A New Method of Remote Sensing Image Fusion Based on Modified Kohonen Networks

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Abstract: In this article, a new remote sensing image fusion model based on modified Kohonen networks is given. And a new fusion rule based on modified voting rule was established. Select Shaoxing City as the study site, located at Zhejiang Province, P.R.China. The fusion experiment between Landsat TM data (30m) and IRS-C Pan data (5.8m) was performed using the given fusion method. The fusion results show that the new method can gain better result in applying to the lower hill area, and the whole classification accuracy was 10% higher than the basic Kohonen method. The confusion between the woodlands and the waterbodies was also diminished.

Keywords: Remote Sensing Image Fusion, Modified Kohonen Networks, Kohonen Networks, Lower Hill Area

1. Introduction

Remote sensing image fusion is the most valuable method to enrich mass data from different data source, which is a research priority of remote sensing application. At present, multi-source remote sensing image fusion improves from laboratory research to practical application. Much research is developed on transforming fusion layer to the decision-level.

In recent years, there are many researchers who had applied neural networks methods to multi-source remote sensing image fusion. For examples, Benediktsson, et al (1990) and Cappellini (1994) studied remote sensing image fusion using neural networks and applied to land cover classification. Serpico et al (1995) carried out fusion classification between optical image and SAR image using neural networks. Liis O.Jimenezz et al (1999) studied high dimension data classification based on feature level fusion and decision level fusion using project trail, major voting and neural networks. Weijian Wan & Donald Fraser (1999) researched on multi-layer Kohonen networks applied to multi-source remote sensing data fusion. Liu Chunping (2002) applied fuzzy Kohonen networks to multi-sensor data fusion and gained good effect.

Kohonen Networks is a competitive learning network. And it makes supervised model recognition based on unsupervised learning. Thus it will be in favor of processing complicated great remote sensing data. In the paper, a new model of remote sensing image decision-level fusion based on modified Kohonen networks is given by combining thematic information extraction technique with Kohonen networks. Then it gave a fusion rule suitable to the fusion model. Finally experiments and discussions are given.

2. Remote Sensing Image Fusion Method Based on Modified Kohonen Networks

1) Modification of Kohonen Networks

Considering the exist problems of the basic Kohonen networks which is applied to take classification, the thematic information extraction technique joins in the Kohonen networks model. And the modified model is given. Its arithmetic is as follows.

(1)Thematic Information Extraction: include waterbodies, construction land, etc.

(2) Layer Processing: to erase the extracted thematic information from the original image.

(3) Classification Using Kohonen Networks: the remained ground objects information are classified again, and the classification process will not be affected by extracted information.

(4) Merging Process of Classification Information

2) Fusion Method

Remote sensing image decision-level fusion method

based on modified Kohonen networks is described as follows. Firstly to preprocess muliti-source remote sensing image, and the different images are matched in a certain condition; Secondly, to clustering analysis on each remote sensing image using modified Kohonen networks model, and classification results of each remote sensing image are gained; Finally, to fuse the classification results by given fusion rule, and the fusion image is gained.

3) Fusion Rule

Voting rule is a kind of methods used to combine multi-classification machine. However, these voting rules vote by "one person one ticket" principle, and they have not considered the characteristics of every classification machine. In fact, each classification machine capacity is not the same and has some mutual supplement (Lv yue et al, 2000). In the paper, to select confusion matrix of each classification result as classification machines' pre-experiential knowledge, and to vote complying with the above knowledge. Here regarding the modified voting rule as the fusion rule of remote sensing image fusion based on modified Kohonen networks.

Suppose that $C(x,y)$ express the fusion result gained by the modified Kohonen networks fusion method, then, the fusion rule expression can be described as follows.

$$C(x,y) = \arg \max_{j=1,2,...,N} (\sum_{i=1}^{K} A_i A_j(x,y)) \quad (1)$$

Where, A_i is contribution ratio of different remote sensing data source, denoted by whole classification accuracy, $i = 1,2,...,K$; $A_j(x,y)$ is contribution ratio of different kind, denoted by each classification accuracy, $j = 1,2,...,N$.

3.Experiment & Discussion

1) Dataset

Shaoxing City, Zhejiang Province is selected to be the research area; the datasets are pre-processed Landsat TM (30m) image of 6 spectral bands and IRS-C Pan (5.8m) image. The size is 256×256 pixels (Landsat TM 30m), and the corresponding size of fusion image is 1280×1280 pixels.

The test area is typical of low hill in the South of Yangtze River and fragmentary land parcel, which can be classified into six types of land cover: construction land (including town, village, industrial land and transportation land), waterbody, woodland, tea garden, paddy field and naked land.

Data is processed before fusion through precise registration between two images, histogram match and sampling of training data. According to the above modified Kohonen networks fusion, the experiment is conducted to fuse the Landsat TM and IRS-C Pan using Matlab 6.1 programming; the result is then compared with the basic Kohonen networks fusion model.

