Water System Segmentation Method of High Resolution Remote Sensing Image Based on eCognition

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Abstract: High-resolution remote sensing images contain abundant ground object information. In this paper, water system elements are segmented and interpreted based on eCognition platform. Three segmentation methods, multi-scale image segmentation, quadtree segmentation and checkerboard segmentation, and their segmentation principles are introduced. The advantages and disadvantages of different segmentation methods are obtained through experimental analysis, and the optimal segmentation parameters of multi-scale segmentation are obtained by setting different segmentation parameter experiments. This paper is of guiding significance for the interpretation of water system data and the dynamic update of geographical survey elements in later remote sensing images.

1. Introduction
With the rapid development of modern surveying and mapping technology, remote sensing images have become one of the popular big data. With the increasing of resolution, the traditional classification methods of remote sensing images can no longer meet the regional classification of images, which puts forward higher requirements for image processing software and hardware. Therefore, the classification of high-resolution remote sensing images and the interpretation and extraction of rich and detailed ground object information have become one of the research hotspots. Traditional remote sensing image interpretation is mainly based on manual interpretation, which is greatly influenced by the translator’s subjective factors, and is time-consuming and inefficient. In order to meet the development requirements of big data at this stage, computer vision and artificial intelligence are applied to improve the image segmentation and classification methods and the interpretation accuracy of ground objects.

Water system is the basic geographic information element, and the common collection method is manual visual interpretation, which is mainly based on the different physical and geometric characteristics of ground objects in remote sensing images, and comprehensively divides the characteristics of different ground objects and their relationships. Commonly used remote sensing image interpretation methods also include information extraction based on classification and remote sensing information extraction based on knowledge discovery. This paper mainly adopts automatic extraction of water system information based on classification method.

2. Principle of eCognition Segmentation
eCognition is a professional remote sensing image classification software[1] that uses object-oriented
information extraction technology to classify and analyze images. The decision-making expert system is adopted to carry out the comprehensive intelligent analysis of images by imitating human thinking, and the object segmentation\textsuperscript{2} of image data is carried out according to different defined segmentation scales, shapes, colors and other characteristics through man-machine interaction. A large number of classification interpretation rules and member functions are integrated, which breaks through the limitations of traditional classification methods of remote sensing images and improves the efficiency and quality of recognition and interpretation of high-resolution image data\textsuperscript{3}. Therefore, this paper mainly studies the classification, recognition, interpretation and extraction of water system information in high-resolution remote sensing images based on eCognition software platform and object-oriented classification method.

The classification of image data based on object-oriented thinking is mainly the selection of image segmentation methods. Image segmentation mainly refers to the division of non-overlapping regions in an image according to a specific segmentation method\textsuperscript{4}. The division is based on comparing each pixel with a set threshold, and there are some same or similar features between the divided regions.

In eCognition software, the commonly used segmentation algorithms are multi-scale segmentation, quadtree segmentation and chessboard segmentation.

2.1. Multi-scale Segmentation
Multi-scale segmentation is one of the most commonly used segmentation algorithms in eCognition software. It uses the spectral features and shape features of remote sensing images to realize image segmentation based on region merging technology, which mainly aims at merging adjacent pixels or small segmentation objects\textsuperscript{5}. The segmentation principle is as follows: (1) Calculate the comprehensive eigenvalue of spectral heterogeneity and shape heterogeneity of each band in the image; (2) According to the weight of each band, calculate the weighted value of all bands of the image; (3) Compare the spectral and shape weighted values of the segmented pixels with the specific threshold value. When it is less than the threshold value, calculation is repeated; and when it is greater than the threshold value, multi-scale segmentation is completed. It can be seen that the factors of image accuracy mainly include spectral features and shape features, and the process of repeated calculation is the process of setting optimal parameters for spectral features and shape features. The obtained result is that its homogeneity is the highest, and the obtained segmentation result is satisfactory.

2.2. Quadtree Segmentation
Quadtree segmentation method is a new tree segmentation method, which is a process of dividing an image or a parent object into many small square objects in the form of quadtree\textsuperscript{6}. The segmentation principle is as follows: (1) The image is segmented in X and Y directions according to a specific similarity criterion to form four sub-blocks; (2) Judge the similarity between the sub-blocks and the threshold set initially; (3) When the similarity is higher than the threshold, continue to divide the sub-blocks, and judge the division repeatedly until the similarity of the divided sub-blocks is lower than the given threshold.

2.3. Chessboard Segmentation
Chessboard segmentation is a simple segmentation method, which divides an image or a parent object into many small square objects. It mainly adopts the principle of matrix partitioning, and divides a large image matrix into many sub-matrices with the same size according to the size of pixels\textsuperscript{7}. The accuracy of chessboard segmentation results is only affected by the set segmentation scale parameters.

