Object Detection from High Resolution Satellite Image by Using Genetic Algorithms

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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 spectrum information of each pixel for image classification. By applying this method for high resolution satellite image, number of class becomes increase. This situation is remarkable for house, because the roof of house has variety of many colors. Even if the classification is carried out for many classes, roof color information of each house is not necessary. Most of the case, we need the information that object is house or not. In this study, we propose the method for detecting the object by using Genetic Algorithms (GA). Aircraft was selected as object. It is easy for this object to detect in the airport. An aircraft was taken as a template. Object image was taken from QuickBird. Target image includes an aircraft and Haneda Airport. Chromosome has four or five parameters which are composed of number of template, position (x,y), rotation angle, rate of enlarge. Good results were obtained in the experiment.

Key Word: Object Detection, High Resolution, GA, QuickBird

1. Introduction

Image classification is very important in remote sensing image processing. Conventional method of image classification is land cover classification by using maximum likelihood method for each pixel. In this method, optical spectrum information of each pixel was used. However, this method cannot be applied for high resolution satellite image. In high resolution satellite image, each object can be detected. We cannot classify the land cover as large area. In this study, we propose the method for detecting the object by using Genetic Algorithms (GA).

GA is a search technique used in computer science to find approximate solution to combinatorial optimization problem. GA is typically implemented as a computer simulation in which a population of abstract representations of candidate solutions to an optimization problem evolves toward better solutions. It is popularly used in artificial field.

In the field of satellite image processing, high ground resolution satellite image, for example, IKONOS and QuickBird image became popular. It is difficult to detect the objects from high resolution satellite image by using spectrum data only. Recently, it is focused on detecting object by using shape data.

2. GA System Used in This Study

Genetic algorithms are particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, natural selection, and crossover. The evolution starts from a population of completely random individuals and happens in generations. In each generation, the fitness of the whole population is calculated, multiple individuals are stochastically selected from the current population (based on their fitness), modified (mutated or recombined) to form a new population, which becomes current in the next iteration of the algorithm. These operations are shown in Fig.1.

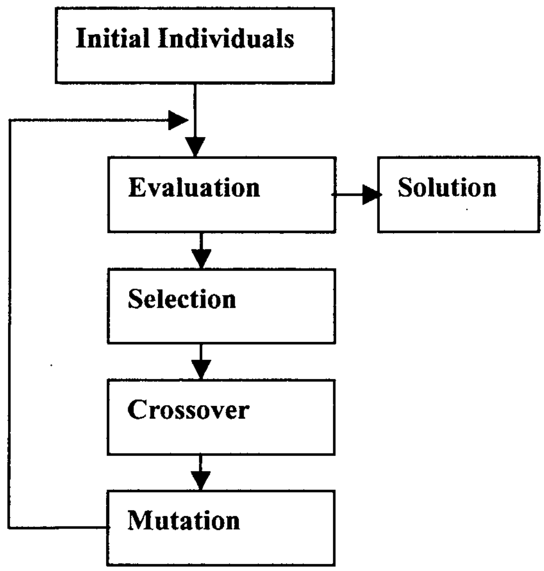

Fig.1 Operations used in GA

In this study, we designed five parameters, template number (num), position of template (x, y), enlarged rate (m), and rotation angle (angle). The chromosome used in this study is explained as follows.

$$\text{Chromosome} = (\text{num}, x, y, m, \text{angle}) \quad (2.1)$$

Fitness function was explained as follows.

$$\text{Fitness} = f(\text{num}, x, y, m, \text{angle}) \quad (2.2)$$

$$f = \Sigma\,\Sigma \,|\, \text{image2}(y,x) - \text{image1}(y,x) \,| \quad (2.3)$$

Where, image2(y,x) : object image data

Image1(y,x) : template image data transformed by translation, rotation and expansion.

3. Experiments

In this study, we used a QuickBird pancromatic image whose size is 600 x 600 pixels. Object area is Haneda Airport in Tokyo. This image was obtained on 2002 May 2. Object image is shown in Fig.2.

Fig.2 Object Image Used in This Study

Three experiments are implemented in this study.

