to form straight line segments or polygons in vector format.

(1) Multi-scale segmentation algorithm

A multiscale image partition was a technique of bottom-up region merging, starting from a single pixel target. The key to the multi-scale segmentation technique is to set similar criteria for pixel merging and determine the conditions for stopping pixel merging. Therefore, the rationality of the criteria setting directly affects the effectiveness of the image objects after segmentation [29]. The condition for stopping segmentation is determined by the segmentation scale and depends on the category attributes of interest for image analysis. Since adjacent similar pixels are synthesized into a polygonal object in the segmentation process, the growing heterogeneity in the object needs to be minimized, so as to ensure that the average heterogeneity of all image objects in the entire image at a given scale is the smallest.

(2) Mean Shift segmentation algorithm

The basic calculation module of the Mean Shift algorithm uses the traditional pattern recognition program, which achieves the purpose of segmentation by analyzing the feature space and clustering method of the image, that is, the elements in the image space are represented by the corresponding feature space. The result of segmentation is obtained by clustering the points in the feature space into clusters, and then mapping them back to the image space [30]. In classification with features, the pixel is regarded as the target point of classification, and classification is segmentation. If you already know the probability distribution density of various properties, the probabilities of each type can be classified according to the criteria for minimizing the expected classification error. This is the parameterization method we usually say.

3. Experimental Study on Building Identification as well as Building Extraction in Satellite Remote Sensing Images

3.1 Confidence-Based Image Enhancement Method

By combining image segmentation algorithms with edge detection algorithms, the visual handling of low-level pictures can be used to enhance segmented image quality. Edge confidence maps are combined with a mean shift based method for colored picture segmentation. This method allows restoring areas of signal weakness but strong edges providing exact data as input for higher-order explanation.

The ρη map is used in reliability fringe inspection and the weights which are distributed among every single pixel (i, j) could then be specified in the following way.

$$w_{ij} = a_{ij} * \rho_{ij} + (1 - a_{ij}) * \eta_{ij} \tag{7}$$

This parameter is called the mixing parameter because aij is an arbitrary value in [0,1] that controls the mixing information of ρ and η. The closer a pixel is to the edge, the smaller the weight is, further improving the effect of mean shift filtering.The filter image enhancement effect is shown in Figure 3;

Figure 3: Image enhancement effect

3.2 Experimental Process

This fundamental knowledge includes a building's geographical position, a building's height and a building's area. In higher resolute remotely felt pictures, shadows feature distinct spectral characteristics with low and constant grayscale values.

First, we perform image enhancement processing, that is, non-linearly stretch the image image of the image to make the gray value of the shadow area more consistent, and then increase the gray value of other objects that are not shadow, so that the shadow area can be further improved Contrast effect with non-shaded area.

Then we select shadow samples for training, that is, when the target of the training sample is to collect the measurement numbers of the spectral response mode, in order to obtain satisfactory classification results, the focus of the training sample is to make it representative and to ensure the integrity of the shadow sample, You can get all the components of this information type spectrum category.

In the third step, we need to classify the image. In the classification process, the focus is on the selection of the range of numerical variation. If it is too large, the data of a large area that is not a shadow area will be read; if it is too small, it will cause shadows. Reading of zone data will be insufficient. Therefore, the change range of the value should be moderate, and it should be selected according to the data of the shaded area of the picture.

In the fourth step, we perform post-processing of image classification, that is, remove scattered speckle shadows, which have too low pixels compared to shadows.

In the fifth step, we perform vectorization operations on the processed image. The vectorized image is called a vector diagram, which is defined as a wired connection point in the science of mathematics. The vectorized shadow file can be read, and then calculated to the required data.

Finally, calculate the shadow length, combine the building orientation, the sun direction angle and the altitude angle to calculate the shadow length, and use the vector diagram of the shadow itself to divide the straight line in the direction of sunlight projection to read the shadow length.

4. Construction Recognition and Extraction Analysis in Distant Sensor Images

4.1The Analysis of Sample Size

For the sample of satellite remote sensing images used in this experiment, This study takes high-resolution remote sensing satellite images of Yancheng City, Jiangsu Province as the research object. As shown in Figure 4. Not only buildings, but also roads, grass, and shadows.

