AIRPLANE EXTRACTION FROM HIGH RESOLUTION SATELLITE IMAGE USING BOUNDARY FEATURE

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ABSTRACT:

Many researchers conducted the effort for improving the classification accuracy of satellite image. Most of the study has used optical spectral information of each pixel for image classification. By applying this method for high resolution satellite image, number of class became increase. This situation was remarkable for objects in urban area. In this study, we propose the method for extracting some objects using boundary features. Airplane was selected as a target object. Airplane extraction algorithm is as follows. Supervised land cover classification is carried out for multiband satellite image. The pixels recognized as airplane were set to 1. The other pixels were set to 0. We could binarize the target image using this method. However, some roof of buildings had same characteristics of airplane. We introduced some boundary features in order to specify the airplanes from other land covers. Such procedure was carried out for each pixel by moving window. We can extract the boundary of each airplane easy using boundary features. This algorithm was applied for Quickbird image. We obtained the good result.

1. INTRODUCTION

Object extraction from high resolution satellite image is important. There are many objects in satellite images, for example, building, road, forest, crop land and airplane. Among these objects, boundary feature of airplane is special characteristics compare with other objects. We selected airplane as target object in this study.

Many airplane extraction algorithms are already proposed for this purpose. These algorithm can be divided into two groups. One group uses figure features of panchromatic image. Another group uses features of electromagnetic spectrum obtained from multispectral image.

Panchromatic image has a merit of high resolution characteristic compare with multispectral image. Geometric features are extracted from panchromatic image. However, panchromatic image has not color information. Thresholding is very useful technique for object extraction. The result of thresholding affect on the accuracy of the extraction. Thrsholding result obtained from only grayscale image is not so good. When intensity value of target object is same as that of background, it is difficult to distinguish each other.

We propose a method which uses both geometric and color features extracted from multispectral image. Quickbird image was used in this study. Haneda airport which locate near Tokyo was selected as target area. Ground resolution of multispectral image of Quickbird is less than that of panchromatic image. However, we can detect airplanes from multispectral image clearly. Multispectral image which has advantage of utilization of color information was used for classification. Any classification algorithm can be used for this purpose. In this study, supervised classification method was used.

After applying this classification method, we binarize the classified result. Binarized result has many noises. These noises contain two types. One is shadow on main wing. Another is small objects compare with the size of airplane. Modification program for the shadow on wing and small noise elimination program were created in this study. After executing these programs, we selected one airplane as standard pattern.

In order to extract airplane, we used some boundary features, for example, roundness, center of gravity, perimeter, area and bounding box. Extracted result was shown by circle whose center and radius are center of gravity and maximum distance between the pixel within the object and center of gravity.

2. PREPROCESSING

There are three preprocessing algorithms. First is supervised classification. Second is modification algorism of shadow on the wing. Third is elimination algorithm of small objects.

2.1 Supervised Classification

Training data were taken from infrared color image which combined with green, red and near infrared images. Three classes were created for airplane. After executing the classification, these three classes were unified to one class. Other classes are also combined to one class.

There are two types misclassification in the classified result. First case is that parts of airplane are classified to other class. Second case is that some objects except airplane are classified to airplane.

2.2 Modification Algorithm of Shadow

Most of shadows on airplane were classified into shadow. In order to modify these shadows, we used closing algorithm. This method combined dilation and erosion.

2.3 Elimination of Small Objects

Some objects that were actually not airplane classified into airplane. These objects were divided into three groups by the object size. Small objects can be eliminated by using the perimeter of object..

3. EXTRACTION OF AIRPLANE

Geometric feature parameter is very useful for the extraction of objects from image. Representative geometric feature parameters are center of gravity, bounding box, area, perimeter, roundness, Euler number and moment feature. Roundness is the most effective parameter for the airplane extraction. However, we cannot extract the airplane by using roundness only. We used other parameters also. Airplane extraction algorithm consists of five steps. First step is labeling. Second step is contour tracking. Third step is calculation of geometric feature parameters. Fourth step is extraction of airplane. Fifth step is drawing a circle on the successfully extracted airplane.

3.1 Labeling

Labeling algorithm assign the sequential number on each connected component by using lookup table.

3.2 Contour Tracking

Contour tracking is to find the boundary of connected component. In this study, we used the contour tracking algorithm by using raster scanning.

3.3 Calculation of Geometric Feature Parameter

We used area, perimeter, roundness, center of gravity, ratio of vertical and horizontal size.

3.3.1 Area

Area S can be calculated by counting the number of pixels in each connected component.

3.3.2 Perimeter

Perimeter can be calculated by counting the number of pixels on the boundary of each connected component. In this case, we used 8-connection. Distance between two pixels connected vertically or horizontally denote C_1. Distance between two pixels connected corner denote C_2. Perimeter L can be calculated following equation.

$$L = C_1 + \sqrt{C_2} \tag{1}$$

3.3.3 Roundness

Roundness shows the degree of resemble to circle. Roundness F can be calculated by following equation.

$$F = \frac{4\pi S}{L^2} \tag{2}$$

where S:area, L:perimeter

3.3.4 Center of gravity

Center of gravity shows the average position of pixels contained in connected component. Center of gravity can be calculated by following equation.

$$\left(\frac{\sum_{i=0}^{n-1} x_i}{n}, \frac{\sum_{i=0}^{n-1} y_i}{n}\right) \tag{3}$$

Where n: area, (x_i, y_i): position of each pixel.