3. Classification Experiments

3.1. Segmentation Method
Taking a river in a certain area of Xi’an as the experimental area, landsat remote sensing image data with spatial resolution of 2 meters are used. First, image preprocessing, including image
orthorectification and image fusion, is carried out. Then, the experiments are carried out, of which the experimental area is set with the same size of segmentation scale of 90, and image data segmentation experiments are carried out by using multi-scale segmentation, quadtree segmentation and chessboard segmentation methods respectively (Figure 1).

Figure 1 Results of Quadtree Segmentation, Chessboard Segmentation and Multi-scale Segmentation

According to the segmentation results, accuracy, omission error and redundancy error\(^{[8,9]}\) are introduced to evaluate the segmentation accuracy. The correct object is obtained by manual interpretation.

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\text{Accuracy} = \frac{\text{Correct Objects Segmented by Segmentation Algorithm}}{\text{Correct Objects}}
\]

\[
\text{Omission Error} = \frac{\text{Correct Objects without being Segmented by The Segmentation Algorithm}}{\text{Correct Objects}}
\]

\[
\text{Redundancy error} = \frac{\text{Objects Incorrectly Segmented by The Segmentation}}{\text{Correct Objects}}
\]

Multi-scale segmentation, quadtree segmentation and chessboard segmentation are adopted, and the unified parameters with a segmentation scale of 90 are set. The obtained water system segmentation results of remote sensing images are imported into Arcgis software according to vector format. The water system areas and manually collected water system areas obtained by different segmentation methods are calculated by spatial analysis function, and then the correct segmentation area, non-segmentation area and wrong segmentation area are calculated by spatial statistics function, and the accuracy, omission error and redundancy error of segmentation accuracy evaluation are calculated. The segmentation results and accuracy of each segmentation algorithm are shown in Table 1.

| Segmentation Method       | correct segmentation area \( \text{(m}^2) \) | wrong segmentation area \( \text{(m}^2) \) | non-segmentation area \( \text{(m}^2) \) | correct area \( \text{(m}^2) \) | Accuracy \( \% \) | Omission error \( \% \) | Redundancy error \( \% \) |
|---------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|-----------------|-----------------|-----------------|
| Multi-scale Segmentation  | 5074.8635                                   | 315.3705                                   | 75.3935                                     | 5390.234                                   | 94.15\%         | 5.85\%          | 1.40\%          |
| Chessboard Segmentation   | 4800.2855                                   | 589.9395                                   | 126.2265                                    | 5390.234                                   | 89.06\%         | 10.94\%         | 2.34\%          |
| Quadtree Segmentation     | 4764.0065                                   | 626.2275                                   | 150.332                                     | 5390.234                                   | 88.38\%         | 11.62\%         | 2.79\%          |

For the experimental area, the relationship diagram of the quality evaluation indexes of the above three segmentation methods is shown in Figure 2 below.

Figure 2 Accuracy Comparison of Three Segmentation Algorithms
It can be seen from Table 1 and Figure 2: (1) Accuracy: multi-scale segmentation > checkerboard segmentation > quadtree segmentation; (2) Redundancy error: multi-scale segmentation < chessboard segmentation < quadtree segmentation; (3) Omission error: multi-scale segmentation < chessboard segmentation < quadtree segmentation. Comparative analysis shows that the multi-scale segmentation method is obviously superior to chessboard segmentation and quadtree segmentation, that is, with the help of eCognition platform, the segmentation of water system information in high-resolution remote sensing images using multi-scale segmentation has higher accuracy and more accurate data.

3.2. Segmentation Scale
The quality of remote sensing image segmentation and the accuracy of later classification depend on the segmentation algorithm to a great extent. For the same segmentation algorithm, the data results obtained by choosing different segmentation scales are also different. In the process of image segmentation, the selection of segmentation scale plays an important role in the accuracy and reliability of ground object information extraction and recognition. The larger the segmentation scale is, the coarser the details of ground objects segmentation will be, and the fewer polygons obtained from the whole image segmentation will be, which is suitable for the segmentation of large-area continuous ground objects of the same class; on the contrary, the smaller the segmentation scale is, the more prominent the details of the polygon will be, and the smaller the area of each polygon will be, which is generally suitable for areas with complicated land types. In order to improve the recognition accuracy of ground object information, the quantitative selection of different segmentation scales has become the research focus of object-oriented remote sensing image information extraction. According to the analysis requirements of different types of ground objects, it is necessary to adjust the segmentation scales to obtain the best segmentation effect.

