Surface Feature Detection Using Multi-temporal SAR Interferometric Data*

Jingjuan Liao Huadong Guo Yun Shao
Laboratory of Remote Sensing Information Sciences, Chinese Academy of Sciences, Beijing 100101
P.O. Box 9718, Beijing 100101, China
Tel: 86-10-64838047, Fax: 86-10-64889786
Email: ljj@irsa.irsa.ac.cn

Abstract: In this paper, the interferometric coherence was estimated and the amplitude intensity was extracted using the repeat-pass interferometric data, acquired by European Remote Sensing Satellite 1 and 2. Then discrimination and classification of surface land types in Zhangjiakou test site, Hebei Province were carried out based on the coherence estimation and the intensity extraction. Seven types of land were discriminated and classified, including in two different types of meadows, woodland, dry land, grassland, steppe and water body. The backscatter and coherence characteristics of these land types on the multi-temporal images were analyzed, and the change of surface features with time series was also discussed.

Key words: Multi-temporal; Interferometry; Surface features; Detection

1. Introduction

At recent years, imaging radar interferometric technique with its all weather, day and night capabilities, can generate the digital elevation model (DEM) and monitor surface change using amplitude and phase information from radar signal. So it has become a potential tool to acquire more resource and environmental information [1-3]. The repeat-pass interferomety acquires two images by using one antenna for repeat passes over the same area at two different times. The two images can be used for further information extraction only while they have somewhat coherence. Therefore, the coherence of the two images should be estimated at the interferometric data processing. On the other hand, the coherence is related to surface changes, so it is used for discrimination and classification of land types, land use survey, and estimation of vegetation density and biomass. In the paper, the surface features are studied based on the interferometric coherence and amplitude information, and discrimination and classification of land types are carried out. Finally, the backscatter and coherence characteristics of land types on the multi-temporal images are analyzed, and the change of surface features with time series is discussed.

2. Test Site and Data Sources

1) Test Site

The test site is selected in the north area of Zhangjiakou, Hebei Province of northern China. It is located in the transitional belt of North China Plain to Inner Mongolia Plateau. The test site has an elevation of 1300m to 1500m. The annual average temperature is 4-10ºC without frost period of 110 to 170 days. The annual average rainfall is 600 to 700mm. It is a temperate, monsoon climate. In the test site, land types have meadow, steppe, grassland, dry land, woodland, lakes and wetland.

2) Data Sources

The data source is the raw data from repeat-pass interferometry, acquired by European Resource Satellite 1 and 2. The acquisition dates is in Table 1. The data is C-band (5.67cm) operating in VV polarization with the incidence angle of 23.3º at imaging center. The swath is 39 km and the pixel spaces of range and azimuth are 7.904 m and 3.978 m, respectively. In addition, 1:1000000 land use map [4] is collected as references for

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discrimination and classification of land types.

Table 1. The acquisition dates and sensor of data sources

Track	Acquisition date	Sensor
36593	15 July 1998	ERS-1
16920	16July 1998	ERS-2
14415	22 January 1998	ERS-2
32585	8 October 1997	ERS-1
20427	18 March 1999	ERS-2

3 Data Processing

Firstly, the raw data are processed into single look complex data using APP software provided by Atlantis Inc. Then the degree of coherence is used to define the correlation of the repeat-pass data, and is calculated as:

$$\gamma = \frac{\left|\left\langle g_1 \cdot g_2^* \right\rangle\right|}{\sqrt{\left\langle g_1 \cdot g_1^* \right\rangle \left\langle g_2 \cdot g_2^* \right\rangle}} \qquad (1)$$

where $\langle \cdot \rangle$ denotes expectation value, and * means complex conjugation, and

$$\langle g \rangle = \frac{1}{N} \sum_{i=1}^{N} g_i \qquad (2)$$

indicates the spatial expectation over N pixels windows. According to these formulas, the degree of coherence related to pixel values can be estimated. Here, an optimal window size of 25 (azimuth) by 5 (range) pixels is retained [5].

Finally, the color composite image is generated by the degree of coherence, amplitude information extracted from the single look complex data.

4 Discrimination and Classification of Surface Land Types Using Multi-temporal SAR Interferometric Data

Using the color image composed by coherence and multi-temporal amplitude images, and referred from 1:1000000 Land Use Map, a supervised classification, maximum likelihood method was employed. The classification map is showed in Figure 1. Seven types of land were discriminated and classified, including in two different types of meadows, woodland, dry land, grassland, steppe and water body on the images. The classification results showed that water body and meadow 1 had the best classification accuracy at 86.3% and 82.8%, respectively. Dry land, woodland and meadow 2 had the accuracy of 73.2%, 66.2% and 56.8%, respectively. Grassland and steppe had lower accuracy of 48.9% and 40.7%. The average classification accuracy was 64.98%, and the overall accuracy was 70.4%.

