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Application Of Radar Image in Land-Use Dynamic Monitoring in Beijing

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ABSTRACT Due to severe weather with wide cloud and fog covers, it is generally difficult to acquire satisfied optic image from satellites for interpretation. This has an influence on land-use dynamic monitoring around Beijing in timely fashion. As a complementary data source, radar remote sensing has its advantage of less effect of weather in comparison with Landsat TM data. There are sufficient radar remote sensing data covering many regions of China. One of the national interests is to use the available radar remote sensing data to monitoring land use changes around big cities cross the country.

In this research project, radar data captured in 1997, 1998 and 2000 covering the Metro Beijing together with TM images were applied to characterize the features of the main land use types and their changes for the past three years. Different techniques have been implemented for processing these remote sensing data. Automated processes for extracting land use change information were investigated. The techniques applicable to the radar data and to TM data as well as the precision of the results obtained for land use monitoring have been systematically compared.

1. INTRODUCTION

Timely monitoring land use changes around big cites in China has become a major issue for protecting rapid conversion of non industrial and commercial land to industrial and commercial use, which has a significant impact on the sustainable development in those heavily populated cities of China. It was noticed an urgent need to measure the change rate and nature of the land use in a timely fashion so that proper land use policy and plan can be optimized. Remote sensing technology was selected without doubt as a main effective mean for assistance in the processes. This paper will present an example to show what roll remote sensing technologies have played in the process. Various remote sensing data such as RADAR SAR, Landsat TM and SPOT data have been used for different purposes in various cites. The focus of this paper will be given on the application of Radar SAR data in land use monitoring in Beijing, one of the largest city of China. The area is about 16000 km^2 with a population of 12 million people.

Radar data in 1997, 1998 and 2000 were used as the main datasets in the study. Multi-parameter radar remote sensing data were applied to measure the changes of land uses. Combining visual interpretation and computer automated classification, potential targets with land use changing can be evaluated on the basis of relative change of image patterns by comparing the field survey results with the results obtained from processing Radar SAR remote sensing data and other optic remote sensing data with various parameters and for three different time periods.

2. RECTIFICATION AND REGISTRATION OF RADARSAT DATA

Rectification and registration of Radar SAR data (2000/5/32) were based on control points collected from 1:50000 topographic maps. 30-40 control points were selected from the study area. Resampling involved in the rectification was conducted by means of three-convolution algorithm. The results of rectification and registration are summarized in the **Table 1.**

Table1: Summary of Rectification and Registration of Radar SAR Data

Image and Date	Control Points	Pixel Size	RMS (Pixel)
2000/06/16SAR	35	6.25m	0.535
1998/07/21SAR	34	6.25m	0.58
1997/11/20SAR	36	6.25m	1.26

3. ENHANCEMENT OF RADARSAT IMAGE

In SAR radar imaging processing, it often needs to smooth out noises while retaining edges or shape features in the image. The filtered image is therefore easier for visual interpretation. There are a number of filtering techniques available for this purpose. A set of filters can be found from PCI on line documentation or at website: http://www.pcigeomatics.com/cgi-bin/pcihlp/GEODIS. In this application, some of these filtering techniques have been conducted using PCI and the results obtained have been compared. Firstly, median filter and edge enhancement filter were combined to remove high frequency noise and preserve variation of edge features. The results show that the combination of low and high frequency filtering can remove speckle noises and retain edge feature, however significant changes have been brought in so that it is difficult to delineate the edges of the land use patterns precisely. Many other types of filtering techniques have the similar problem as what we have mentioned above. The Lee Filter is primarily used on radar data to remove high frequency noise (speckle) while preserving high frequency features (edges). Lee filtering has provided better results with edges clearly maintained. The filtered SAR images of 1997, 1998, and 2000 have been further fused with Landsat TM images, which has been shown effective for distinguishing land use patterns. These techniques have been used in the applications of SAR and TM data for dynamically monitoring land use change in big cities of China.

4. TEXTURE ANALYSIS OF SAR IMAGE

There are two common types of methods for texture analysis: statistical texture analysis and structural texture analysis methods. The indistinctiveness and uncertainty of remote sensing data due to multiple factors including random factors, the textures reflected on remote sensing images are not regular and generally do not repeat as cloth patterns. Therefore, texture information only has statistical meaning. Statistical texture analysis method is prevalent now. A number of statistical texture analysis methods have been used in the remote sensing image processing literature such as spatial autocorrelation function, Fourier power spectrum and gray scale symbiosis matrix. RADARSAT-1 SAR image usually has rich texture information for spatial analysis. Conventional methods for statistical texture analysis involve predetermined fixed window size of neighborhood that often decide the size and scale of textures to be detected. For edge enhancement of land use coverage, the window sizes 5×5 was used and the result obtained is shown in **Fig. 1**

Figure 1 nhanced Radar SAR image by edge enhancement filtering. Window size was 5x5.