In practical application, it is necessary to select the appropriate segmentation scale according to the features of ground objects. First, different segmentation scales are selected to carry out multi-scale segmentation experiments on a certain ground object in the same area, and then the results are compared and analyzed, and the best segmentation scale is summarized. In this paper, multi-scale segmentation of experimental area is selected, and the parameters of segmentation scale are set to be 50, 90 and 120 respectively, and the results of different segmentation scales are obtained (Figure 3).

![Figure 3 Results of Different Segmentation Scales at 50, 90 and 120](image)

According to the segmentation results of the experimental area obtained by setting different segmentation scales, the accuracy, omission error and redundancy error of the water system under different segmentation scales are calculated. The results are shown in Table 2:

**Table 2 Segmentation Results and Accuracy of Each Segmentation Algorithm**

| Segmentation Method | correct segmentation area (m²) | wrong segmentation area (m²) | non-segmentation area (m²) | correct area (m²) | Accuracy (%) | Omission error (%) | Redundancy error (%) |
|---------------------|-------------------------------|----------------------------|---------------------------|------------------|---------------|-------------------|---------------------|
| 50                  | 5367.595                      | 42.583                     | 22.639                    | 5390.234         | 99.58%        | 0.79%             | 0.42%               |
| 90                  | 5380.532                      | 30.185                     | 29.107                    | 5390.234         | 99.82%        | 0.56%             | 0.54%               |
| 120                 | 5372.446                      | 5.498                      | 19.405                    | 5390.234         | 99.67%        | 0.10%             | 0.36%               |
It can be seen from the above table that the accuracy of segmentation results obtained by different segmentation scales is greater than 99%. The correlation between redundancy error and omission error is shown in Figure 4:

![Figure 4 Segmentation Results and Accuracy of Different Segmentation Scales](image)

It can be concluded from figure 4 that when the segmentation scale parameter is set to 90, the omission error and redundancy error intersect at one point, thus reaching the error balance. Therefore, the compromise segmentation scale obtained between omission error and redundant error is the optimal water system segmentation scale of experimental area, that is, the optimal segmentation scale of the multi-scale partition of the experimental area water system is 90.

4. Conclusion

Based on eCognition platform, this paper selects different methods for water system segmentation in high-resolution remote sensing images. Through experimental comparison and verification, this paper introduces accuracy, omission error and redundancy error, and obtains the segmentation accuracy of three image segmentation methods: multi-scale segmentation > chessboard segmentation > quadtree segmentation. For multi-scale segmentation, quantitative experiments show that when the segmentation scale parameter is set to 90, the segmentation effect is the best. This paper aims to realize accurate extraction and rapid update of large-scale water system information.

References

[1] Zhou Lei, Zhao Ke, Sun Hong, Zhang Limin. Application of eCognition software in ecological remote sensing monitoring of Benxi typical area [J]. Environmental Protection and Circular Economy, 2011, 31(05): 65-66.

[2] Shi Yiqiang, Zhu Xiaoling, Lin Fang. Road extraction of high spatial resolution remote sensing image based on multi-factor objects[J]. Journal of Jimei University (Natural Science Edition), 2010, 15(04):312-316.

[3] Jiang Haochen, Ren Hongquan, Qin Xianfeng, Wang Yonglong. Automatic interpretation and accuracy evaluation of eCognition images[J]. Bulletin of Surveying and Mapping, 2015(10): 81-84+106.

[4] Wang Tiejun, Ren Sisi, Xu Ming. Research on eCognition-based mixed object classification method[J]. Bulletin of Surveying and Mapping, 2014(03): 137-138.

[5] Chen Rui, Zhang Jichao. Research on object-oriented classification method of remote sensing images based on eCognition [J]. Surveying and Spatial Geographic Information, 2020, 43(02): 91-95.

[6] Wang Tiejun, Ren Sisi, Xu Ming. Research on eCognition-based mixed object classification method[J]. Bulletin of Surveying and Mapping, 2014(03): 137-138.

[7] Liu Jinli, Chen Zhao, Gao Jiping, Gao Xianlian, Sun Zhongqiu. The method of determining the optimal segmentation scale for high-resolution image tree species classification[J]. Forestry Science, 2019, 55(11): 95-104.

[8] Li Binbing, Huang Lei. Research on Remote Sensing Extraction Method of Cutting Gully in Loess Hilly and Gully Region Based on Object-oriented Technology [J]. Soil and Water Conservation Research, 2013, 20(03): 115-119+124.
[9] Zu Qi, Yuan Xiping, Mo Yuanfu, Yuan Lei. Feature information extraction in SPOT images based on object-oriented classification method [J]. China Karst, 2011, 30(02): 227-232.