Improvement of Land Cover / Land Use Classification by Combination of Optical and Microwave Remote Sensing Data

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Abstract: Optical and microwave remote sensing data have been widely used in land cover and land use classification. Thanks to the spectral absorption characteristics of ground object in visible and near infrared region, optical data enables to extract different land cover types according to their material composition like water body, vegetation cover or bare land. On the other hand, microwave sensor receives backscatter radiance which contains information on surface roughness, object density and their 3-D structure that are very important complementary information to interpret land use and land cover. Separate use of these data have brought many successful results in practice. However, the accuracy of the land use / land cover established by this methodology still has some problems. One of the way to improve accuracy of the land use / land cover classification is just combination of both optical and microwave data in analysis. In this paper for the research, the author used LANDSAT TM scene 127/45 acquired on October 21, 1992, JERS-1 SAR scene 119/265 acquired on October 27, 1992 and aerial photographs taken on October 21, 1992. The study area has been selected in Hanoi City and surrounding area, Vietnam. This is a flat agricultural area with various land use types as water rice, secondary crops like maize, cassava, vegetables cultivation as cucumber, tomato etc. mixed with human settlement and some manufacture facilities as brick and ceramic factories. The use of only optical or microwave data could result in misclassification among some land use features as settlement and vegetables cultivation using frame stages. By combination of multitemporal JERS-1 SAR and TM data these errors have been eliminated so that accuracy of the final land use / land cover map has been improved. The paper describes a methodology for data combination and presents results achieved by the proposed approach.
Keywords: Land cover, Classification, Optical and Microwave data, Remote sensing, Combination.

1. Introduction

Land cover mapping has been one of activities of utilization of remote sensing data in earth sciences for a long time. Both optical and microwave remote sensing data were intensively used for this purpose. Thanks to the spectral absorption characteristics of ground object in visible and near infrared region, optical data enables to extract different land cover types according to their material composition like water body, vegetation cover or bare land. On the other hand, microwave sensor receives backscatter radiance which contains information on surface roughness, object density and their 3-D structure that are very important complementary information to interpret land use and land cover. Separate use of these data have brought many successful results in practice. However, the accuracy of the land use / land cover established by this methodology still has some problems. One of the way to improve accuracy of the land use / land cover classification is just combination of both optical and microwave data in analysis. The ways of combination of these two data types are several. According to [2] one can fuse optical and microwave data by pixel, feature and decision based approach. In pixel based fusion, the data are merged on a pixel-by-pixel basis. Feature based approach always merge the different data sources at the intermediate level. Each image from different sources is segmented and the segmented images are fused together. Decision based fusion, the outputs of each of the single source interpretation are combined to create a new interpretation. Another concept is usage SAR data as complementary information source for interpretation of optical imagery [1]. In this study, the author presents a decision based combination of Landsat TM and JERS-1 SAR data for land cover mapping of Hanoi City and surrounding area. A comparison study of using only optical, single data SAR and multi-temporal SAR data for land cover mapping have been carried out. Finally a method for combination of optical and microwave data has been proposed. Land cover map which was compiled by the proposed method seems to be the best because it separates well many land cover categories that can not be classified if only optical or microwave data were used.

2. Study Area

The study area is Hanoi City and surrounding area that is located in north of Vietnam. Land cover of the study area contains mainly categories as: urban, built-up, rural human settlement, perennial and short term agricultural cultivation, rice crop, water bodies etc. The terrain is flat so there is no need of ortho-rectification of SAR data. Both optical and SAR can be resample to the same spatial resolution and overlaid each on the other. On figure 1 is outline map of the study area.

Fig. 1. Location of study area in North of Vietnam

3. Materials and Methods

The data used for this research consists of Landsat TM scene 127/45 acquired on October 21, 1992, March 8, 1993 and August 18, 1993. Aerial photos taken on October 21, 1992 were used as ground truth information. Before analysis, all the image data were geometrically corrected using topographical map 1:100000. The accuracy of correction is within one pixel limitation. The JERS-1 SAR data were resampled to 30m resolution as the same of Landsat TM data.

3.1 Classification of Landsat TM data

The Landsat TM data was classified using Maximum likelihood method. Training samples were selected for the following classes:

Sand	Sand, sandy beach located along Red river
Veget1	Agricultural cultivation and secondary crop as maize, berry, sugarcane,
Veget2	Vegetation with canopy structure
Built	Built up area, urban and construction
water	water body as lake, pond, reservoir and river
wetld	Wetland as shallow ponds, flooded rice field, irrigated paddy
Agrld1	Harvested paddy field
Agrld2	Paddy field with young secondary crop

After selecting training samples, MLC (Maximum likelihood classification) has been carried out. Figure 2 shows false color composite of study area and figure 3 displays MLC result.

The classified image shows, in general, well distributed land cover categories. However, there are some misclassifications in classes built up and agricultural land. It was also impossible to separate rural human settlement and perennials that were merged into class Veget2.