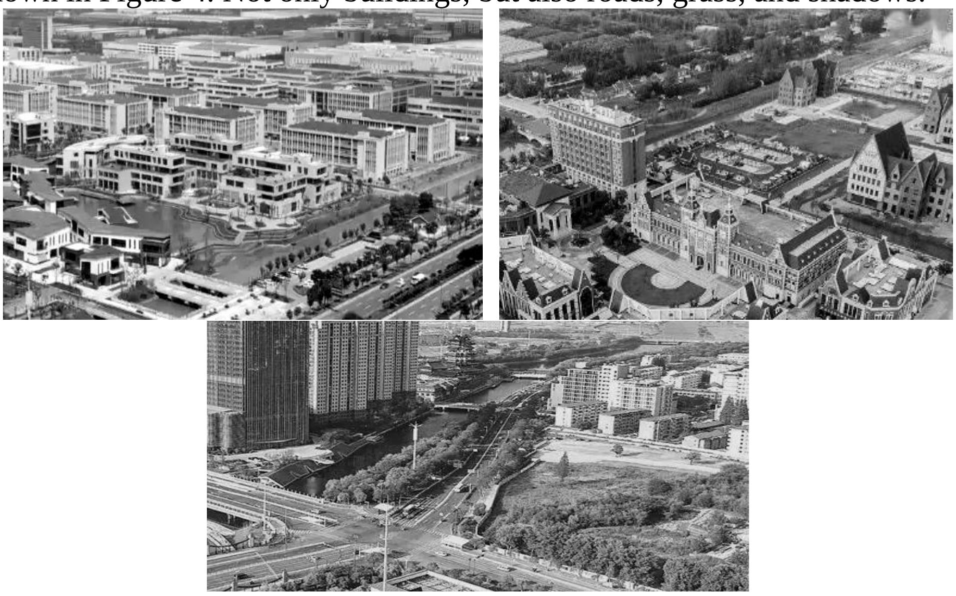


Figure 4: Satellite Remote Sensing Image of Yancheng City

We will train some systems and calculate normalized mean square error to evaluate the accuracy of models' judgment. The quantitative relationships between the training and testing examples in

Table 1 are shown.

Table 1: The number of training samples and test samples of X university images

category	Training samples	Test samples
the way	897	11235
Grassland vegetation	758	18003
building	1408	9415
shadow	637	1347
Total number of samples	3700	40000

From Table 1, we can get the number of various ground features in the image samples with a spatial resolution of 2 meters, including 3700 training samples and 40,000 test samples.

4.2 Analysis of Classification Accuracy of Land Cover by Different Segmentation Algorithms

(1) Analysis of the accuracy of ground object classification by different segmentation algorithms

Classify the ground features through different spectral data to obtain an accurate accuracy map. The spectral data includes 120-dimensional hyperspectral data, This is transformed by an Object-Oriented Polyscale Partitioning System. and the spectral data with a band number of 3 is transformed by the Mean Shift segmentation algorithm. The converted spectrum data with the number of bands is 3, as shown in Figure 5.

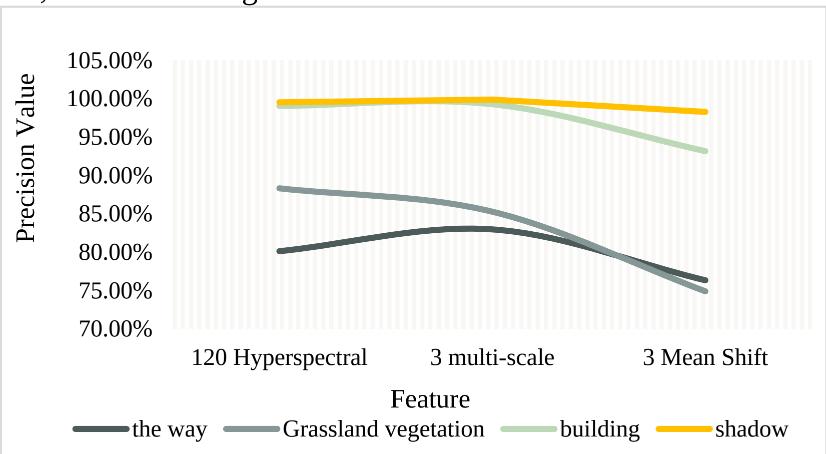


Figure 5: Comparison of land cover classification accuracy of different segmentation algorithms

As we can see in Fig. 5, the accuracy of classifying the spectral data with a band number of 3 using the object-oriented multiscale segmentation algorithm is very close to that of the 120-dimensional hyperspectral data. which is much higher than that of the band transformed by the Mean Shift segmentation algorithm. The classification accuracy of the spectral data with a number of 3, which shows that it is reasonable and feasible to use the former as the spectral feature of the test area.

(2) Reflectance analysis of various ground objects under different spectral data

The spectral curves of various features in the hyperspectral data of the X University image. Each spectral curve represents a specific type of feature. The spectral value of each type of feature is the average of the spectral reflectance of all reference samples of the feature, as shown in Figure 6.