5. RADAR DATA FUSION

Data fusion normally refers to the process to integrate and view several types of data from different sources. Using PCI, a new color image can be generated by fusing the color component of one input image with the intensity component of another input image. Image fuse has been commonly applied for synthesis multiple image for interpretation. There have been developed a numerous synthetic methods for remote sensing data fusing such as Lab transfer, IHS transform, Brovey transform, and wavelet transform, to name a few.

These methods work for different purposes on different application conditions. In the current study, IHS, and Brovey transform methods were applied. The applications of these methods to the SAR and TM image fusion in the study area will be introduced in the next few sections.

The advantage of encoding of HIS is that it can separate the intensity (I), colors (H) and amount of color (S). The Brovey transform is a kind of modified RGB transform that involves a normalization of RGB bands by the sum of all bands (R+G+B) and then multiplied by the intensity layer. It can be used to integrate different data for example, taking TM 7, 4, 3 as RGB bands and the enhanced SAR data as the intensity layer. This is helpful for differentiating patterns reflecting mountains, water and plants, construction areas and green areas. It is somewhat murky for smoke in cities, especially in the center of cities with high density of buildings in Beijing. It becomes sharper of the building outlines in the suburb areas. Two combinations of TM bands 7, 4, 3 and SAR data were implemented in HIS and Brovey transforms and the results obtained for a selected small area are shown in **Figs. 2**and **3** respectively.

Figure 2 HIS fused TM and SAR images. RGB – TM bands 7 4 3 and Intensity – SAR

Figure 3 Brovey fused TM and SAR images R G B – TM bands 7 3 4 and Intensity – SAR

6. EXTRACTION OF LAND USE CHANGES FROM 1997 TO 2000

In order to compare the results, two sets of SAR images with different parameters and slightly different times were used separately: first combination includes SAR images 2000.6.16, 2000.5.13, and 1998.7.11 and the second one 2000.6.16, 2000.5.13, and 1997.11.23 with different parameters from the previous set. The same processes and methods were applied to these two sets of images.

The change of land use can be reflected as spectrum change or texture change in one or more images depending on the properties of the land type change. A commonly used approach to check the land use change is to do a classification on each or a set of images captured in difference times and then to compare the differences between the classified features. However, classification of land types often involve errors which could, some times, significant if the new land use type does not show very different nature spectrum from the previous land use type. Therefore, the conventional way may not be appropriate. The method used in the current project is to fuse images of different sources such as TM and SAR as mentioned above and then integrate the fused images of different times in such that the changes of these images can be highlighted. Finally, a classification and identification of land patches can be made both based on the change of spectrum and textures of the images in different years shown in **Figs. 4** nd **5** respectively.

Figure 4. HIS fused TM and SAR images RGB – TM bands 7 4 3 and Intensity – SAR shown land patches(low green)

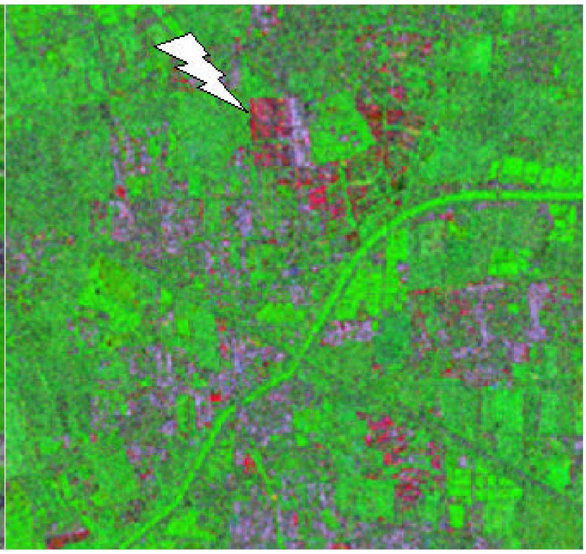

Figure 5. fused different time SAR images R 00/06,G 00/05,B 97/11 – SAR shown land patches(red)

All together 532 land patches have been identified which are the potential areas with land use changed. Field validation was conducted at 173 sites, which accounts about 33% of the total number of classified patches. A number of small patches with areas smaller than 6500 m^2 were left away from field-testing.

The field validation results show that for most of the large patches with areas bigger than 33000m^2, the areas of the classified patches are slightly smaller than their actual sizes, whereas the sizes of the patches with areas smaller than 6500m^2 are somewhat larger than their actual sizes. If the patches grouped into four classes on the basis of areas: < 6500m^2, 6500-13000m^2, 13000-33000m^2, and > 33000m^2, the success rate of the detection of land use changes from these 173 testing sites was 90%.

7. CONCLUSIONS

It has been demonstrated that applying proper image processing and analysis techniques to Radar SAR data only or together with TM images can effectively monitor the land use changes. Removing the influences of noise and edge effects of SAR data by image filtering is essential for detection of patches with true land use changes. Field validation of a significant number of sites is always necessary for evaluating the classification results to ensure the results meet the government-required standard.

8. REFERENCES

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