3.2 Analysis of single date JERS-1 SAR data

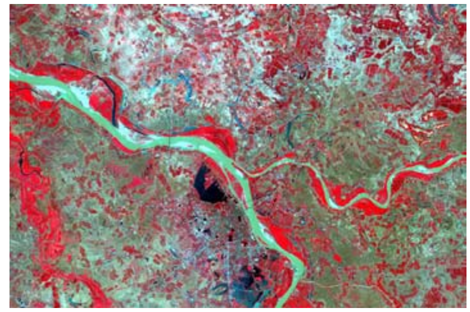

Fig. 2. Landsat TM false color composite of study area

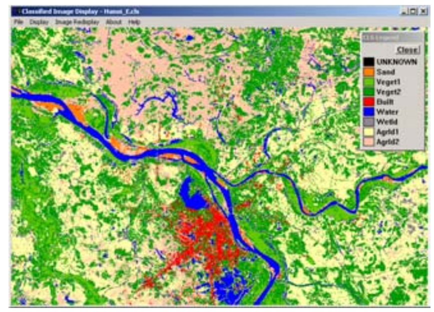

Fig.3. Land cover of study area established by TM data and ML classification

The single date JERS-1 SAR data provides information on land cover through backscatter radiance. The understanding of this image requires auxiliary information and local knowledge of land cover. Solely usage of SAR data for land cover still faces difficulties. A simple analysis has been applied for single date SAR data. The analysis was confined to usage of backscatter values for classification of land cover objects. On figure 4 is shown level sliced SAR image of Oct. 21, 1992. The land cover was separated one from the other mainly by their surface structure and not by material composition as in case of optical sensor. Five categories were classified and they are:

To 1	Very flat object. In the study area, it represents mainly water body
To 2	Paddy field, flat object
To 3	Low density or light structural object
To 4	Medium density or moderate structural object
To 5	high density or complicated structural object

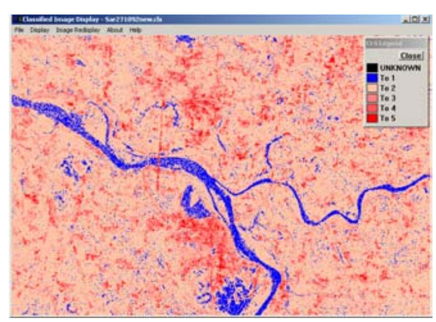

Fig. 4. Level sliced JERS-1 SAR image

3.3 Change extraction using multitemporal JERS-1 SAR data

The multitemporal JERS-1 SAR dataset consists of three dates: Oct. 21, 1992, Mar. 8, 1993 and Aug. 18, 1993. The dates were chosen so that seasonal variability in land cover (particularly agricultural cultivation) is maximal. Color composite of three SAR data is shown on figure 5. Color assignment is Red= Aug. 18, 1993, Green= Mar. 8, 1993 and Blue= Oct. 21, 1992. Land cover objects that changes seasonally are shown in different color shades. Stable objects are displayed in gray tone. It is very easy to extract urban, rural human settlement and perennials from agricultural cultivation by visual interpretation. This interpretation can be carried out digitally by conversion the color composite to IHS image and extracting uncolored objects from colored ones. The figure 5 shows color composite of multitemporal SAR dataset and stable objects extracted from that are shown on figure 6.

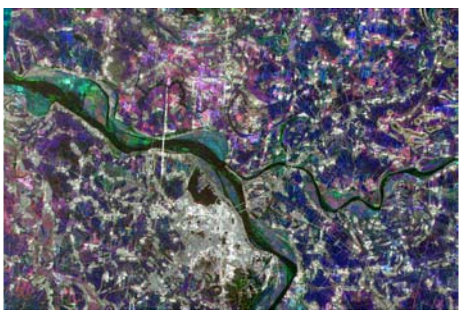

Fig. 5. Color composite of multitemporal SAR dataset

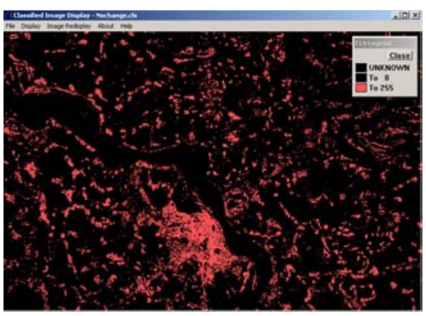

Fig. 6. Stable objects extracted from multitemporal SAR data

3.4 Land cover classification by combination of SAR and optical data

Obviously, solely application of optical data as stated in previous paragraph enables to establish good land cover map, however, there are still some misclassification and the result needs to be refined for practical use. Combining analysis results of both optical and JERS-1 SAR we could obtain the best result. The figure 7 shows final land cover map that was established using both optical and SAR data.

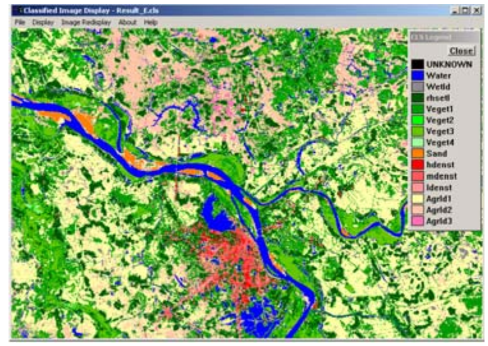

Fig. 7. Land cover map established by combination of optical and microwave data

Beside the classes that were segmented using only optical data, new classes coming from SAR data were added and they are:

rhsetl	rural human settlement
hdenst	high density construction area
mdenst	medium density construction area
ldenst	low density construction area
agrld3	non flat paddy field (furrows, beds)
veget4	broad leave agricultural cultivation as edible canna

4. Conclusion

The decision based combination of optical and mutitemporal SAR data is quite simple but effective because it enables to extract rural human settlement, different agricultural cultivation types, urban and built up area with different construction density that are impossible to be classified if only optical or SAR data was used. The approach presented in this study does not requite any special software therefore it can be applied even in very modestly equipped remote sensing laboratory.

Acknowledgement

The author would like to acknowledge the Basic Research Program of Vietnam for funding this research. Thanks also belong to staff of Department of Environmental Information Study and Analysis for collaboration in field work and data analysis.

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