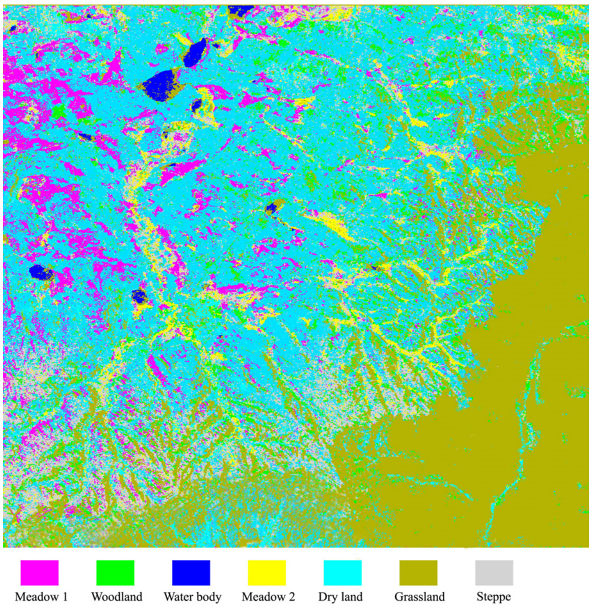

Fig.1. Classification map based on the multi-temporal SAR interferometric data

5 Analysis of Surface Features Detection Using Multi-temporal SAR Interferometric Data

Based on the coherence and backscatter coefficients extracted from the multi-temporal SAR interferometric data (Table 2), the backscatter and coherence characteristics of these land types on the multi-temporal images were analyzed, and the change of surface features with time series was also discussed. Water body has the lowest coherence and backscatter coefficient so that it is easy to discriminate from the other land types. Two different types of meadows have similar coherence, but have different backscatter coefficients on multi-temporal SAR images. Woodland has similar backscatter features with meadow, dry land and steppe, but can be discriminated with the low coherence. Dry land and steppe have high coherence, and the backscatter coefficient of steppe is higher than that of dry land. Grassland has low coherence and different backscatter coefficient on different temporal images.

Table 2. Degree of coherence and backscatter coefficients of surface land types extracted from the multi-temporal SAR interferometric data

Surface land types	Degree of coherence				Backscatter coefficient (dB)			
	γ1	γ2	γ2	γ4	8 Oct. 1997	22 Jan. 1998	15 July 1998	18 Mar. 1999
Water body	0.08	0.10	0.12	0.12	-18.5	-21.3	-18.1	-27.8
Meadow 1	0.31	0.10	0.15	0.14	-16.5	-20.1	-15.2	-18.8
Woodland	0.13	0.10	0.13	0.13	-14.2	-18.7	-12.1	-15.7
Meadow 2	0.33	0.06	0.14	0.12	-13.8	-18.5	-13.2	-17.0
Dry land	0.36	0.09	0.12	0.13	-14.5	-19.5	-13.6	-17.8
Grassland	0.11	0.11	0.14	0.15	-13.0	-18.2	-13.0	-16.7
Steppe	0.48	0.12	0.14	0.13	-12.5	-17.0	-12.0	-15.7

γ1: the degree of coherence extracted from ERS-1/2 Tandem data on 15 and 16 July 1998;

γ2: the degree of coherence extracted from ERS-2 data on 22 January 1998 and 18 March 1999;

γ3: the degree of coherence extracted from ERS-1 data on 8 October 1997 and 15 July 1998;

γ4: the degree of coherence extracted from ERS-1 data on 15 July 1998 and ERS-2 data on 22 January 1998.

These land types have different backscatter features with time change on the multi-temporal images. They have stronger backscatter in summer and fall than in winter and spring, and the backscatter is stronger in spring than in winter.

Conclusions

(1) Using the coherence and backscatter information from the multi-temporal SAR interferometric data, the surface types of land can be discriminated and classified. At Zhangjiakou test site of Hebei Province, North China, seven types of land were discriminated and classified, including in two different types of meadows, woodland, dry land, grassland, steppe and water body.

(2) Different land types had the different coherence in the multi-temporal interferometric SAR images, and the backscatter characteristics also were changed with the time series.

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