COMBINATION OF MULTISPECTRAL AND SAR REMOTE SESNING DATA FOR URBAN STUDY

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ABSTRACT:

Multispectral remote sensing data has been widely used for land cover mapping as well as urban study. The mechanism of ground object recognition is based mainly on its spectral reflectance characteristics. This mechanism has been implemented in different classification techniques such as maximum likelihood or pipeline classifier etc. However, in most cases, spectral information does not provide sufficiently information on texture and surface roughness which are important for land cover classification and usually are different even for objects with almost the same spectral reflectance characteristics. SAR remote sensing data on the other hand supplies information on surface structure, texture patterns and even sub-surface layers that are now widely used in geological mapping, terrain study and forestry research. Conventional independent application of these data leads to certain limitation of accuracy in ground objects recognition. To achieve the best result it is strongly required to combine both these data for the analysis. In this paper the author presents research results on combination of multispectral and SAR remote sensing data for urban study. The used dataset is composed of Landsat TM of October 21, 1992 and JERS-1 SAR of October 27, 1992 of Hanoi city. The time difference between two data is only 6 days which could be neglected. At first the maximum likelihood classification was used to extract urban area. The classified image was then combined with SAR data to segment out different land cover categories including built up and construction areas according to its texture and surface roughness. By combination of both multispectral and SAR data, the land cover condition of urban environment was better classified. Some errors caused by misclassification of TM data was corrected by using SAR. Thanks to SAR information, several types of urban environment have been detected. These types would not be able to be interpreted if only Landsat TM data was used. The result was validated by interpretation of aerial photos that were acquired at the same year.

1. INTRODUCTION

Optical remote sensing data such as LANDSAT TM, SPOT HRV have been widely used in urban study. The mechanism of ground object recognition of these sensors is based on spectral reflectance characteristics of land cover categories that are, in general, independent on their surface roughness and texture patterns. This limits in certain way classification capability of these data types. The SAR, on the other hand, provides information mostly on surface roughness or texture that have no correlation to material composition of the ground object. Separate use of both multispectral and SAR data has brought fruitful results in thematic mapping, however, a combination of both data types for land cover mapping in general and urban study in particular could be one of the way to improve accuracy of classification. In this paper, the author presents preliminary result on combination of multispectral and SAR remote sensing data in urban study. Even the optical and SAR data were not acquired in the same time, how ever, the research could be useful for the study of potential application of the future AVNIR-2 and PALSAR of ALOS mission when the sensors will generate a simultaneous observation of land area.

2. MATERIALS

The materials used in this study are composed of:

+ LANDSAT TM scene 127/45 acquired on October 21,1992
+ JERS-1 SAR scene 119/265 acquired on October 27, 1992
+ Aerial photos taken on October 21, 1992
+ GPS photo database

The LANDSAT TM was at first geo-rectified with GCP collected from 1/100000 topographic maps. Accuracy of the geo-rectification is within 1 pixel. The SAR image was subsequently registered to the TM scene using image to image registration technique. The study area was chosen as city of Hanoi with boundary of the year 2001 that has been defined using ASTER image. Hanoi city and neighborhood is shown on figure 1. On this figure is also JERS-1 SAR data of the same area. The SAR data has been converted from power to normalized radar cross section using the following equation that is given in the User's Guide to NASDA's SAR Product ver.2

$$NRCS=20\log_{10}(I)+CF(dB)$$

The value I stands for digital count of the pixel.