3.3.5 Ratio of vertical and horizontal size

Horizontal size corresponds to the difference of maximum position and minimum position in horizontal direction. Vertical size also corresponds to the difference of maximum position and minimum position in vertical direction. This ratio can be calculated by vertical size / horizontal size.

3.4 Extraction of Airplane

Previously extracted template image was examined. Geometric feature parameters of template airplane were calculated. Connected components in a binarized image were extracted. Geometric feature parameters of those connected components were also calculated. As roundness is the most effective parameter, the value of this parameter should be examined at first. The value of other parameters were examined successively.

3.5 Drawing a Circle

A circle was drawn on the successfully extracted airplane. Center of this circle corresponds to the center of gravity of the airplane. Radius of this circle is the maximum distance of pixel included in this airplane + 5 .

4. EXPERIMENT

Airplane extraction experiment was conducted by using the Geometric feature parameters.

4.1 Object Image Used in This Experiment

The proposed airplane extraction algorithm was applied for QuickBird image. Multi spectral image in Quickbird image has 4 band images that are composed of 3 visible band images and one infrared band image. The ground resolution is 2.44m. The object image is shown in Figure 1 and Figure 2. Figure 1 shows natural color combined image and Figure 2 shows color infrared image.

This image is obtained on 2 May 2002. This area is included in Haneda that is located at the south west of Tokyo in Japan. There are many airplanes, many buildings, many bare grounds and many glass lands in this area. Most of airplanes have same size and white color. Some part of airplanes show blue color in Quickbird natural color combined mage. This color changed to orange in the color infrared combined image.

Figure 1. QuickBird natural color image used in this experiment

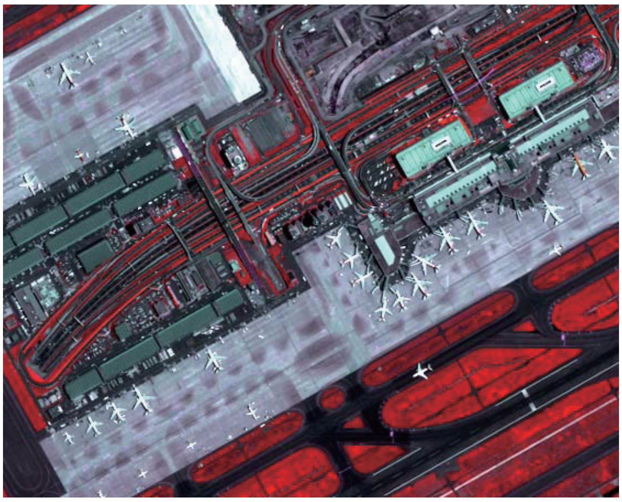

Figure 2. QuickBird color infrared image used in this experiment

4.2 Preprocessing

4.2.1 Supervised Classification

Training data were taken from infrared color image shown in Figure 2. Three classes were created for airplane. These three classes are shown white, light blue and orange in Figure 2. After executing the classification, these three classes were unified into one class. The other classes were also combined to one class. Figure 3 shows the binarized image by using above method. There are many small white objects and some large buildings. There exist some shadows on airplane tale wings. These objects become obstacles for extraction of airplane. We must eliminate these objects.

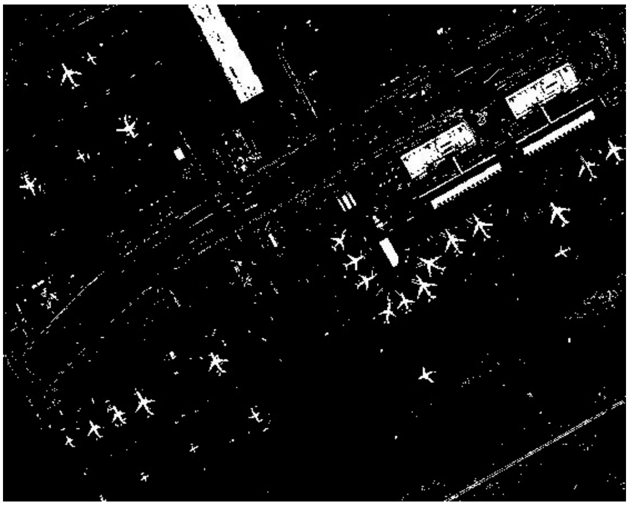

Figure 3. Binarized image

4.2.2 Modification Algorithm of Shadow

Most of shadows on airplane were classified into shadow. In order to modify these shadows, we used closing algorithm. At first, we applied dilation algorithm for the connected components. Next, we applied erosion algorithm for the obtained connected components. Example of the result is shown in Figure 4. Upper result in Figure 4 shows that one part of tail wing connected to airplane. Lower result in Figure 4 shows that the width of main wings becomes fat.

