

THE COMPARATIVE STUDY OF THREE METHODS OF REMOTE SENSING IMAGE CHANGE DETECTION

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ABSTRACT:

This paper discusses three main methods of change detection: 1) Image subtraction method; 2) Image ratio method; 3) The method of change detection after classification. Firstly, the elimination method of influence factors of change detection is discussed. Then the basic principle of the three main methods is introduced and the experiments of the methods are carried on ERDAS software. At last, the analysis comparison is carried on and the relative merits and the applicable scope of the three methods are pointed out. Image subtraction method is a simple concept easy to understand and easy to use, a background value usually be repressed and a subtraction value often be enhanced in the result image. It is beneficial to information extraction, which value of the target and background is smaller, such as the beach zone, the ditch of estuaries. The main disadvantage is that it can not reflect which category is changed. Image ratio method is applicable to be used in change detection of city. Its disadvantage is also that it can not reflect which category is changed. The information of change property is provided in this method. The disadvantage is that the accuracy depends on the classification accuracy; it can not be used for the detail change detection of city.

1. INTRODUCTION

Change detection is an important application of remote sensing technology. It is a technology ascertaining the changes of specific features within a certain time interval. It provides the spatial distribution of features and qualitative and quantitative information of features changes. The quantitative analysis and identifying the characteristics and processes of surface changes is carry through from the different periods of remote sensing data. It involves the type, distribution and quantity of changes, that is the ground surface types, boundary changes and trends before and after the changes.

In the 1980s, some people started to study change detection. In the change detection, multi-band remote sensing image is usually used due to it provides enough information. The change detection methods of multi-band remote sensing image can be divided into image subtraction method and the method of change detection after classification. Principal component analysis method, image subtraction method, changing vector analysis method and spectral features variance method are usually used in the former change detection method. Classifying firstly and then comparing the classified information is the latter change detection method. There is change detection based on elevation change information of digital surface model apart from the change detection of the multi-band remote sensing images.

2. THE MAIN CHANGE DETECTION METHODS

There are many types of change detection methods of multi-spectral image data. They can be classified as three categories: characteristic analysis of spectral type, vector analysis of spectral changes and time series analysis. The aim of characteristic analysis of spectral type method is to make sure

the distribution and characteristic of changes based on spectral classification and calculation of different phases remote sensing images. The methods are multi-temporal images stacking, algebraic change detection algorithm of image, and change detection of the main components of the image and change detection after classification. The aim of the method of vector analysis of spectral changes is to make sure the strength and direction characteristics of changes based on radicalization changes of images of different time especially analyzing the differences of each band. The aim of the method of time series analysis is to analyze the process and trend of changes of monitoring ground objects based on remote sensing continual observation data. Image subtraction method, image ratio method and the method of change detection after classification are mainly introduced in next chapter.

2.1 Image subtraction method

Image subtraction method is a change detection method of the most extensive application. It can be applied to a wide variety of types of images and geographical environment. It is generally conducted on the basis of gray. A subtraction image is gained form the subtracting of the gray value of corresponding pixels of images after image registration. The gray value of the subtraction image is to show the extent of changes of two images. The changed region and unchanged region is determined by selecting the appropriate threshold values of gray of subtraction image. The formula is:

$$Dx_{ij}^k = x_{ij}^k(t_2) - x_{ij}^k(t_1) + C$$

Where i, j as pixel coordinates, k for the band, $x_{ij}^k(t_1)$ for the pixel(i, j) value of k -band image, t_1, t_2 for the time of the first and the second image, C is constant.

For most change detection methods, the choice of the threshold value decides the capability of change detection. Choosing a suitable threshold value can maximum separate the areas of real change and the areas of the impact of random factors. The

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selection of a high threshold value will cause a lot of missed inspecting, and the selection of a low threshold value will cause void inspecting. In the new gained image, positive or negative value of the image denotes the region whose radiation value is changed, and there is no change in the region when the image value is 0. In the 8-bit image, pixel value is ranging from 0 to 255, and its image subtraction value is ranging from -255 to 255. As the subtraction value is often negative, it can add a constant C. The brightness values of subtraction image are often approximating Gaussian distribution, the unchanged pixels are centralizing around average value and the changed pixels are in the distribution of the tail.

2.2 Image ratio method

A pixel value of a time image divides the corresponding pixel of another time image is the image ratio method. In this method, the ratio of corresponding pixels in each band from two images of different periods after image registration will be calculated. The formula is:

$$R_{ij}^k = x_{ij}^k(t_1) / x_{ij}^k(t_2)$$

If the corresponding pixels of each image have the same gray value, namely $R_{ij}^k = 1$, showing that there has been no change occurred.