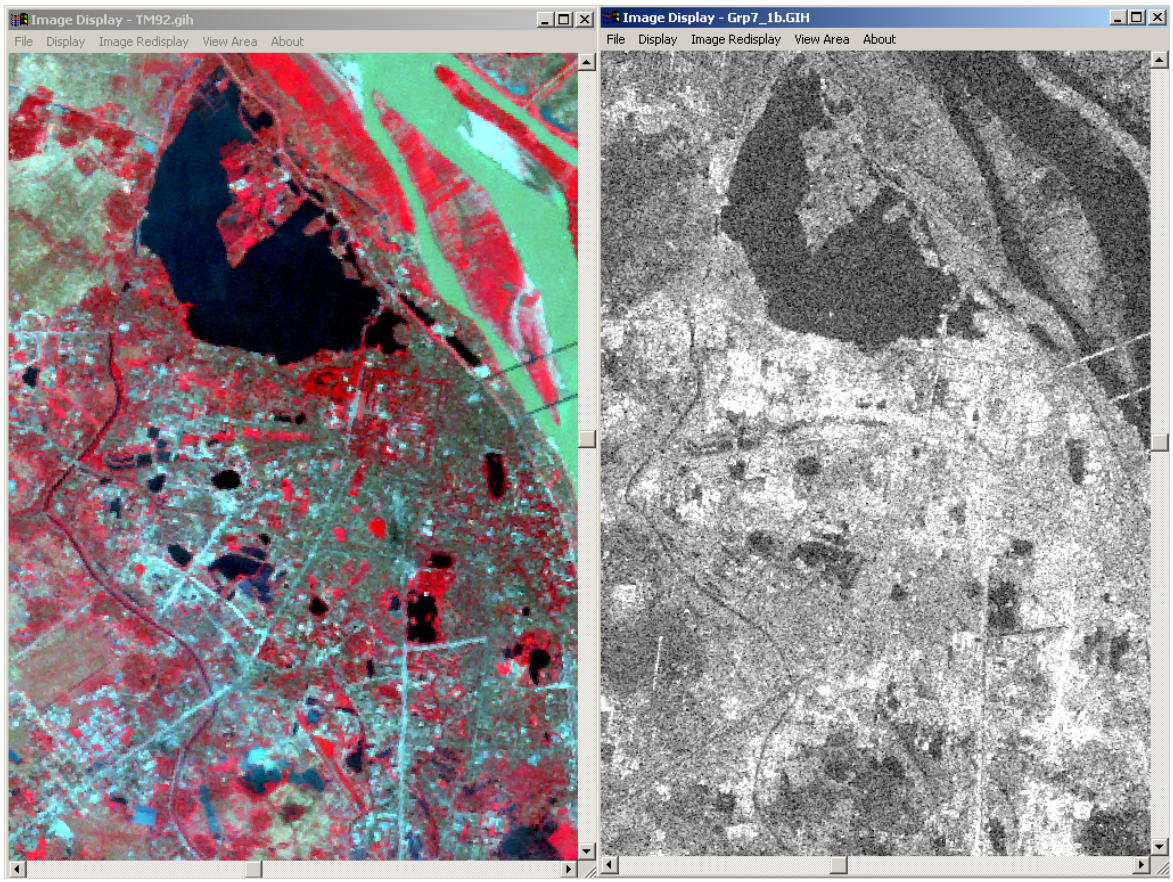


Figure 1. Standard color composite of TM (left) and JERS-1 data after conversion to NRCS (right)

The date of acquisition of both TM and JERS-1 SAR data falls into dry season for Red's river delta. At this moment rice crop has been harvested so dry fallow land appears as same as built up area in urban. It is very high possibility for misclassification of both these categories if only optical data will be used for the classification. On the figure 1 the Hanoi city is located south of the Western lake which is the largest one and located on top of the image. Fallow land is distributed mostly in the left top and bottom parts of image. Housing and built up area is displayed in cyanic colors with various shades, contrast and texture patterns that is recognized very easily by visual interpretation. However, conventional pixel-wise classification algorithms have some difficulties in it detection and especially in separation of housing and built up area into different categories according to their density and texture.

3. URBAN EXTRACTION USING MULTISPECTRAL DATA

The urban area is understood in this study as landscape that is composed of housing and built up area, vegetation, bare land and water bodies. The LANDSAT TM with six spectral channels allows to classify easily these categories. The maximum likelihood classification method has been chosen for this purpose. Four classes have been selected for classification: housing and built up area, vegetation, bare land and water bodies. Before the classification a boundary of Hanoi city has been applied on the dataset. This will reduce some extra work and enable better focus on the study area. On figure 2 is shown classification of Hanoi city by maximum likelihood method. The four categories are displayed in red, green, gray and blue colors respectively. The built up area was classified in to single class, but in practice, it can have different density and structure that is almost impossible to separate using TM data.