3.1 First Experiment

In this experiment, crossover rate and crossover method were examined. We cut and brought down an aircraft image as template. The template is shown in Fig.3. The aircraft is included in rectangular area. As number of template is 1 for this case, num is not necessary in equation (2.1). Number of parameter for chromosome becomes 4.

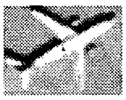

Fig.3 Template Image of Aircraft

It is important to set the transformation parameters. If they are not properly selected, high quality result could not be obtained. After implementing a lot of tests, we set the parameters as follows.

(a) Population size = 90
(b) Maximum number of generations = 300
(c) Three types crossover (one point, two points, uniform) were executed.
(d) Crossover rates were set to three types (0.3, 0.6, 1.0).
(e) Mutation rate = 0.03

When detection is success, template image is overwrite on the object image shown in Fig.4

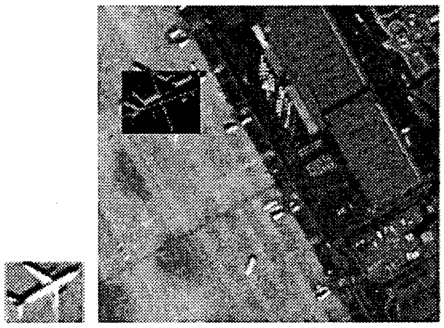

Fig.4 Successfully detected result

Obtained result for experiment 1is shown in Table 1.

Table 1 Detected rates of experiment 1

	One point	Two points	Uniform
0.3	40%	60%	33%
0.6	60%	60%	46%
1.0	40%	46%	67%

When crossover rate and crossover method were selected as 1.0 and uniform respectively, detected rate was obtained maximum value. In this case, similarity of chromosome of parents and children becomes minimum.

3.2 Second Experiment

In this experiment, rotation angle was examined. Ten templates are prepared. Difference of each template is rotation angle. Difference of rotation angle is 20° from 0° to 180° . These template images are shown in Fig.5.

0° 20° 40° 60° 180°

Fig.5 Template images used in this experiment

Parameters set in this experiment is as follows.

(a) Population size = 90
(b) Maximum number of generations = 3000
(c) Uniform crossover is selected
(d) Crossover rate = 1.0
(e) Mutation rate = 0.03

Obtained result for experiment 2 is shown in Table 2.

Table 2 Detected rates of experiment 2

Template	Angle range	Detected rate
0°	10°	95%
20°	50°	85%
40°	90°	80%
60°	130°	35%
80°	170°	15%
100°	210°	25%
120°	250°	45%
140°	290°	10%
160°	330°	10%
180°	360°	20%

When difference of rotation angle for the aircraft in object image and the aircraft in template image is less than 90° , detected rate is very high.

3.3 Third Experiment

In this experiment, templates of five types aircraft are prepared. Detection rate was examined when shape of aircraft was different. These template images are shown in Fig.6. Template image No.3 has the same aircraft included in the object image.

1 2 3 4 5

Fig.6 Template images used in experiment 3

Parameters set in this experiment is as follows.

(a) Population size = 90
(b) Maximum number of generations = 3000
(c) Uniform crossover is selected
(d) Crossover rate = 1.0
(e) Mutation rate = 0.03

Obtained result for experiment 3 is shown in Table 3.

Table 3 Detected rates of experiment 3

Template	Range of enlarge rate	Detected rate
1	1.45~1.65	0%
2	2.5~2.7	0%
3	1.55~1.75	40%
4	1.75~1.95	0%
5	0.9~1.1	0%

This result shows that different type aircraft cannot be detected. Shape of aircraft is very important for the detection of aircraft from satellite image by using genetic algorithms. As fitness is calculated by equation (2.3), shape of aircraft in object image should coincide with the shape of aircraft in template image.

4. Conclusion

From this study, we found that the matching rate is high when the size and background of aircraft in the object is same as the template. It is difficult to find the different type of aircraft from the object image. The quality of final result depends on the selection of parameters. We have to choose the parameters experimentally. Further investigation is necessary for the optimal parameter sets in GA operations.

Acknowledgements

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References

[1] Tomoharu Nagao, 2002, Evolutionary image processing, Syokoudou