In the changed region, the ratio will be much greater than 1 or far less than 1 according to the different direction of changes. As in many cases, $x_{ij}^k(t_2)$ may be equal to zero. In order to overcome this situation, the denominator would be added a very small value (e.g. 0.01) when the denominator is equal to zero on the computer. Because the real ratio is ranging from 1 / 255 to 255, the range of the ratio is usually normalized to 0~255 for display and processing. 1 of the ratio is usually assigned to 128 of brightness. 1 / 255 to 1 of the ratio would be transformed to 1 ~ 128 by the following linear transformation:

$$NR_{ij}^k = \text{Int}[R_{ij}^k \times 127 + 1]$$

1 / 255 to 1 of the ratio would be transformed to 128~ 255 by the following linear transformation:

$$NR_{ij}^k = \text{Int}[128 + R_{ij}^k / 2]$$

A threshold value is needed to select to outlining significant changes region in the ratio image. The ratio image will be converted to a simple change / no change image or positive change / negative change image to reflect distribution and size of the changes. The choice of threshold value must be based on the characteristics of the regional research targets and the surrounding environment. A threshold value will vary in different regions, different times and different images. The threshold value border of "change" and "no change" pixels is often chosen from the histogram of the ratio image.

2.3 The method of change detection after classification

The method of change detection after classification is the most simple change detection analysis techniques based on the classification. After classification compare method can be used to two or more images after registration, including a classification step and a comparing step. Each image of multi-temporal images is classified separately and then the classification result images are compared. If the corresponding pixels have the same category label, the pixel has not been changed, or else the pixel has been changed. There are supervised classification methods and non-supervised classification methods. Non-supervised classification is used in this experiment. Non-supervised classification is also known as cluster analysis or point cluster analysis. That is the process of searching and defining the natural spectrum cluster group in the multi-spectral image. Non-supervised classification does not

need artificial selection training. Only a little artificial initial input is needed, the computer automatically composes cluster group according to pixel spectral or space. And then each group and the reference data will be compared and divided into a certain category. Two remote sensing images of different time after registration are classified separately and two (or more) classification images are gained. The change image is made by comparing each pixel. The type of change of each changed pixel is determined by the change detection matrix.

3. EXPERIMENTAL RESULTS AND ANALYSIS

ERDAS is used in this experiment. Panchromatic band of remote sensing images on April 1, 2002, May 10, 2001 in Beijing were the data used in Image subtraction method and Image ratio method. Three bands remote sensing images in Wuhan in 1995 and 2000 were the data used in the method of change detection after classification.

3.1 Image preprocessing

The objects of remote sensing change detection are images in the same region in different periods. The background environment reflected through the remote sensing image obtained in different instant is different because of the influence of various factors in the acquisition process. These factors can be divided into two categories: remote sensing system factors and environmental factors. The remote sensing system factors are: the impact of temporal resolution, spatial resolution, spectral resolution and radiation resolution. The environmental factors are: the impact of atmospheric conditions, soil moisture and phenological characteristics. The impact at different times and the influence of these factors on the images must be fully taken into account in the change detection. The influence may be eliminated as much as possible by the geometric registration and radiometric correction on the remote sensing images. It makes that this test is built on a unified basis and more objective result can be obtained.

3.2 The experiment and advantages and disadvantages of image subtraction method

The images are put into de-noising processing after subtraction calculation, the result is:

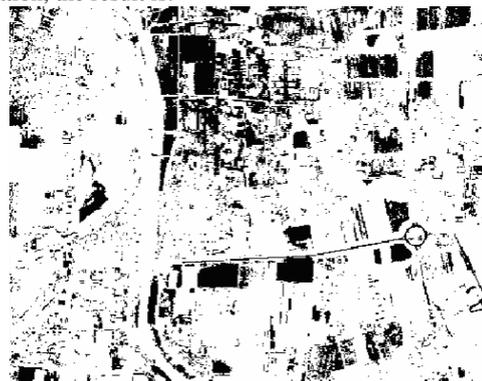


Figure 1. The result of image subtraction method.

The image subtraction method is a simple and straightforward concept. Its advantage is easy-to-understand and easy-to-use. The pixel gray of the subtraction image shows the differences of corresponding pixels of two images. The subtraction image is needed to take only once threshold selecting operation.

Comparing with the method of change detection after classification, image subtraction method reduces the probability of errors. The background gray is restrained and the subtraction gray is enhanced in image subtraction processing. It is benefit for picking-up the information: such as he beach zone, estuaries and underwater channels ditch. It also has a good practical value so it is widely used in detecting coasting environmental changes, tropical forests changes, temperate forests changes, and desertification and crop analysis.