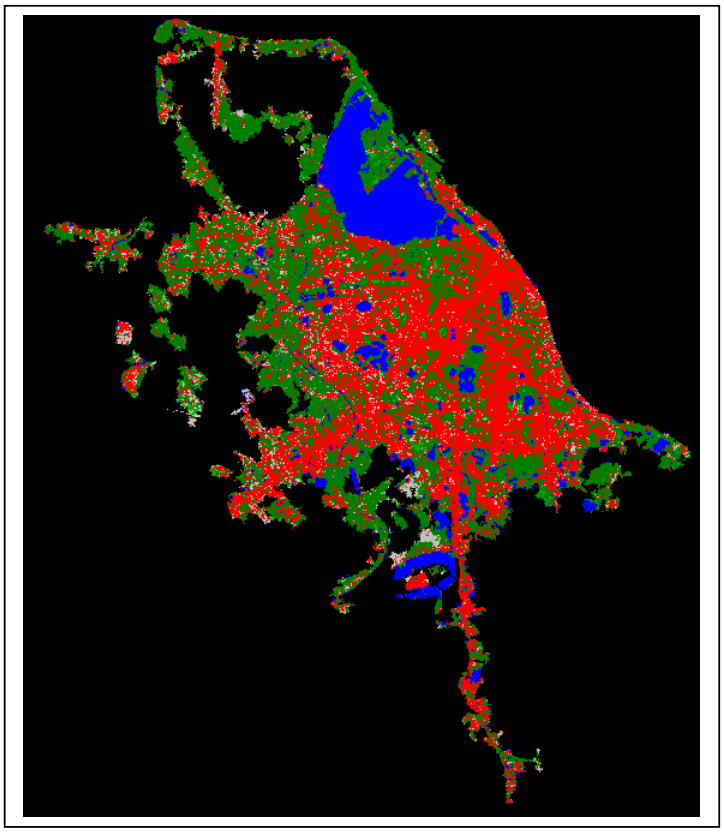


Figure 2. Hanoi City as classified by TM data (left)

4. SAR AND URBAN STUDY

The SAR data as known provides mostly information of surface roughness and therefore texture of land cover categories. Single date SAR data display built up area, tree coverage and crop in different brightness which is in proportion to backscatter level and therefore their surface roughness. Using single date SAR data we can separate by level slicing three groups of objects such as:

+ low back scatter-water bodies, fallow land, flat surface
+ medium back scatter-built up area with low density, sparse vegetation
+ high back scatter-built up area with medium or high density, tree coverage, crop field

Multitemporal SAR data can improve classification. On figure 3 is shown color composite of SAR data taken from three dates: September 13, 1992, October 27, 1992 and March 8, 1993 assigned to color blue, green and red respectively. On this image, crop field is shown in different color shades, water bodies appear in black color, gray shades show distribution of various unchanged objects such as housing and built up area, evergreen tree coverage (parks and zoo). It is still difficult to separate built up area and evergreen tree coverage, however, the land cover has became more understandable.

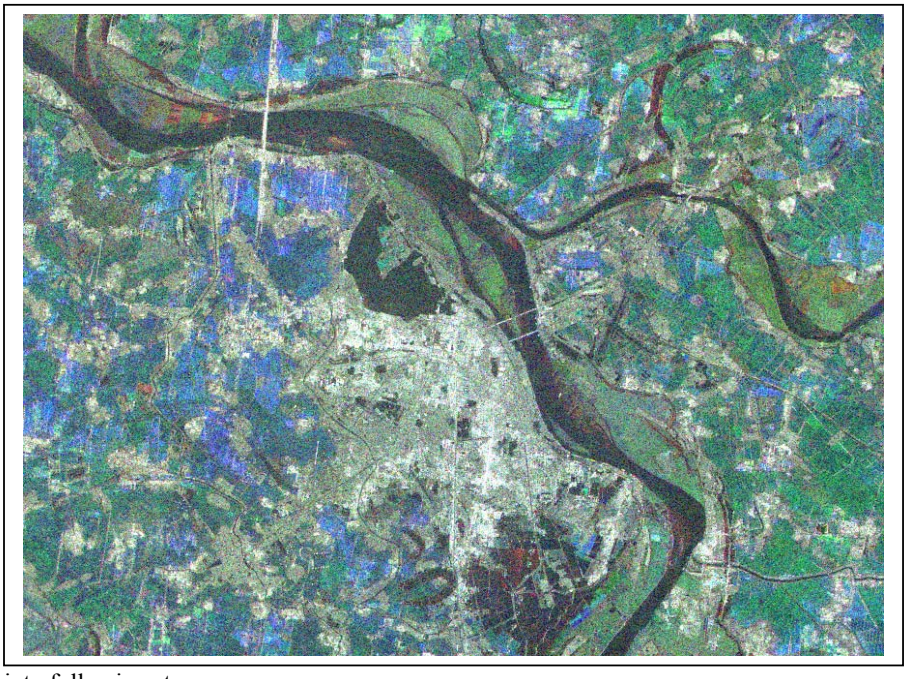


Figure 3. Color composition of multi-temporal SAR images (left)