2) Experiment of Image Fusion Based on Basic Kohonen Networks

The six categories of ground objects are further classified into ten categories to be sampled and the number of sample in each ground objects is 500. After sampling, the spatial resolution of Landsat TM image is 5m, which is fused with IRS-C Pan image using Kohonen networks fusion algorithm programmed by MatLab 6.1. The result image is shown in Fig.1(c).

The result shows that the fused image is enhanced in the spatial resolution capacity and definition compared to the original TM image. Moreover, the texture information is more distinct.

In order to evaluate the classification accuracy of the fusion image, 512 points in the image are randomly sampled. The result shows the classification accuracy of woodland and paddy field is relatively higher while that of tea garden and naked land is lower, and the total classification accuracy is 57.81%, the reason for which is concerned with the fracture zone of the research area. What's more, the fusion image shows that naked land is prone to be confused with the construction land, and the tea garden and paddy field is also difficult to be differentiated. Woodland is mixed with waterbody, which is affected by the shadows of mountain area.

3) Experiment of Image Fusion Based on Modified Kohonen Networks

(1) Process of classification

In the experiment, waterbody and construction land was firstly extracted using thematic information extraction technique, and then the rest ground object were classified using the basic Kohonen networks model.

Finally, results of both classifications were sorted out and combined.

(2) Process of fusion and evaluation

According to the fusion rule, the classified Landsat TM image and classified IRS-C Pan image were fused and the result is shown in Figure 1 (d). The weight here is the whole classification accuracy of mono-source remote sensing data and the classification accuracy of each category is taken as contribution ratio of corresponding remote sensing source.

Fig.1(d) also shows that the spatial resolution capacity and the articulation of fused image is better than the original TM image and the texture is clearer, especially that of the linear objects.

The same sampling method was employed to evaluate the classification effect. The result shows the similar result with that of section 3.2, that is, tea garden and naked land is of low classification accuracy, naked land and paddy field, tea garden and paddy field, woodland and waterbody are still mixed with each other.

For the lower hill area in the south of Yangtze River, the result of confusion using the modified Kohonen networks model shows better results and the total accuracy amounts to 68%.

4.Result

In this paper, thematic information extraction technique was introduced into the model and a decision-level fusion method based on modified Kohonen networks was presented. According to the fusion rule discussed in this paper, the Landsat TM image and IRS-C Pan data were fused. The result shows better spatial resolution capacity and articulation and the total classification accuracy comes to 68%, which is 10% higher than the basic method. The confusion between the woodlands and the water also diminished.

However, the confusion still exists between the paddy field and tea garden because of their similar spectrum value. Further research is required to solve the problem.

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References

[1] Liu Chunping, 2002, Multi-source Remote Sensing Information Fusion Method and Its Application, Phd. Dissertation, Nanjing: Nanjing University of Technology & Engineering.

[2] Lv Yue, Shi Pengfei, Zhao Yuming, 2000, Voting Rule of Multi-classification Machine Combination, *Journal of Shanghai Jiao Tong University*, 34 (5): 680-683.

[3] Cappellini V., Chiuderi A. and Fini S., 1994, Neural networks in remote sensing multisensor data processing, *Proc. 14th EARSeL symposium*, Goteborg, Sweden, pp 457-462.

[4] J.A.Benediktsson, P.H.Swain, O.K.Ersoy, 1990, Neural network approaches versus statistical methods in classification of multisource remote sensing data, *IEEE Transaction on Geoscience and Remote Sensing*, 28(4): 540-552.

[5] Liis O.Jimenezz, Anibal Marales-Morell, Antonio Creus, 1999, Classification of hyperdimensional data based on feature and decision fusion approaches using projection pursuit, majority voting, and neural networks, *IEEE Transaction on Geoscience and Remote Sening*, 37(3): 1360-1366.

[6] Sebastiano B.Serpico, Fabio Roli, 1995, Classification of multisensor remote sensing images by structured neural networks, *IEEE Transaction on Geoscience and Remote Sensing*, 33(3): 562-578.

[7] Weijian Wan & Donald Fraser, 1999, Multisource data fusion with multiple self-organizing maps, *IEEE Transaction on Geoscience and Remote Sening*, 37(3): 1344-1349.

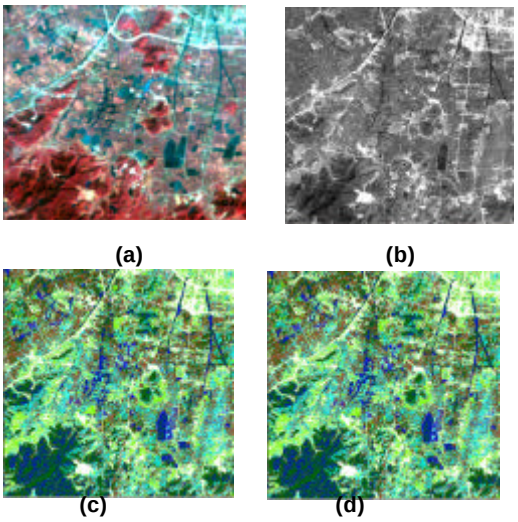

Fig.1 The original images (a, b) and the fusion images (c, d)