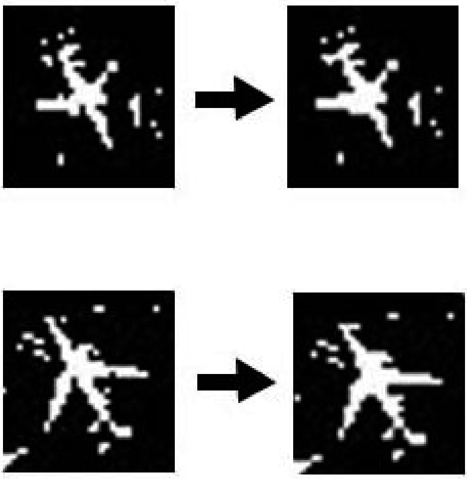

Figure 4. Example of Shadow Elimination

4.2.3 Elimination of Small Objects

Some objects were actually not airplane. But those objects were classified into airplane. Those objects were divided into three groups by the object size. Small objects can be eliminated by using the perimeter of object.. Other type objects could be eliminated by following methods. The result of elimination of the shadows on airplane and small objects is shown in Figure 5.

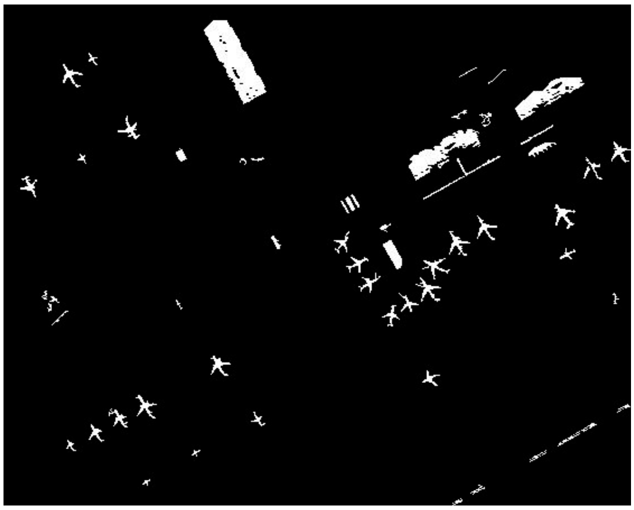

Figure 5. Binarized image after elimination of shadows and small objects

There still exists some small objects. These object can be eliminated by following methods too.

4.3 Airplane Extraction

Previously extracted template image was examined. Geometric feature parameters of template airplane were calculated. Connected components in a binarized image were extracted. Geometric feature parameters of those connected components were also calculated. We compared these parameter values of connected components with that of the template airplane. If this value is near the value of template airplane, target connected component was recognized as airplane. As roundness is the most effective parameter, the value of this parameter should be examined at first. The other parameters were examined successively.

4.4 Drawing Circle on Extracted Airplane

Extracted airplanes are shown in Figure 6. A circle was drawn on the successfully extracted airplane. Center of this circle corresponds to the center of gravity of the airplane. Radius of this circle is the maximum distance between the pixel included in this airplane and the center + 5 pixels.

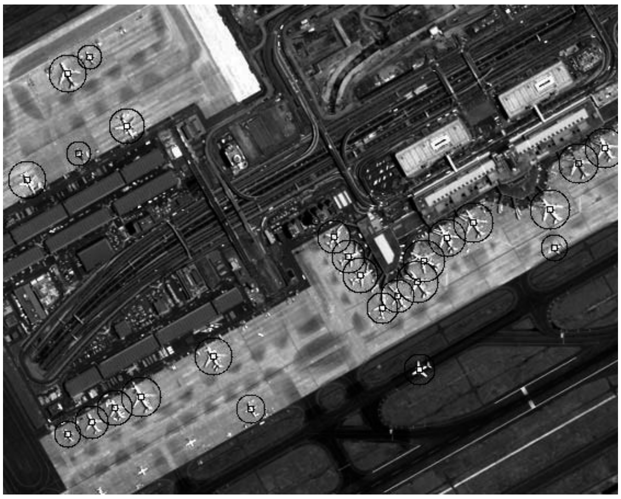

Figure 6. Successfully Extracted Airplanes

The obtained result showed most of airplanes were extracted successfully. Two small airplane near lower left corner could not extracted. Some values of geometric feature parameter calculated from these two small airplanes were different from the value of template airplane. If we change the threshold value of each geometric feature parameters, we can recognize these two small airplanes. However, in this case, some small connected components that are actually not airplane will be recognized as airplane.

5. CONCLUSION

New method was proposed for extraction of airplane. This method is combined supervised classification and geometric feature parameters. We could show the effectiveness of this method.

Obtained result was very good. However, we must find out an effective method for determining threshold value of each geometric feature parameters. In this study, we determined these values experimentally. This work is very troublesome. It is better to find out the threshold value automatically. We need more effort to develop a new method to find out the threshold value.

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References

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