The main disadvantage of this method is that it does not reflect changes in categories. Radiation subtraction value may be produced in two images registration. So the value of subtraction image does not always show the change of the objects because of a variety of factors such as atmospheric conditions, the sun light, sensor calibration, and ground water conditions, and so on. This method is too simplistic to change detection of natural images. It is difficult to take into account all factors and likely to cause the loss of information capacity. There may be a lot of noise (attracted by the image correlation). And this method requires accurate time and domain standardization and image registration. The threshold would be selected separately in change pixels area and unchanged pixels area on the histogram. In actual applications, the choice of threshold is quite difficult. This is also one of its shortcomings. Therefore it does not suitable for change detection of urban areas. Some information would be loss in this simple method. So it is difficult to research the nature of changes and further analysis is needed.

3.3 The experiment and advantages and disadvantages of image ratio method

The computing principles of image ratio method is similar to the mage subtraction method, the result is:



Figure 2. The result of image ratio method.

Rivers texture features and the change information of crops on farmland can be seen from Figure 2. Image ratio method is useful for the extraction of vegetation and texture. However, there is still some changes information not being detected such as the road and the circular feature in the central of the Figure 2. The influence of the slope and aspect, the shadow or sun angle, radiation changing caused by strong seasonal transformation and multiplication noises can be eliminated or inhibited. It is the advantage of image ratio method. It highlighted different slope features between the bands. It has more exact accuracy and applies to research change detection of cities.

The type of feature changes can't be reflected. The choice of threshold value is difficult. Different features of the same slope are easy to confuse and the ratio synthesized image is often compensated in the analysis. This is the main shortcomings of image ratio method.

3.4 The experiment and advantages and disadvantages of the method of change detection after classification

The remote sensing image of Wuhan in 1995 and 2000 are classified respectively and then change detected. The result is:



Figure 3. The result of the method of change detection after classification.

Unchanged part is black, the added part is green and the reduced part is white in Figure 3. But the bridge of the Yangtze River is detected to the reducing part. This error is derived from the classification error.

Thus, the advantage of this method is not only ascertaining the space range of changes but also providing the formation about change characters, such as what type is changed to what type and so on.

The drawback of this method is the high requirements to the reasonable classification of categories. If the categories are so many, the big brink points will be produced, it may cause the increase in detection error. If the categories are little, the differences of some categories may be overlooked, it may not reflect the actual situation. Secondly, it lays isolation of classification step and change detection step. When the classification and change detection become two relatively independent processes, the comparative analysis is based on dealt with information from two images instead of the original information. The amount of information may be reduced and the accuracy may be lost, such as the lakes, the Yangtze River and Hanjiang are classified as water system. Finally, classification error is rather sensitive in this method. Because the images are needed to classify for change detection, any one image's classification error would cause the mistakes of the results. The risk of error is increased. Therefore, the accuracy of this method depends on the accuracy of the classification results. The accuracy of change detection results would be affected greatly. This method is not fit for change detection of the details of urban because of the low-resolution of multi-spectral images and complex spectral characteristics of the cities.

4. ANALYSIS OF THREE CHANGE DETECTION METHODS

From the precision of view, the change region of the image ratio method is more accurate, followed by the image subtraction method, the last is the method of change detection after classification.

On an operational perspective, image subtraction method and image ratio method have relatively simple operation and cost less time. The method of change detection after classification is more complicated and time-consuming.

From the application perspective, image subtraction method and the method of change detection after classification do not apply to the change detection of details of urban. And image ratio method can be used for change detection in the city, particularly analysis of vegetation and soil.

Looking at the results from the image, image subtraction method and image ratio method can only detect the scope and degree of changes and can not give the nature and causes of changes, namely the transformed information of the types. The method of change detection after classification can provide this information.

5. CONCLUSION

Current common methods of change detection are discussed, particularly analysis and comparison of image subtraction method, image ratio method and the method of change detection after classification. This paper proceed form the principles of them, achieving them with ERDAS software, analyzing their results and comparing their advantages and disadvantages.

At present, people study the change detection automatic technology on the computers. The automatic registration of

images, automatic matching of images, automatic extraction of features, automatic interpretation of goals, automatic video integration and automatic cleaning of data and classification are key problems.

Automatic data mining and automatic discover knowledge form GIS database, building intelligent systems of change detection and establishing a unified accuracy evaluation system are also explored. In this experiment, change detection is difficult to accuracy evaluated except using the visual method. It has subjective error. As a result, study of this part will be carried out.

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