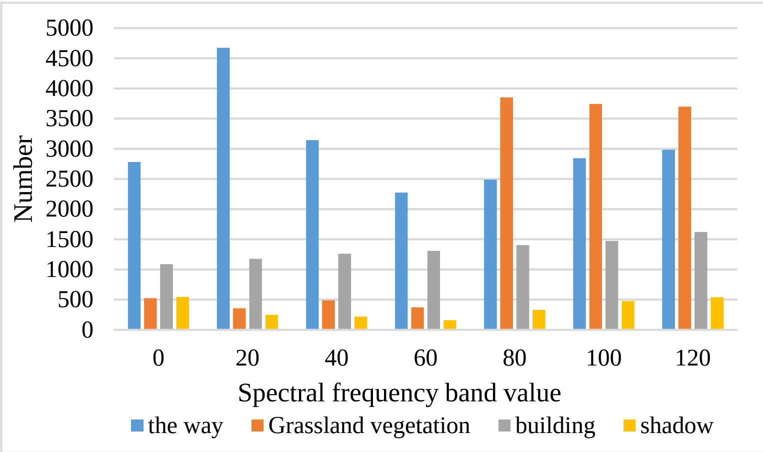
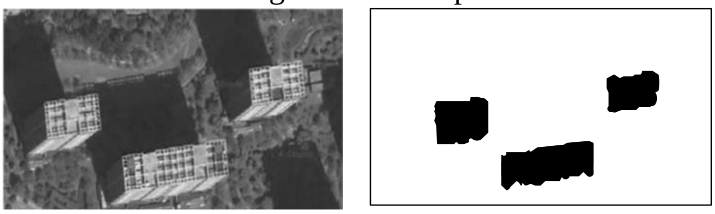


Figure 6: Reflectance diagram of various ground objects under different spectral data

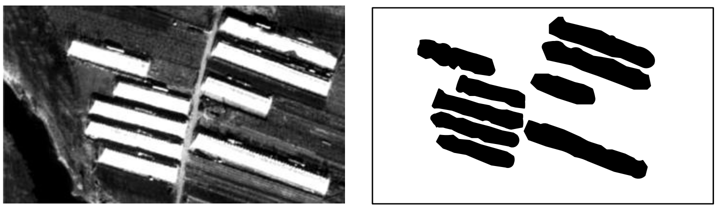
It can be seen from Figure 6 that the road has a high spectral reflectance in the entire waveband, while the shadow has a very low reflectance value in the entire waveband, so the two types of features are easier to distinguish. Green plants have unstable data throughout the band, so you can choose a high frequency band and a low frequency band to distinguish them by comparing them. And the building is in the process of gradually increasing slowly throughout the continuous data, and it is easy to distinguish by taking an image map in each frequency band for comparison.

4.3 Analysis of Extraction Results

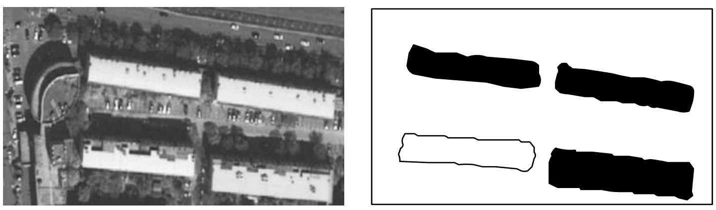
In order to fully illustrate the universality of the algorithm proposed in this paper, the remote sensing images of different scenes, different contrasts and different sizes are now used for building identification and extraction as shown in Figure 7. The experimental results are as follows:



（a）



（b）



（c）

Figure 7: Building extraction results for different scenes

It can be seen from the several sets of experimental results shown in Figure 9 that although the original image contains a variety of different scenes, and the color and spectrum of the buildings are quite different, the algorithm proposed in this paper has generally achieved good results., and recognize that the extracted building outline is close to the actual outline.

Table 2: Evaluation results under different extraction methods

parameter	The method of this paper	SVM
oA (%)	93.9	75.4
Kappa coefficient (%)	90.2	70.4
Time required for extraction (S)	48	36

The data results in Table 2 show that the algorithm in this paper has the highest accuracy, and the extraction accuracy of buildings is 93.7%. Compared with the SVM algorithm, the total accuracy is about 18% higher, and the Kappa coefficient of the method in this paper is above 90%. It shows that the model in this paper has better results in the extraction of building features in high-resolution images.

4.4 Precision Analysis

(1) Comparative analysis of missed points rate, mispointed rate and accuracy rate.

This article uses commonly used evaluation criteria for building extraction, including three aspects: the correct rate of extraction, the rate of misclassification and the rate of omission. According to the calculation method of accuracy, the correct rate of extraction obtained by the two algorithms of invariant moments, the rate of error and the rate of missed points can be calculated,as shown in Figure 8.