5. COMBINATION OF SAR AND OPTICAL SENSOR DATA

One of the way to overcome obstacles pointed out in the above paragraphs is to combine both SAR and multispectral data. There are several approach of combination for example data fusion etc. In this study the author used post classification approach that is divided into following steps:

+ Maximum likelihood classification of land cover
+ Extraction urban area in SAR image using optical image mask
+ Level slicing of the SAR image according to different backscatter values
+ Overlay of the level sliced SAR image on the ML classified image to create final land cover map of Hanoi city

On figure 4 are shown level sliced SAR image and its overlay on the TM classified image. The housing and built up area has been classified into 4 classes: flat surface, low density, medium density and high density of construction. These classes are colored in yellow, light pink, orange and red respectively. Definition of these classes is based on visual interpretation of black and white aerial photos. On the table 1 is shown patterns of these classes on aerial photo and SAR images and on figure 5 is ground photo of high density built up area. The density level of built up area was estimated visually without any measurement. There area several advanced tools for texture definition but due to time limitation we did not apply them in this study.

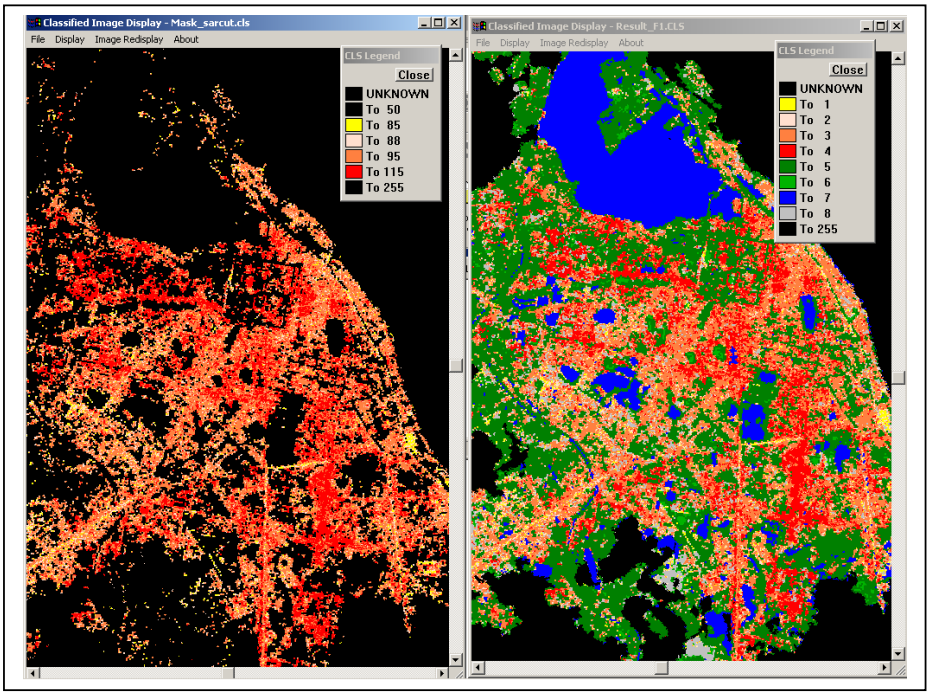


Figure 4. Level sliced SAR image and its overlay on optical classified image

Figure 5. High density of construction area in down town of Hanoi

Table 1. Texture patterns of different built up area seen on SAR image and aerial photos

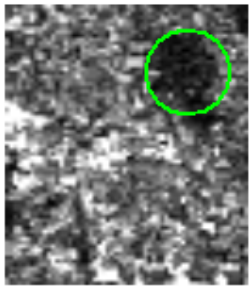
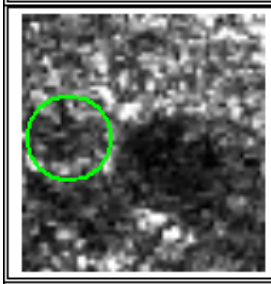
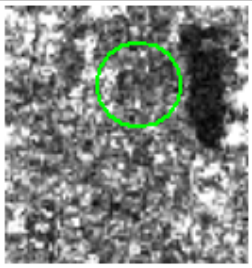
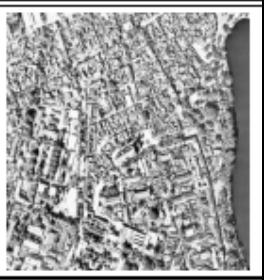
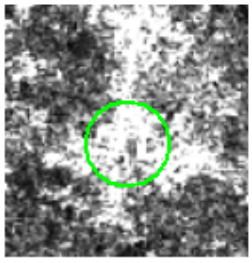
Class name	JERS-1 SAR	Aerial photos
Flat area		
Low density of construction		
Medium density of construction		
High density of construction		

Figure 5 brings closed view on high density construction area on the ground. Small construction of housing and diverse structure of roof has caused high level of SAR backscatter. This pattern is typical for down town and old town of Hanoi. The low density of construction stands in most cases for new apartment blocks, modern office buildings or service centers where is reserved space between buildings (around 20 m in width).

On figure 6 is comparison of ML classified image and result of combination of SAR and TM image for urban study. The left image is result of ML classification and the right is result of combination of TM and SAR. Instead of only one red color (one class) in left image for urban, on the right we could see better structure of urban construction by following different color shades. High density construction is located mainly along old streets, while the medium density construction dominates newly developed parts. The color distribution has enable to enhance urban structure that is impossible to recognize on the optical (TM) classified image.

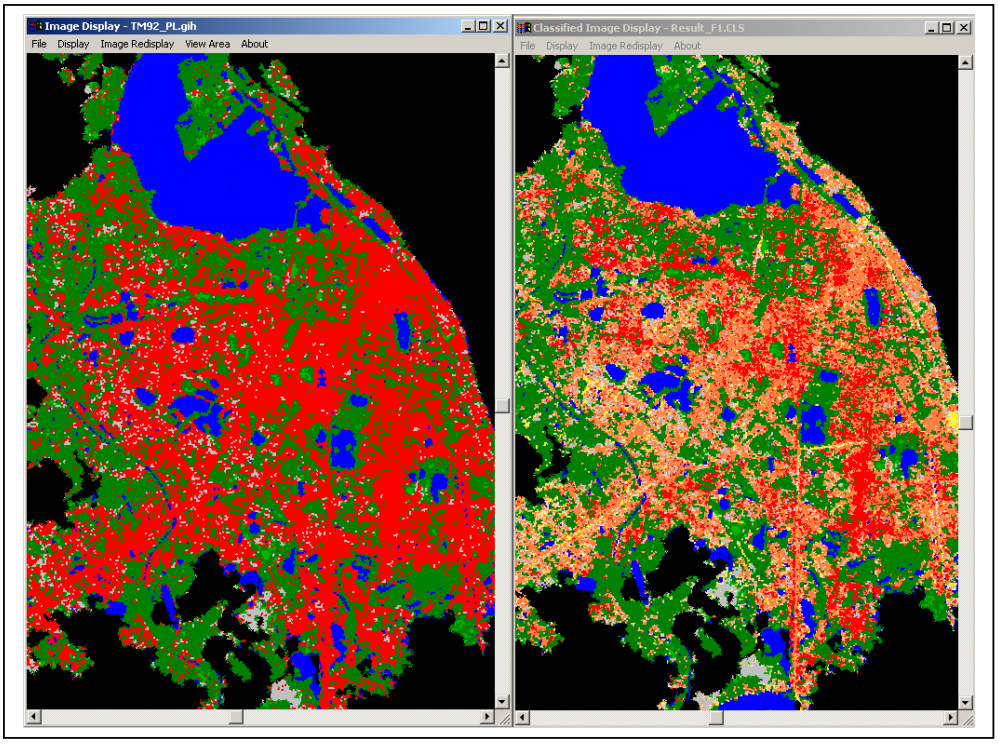


Figure 6. Comparison of urban map established by TM image (left) and combination of TM and JERS-1SAR (right)

6. CONCLUSION

This is a preliminary result on study of combination of SAR and optical data for urban study. The approach used in this study seems to be simple but quite effective. By using the SAR image, the optical classified image has been refined to achieve more classes in built up area. This allows to get better classification on urban area from construction density point of view. The time difference between TM and JERS-1 SAR is 7 days, in ideal case both data should be acquired at the same time. Simultaneous observation by SAR and optical sensors will be possible in the future ALOS mission with AVNIR-2 and PALSAR instruments.

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