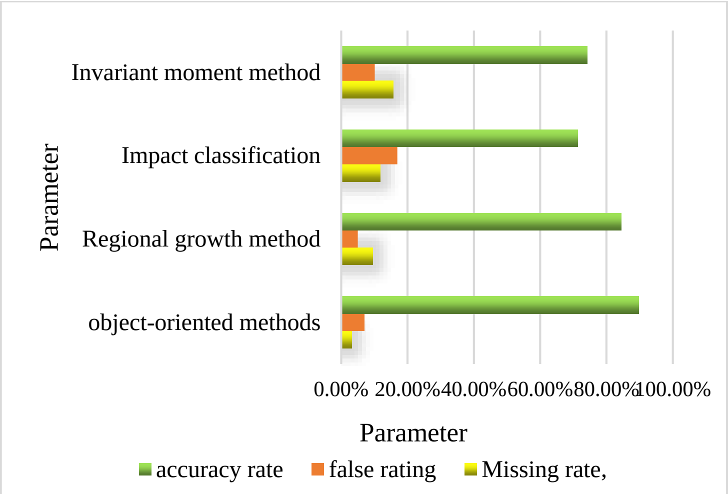


Figure 8: Comparison chart of omission rate, misclassification rate and accuracy rate

According to Figure 8, it can be clearly seen that the accuracy of using the affine moment invariant algorithm to extract high-resolution remote sensing image buildings is higher than that obtained by other methods. This proves that the method of using invariant moments to extract building features is feasible and effective.

(2) Accuracy analysis of extraction

The pros and cons of the extraction algorithm are mainly derived from the accuracy of the extraction and the percentage of the extracted area. The object-oriented multi-scale segmentation algorithm uses affine invariant moments and does not use the Mean Shift segmentation algorithm. Data comparison between torque change and no use, as shown in Figure 9.

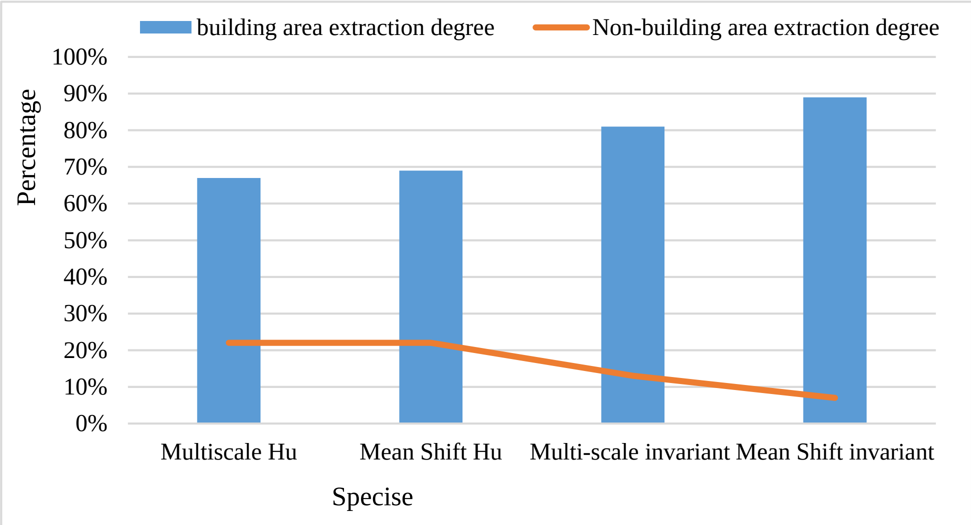


Figure 9: Extracted accuracy map

From Figure 9, we can see from the above figure that whether it is a multi-scale segmentation algorithm image or a Mean Shift segmentation algorithm image data, the percentage and accuracy of buildings in the extracted results using affine invariant moments are significantly higher than using Hu's The results obtained by the invariant moments are much improved, and the area of mis-extraction of non-buildings is also much reduced.

5. Conclusions

This research takes the high-resolution remote sensing satellite image of Yancheng City, Jiangsu Province as the research object. Based on the in-depth study of the object-oriented multi-scale segmentation method and the confidence-based Wean Shift segmentation method, the extraction of artificial land from the high-resolution remote sensing image is carried out. The study of physical characteristics. The traditional segmentation method uses pixels as the processing unit and mainly uses the spectral characteristics of the pixels to segment the image. High-resolution remote sensing images can not only reflect more distinguishable targets, but also reflect the rich geometric, color, texture, and semantic features of the target. Therefore, the results obtained by traditional segmentation methods for remote sensor imaging of high resolution with rich details are always unsatisfactory. In view of the characteristics of high resolution telemetry images, only fragmentation methods with various features based on the target can achieve better results.

The final conclusion proves that the affine moment invariant algorithm has a good extraction effect on buildings. Therefore, this paper proposes that it is feasible to use the moment invariant algorithm to extract features from high-resolution remote sensing images. Compared with mainstream methods such as regional growth and shadow assistance, it shows that the extraction accuracy of this method is significantly improved, and it also proves that this method has certain application research value for remote sensing image feature extraction.

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