COMBINATION OF ALOS PALSAR AND SPOT 5 FOR LAND COVER MAPPING – CASE STUDY OF CA MAU, VIET NAM

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KEY WORDS: Microwave, ALOS PALSAR, Optical Remote Sensing, SPOT5, Land Cover, Mapping, Ca Mau, Vietnam.

Abstract: Optical remote sensing imagery is often used for land use, land cover mapping and monitoring. However, the data is limited due to the frequent cloud cover in tropical regions such as Vietnam. The microwave remote sensing data is utilized to overcome this problem. The aim of this study is to interpret the gap caused by cloud cover on SPOT image by the microwave data in order to improve the accuracy of the land cover map.

The ALOS PALSAR and SPOT 5 images of Ca Mau area, Vietnam were chosen for this study. Firstly, several filters such as Lee, Frost, Gamma, Median and local Sigma filters were applied to the radar image so as to reduce the noise and enhance the image quality. Secondly, the microwave and optical data were geo-referenced to VN-2000 coordinate system. After that, the PALSAR image was combined to the SPOT imagery and data fusion techniques such as NDVI, PCA (Principal Component Analysis) and Color Composite (HIS and Brovey) were used. Then unsupervised and supervised classification methods were applied to the results of the data fusion to generate a land cover map with various categories. The use of the hierarchical analysis, unsupervised classification result of radar image can be grouped following the supervised classification of SPOT. Finally, the result of fused image classification was compared to the SPOT5 classification and edited to establish land cover map. During the processing and mapping steps, the role of ALOS PALSAR data in land cover mapping was estimated.

1. PROBLEM STATEMENT

Remote Sensing is a very common and useful method for establishing land cover maps. It is also frequently used for efficient monitoring of natural resources and for protecting the environment. It is really effective in developing countries with a tropical climate like Vietnam. The data of optical remote sensing satellites such as SPOT, Ikonos, etc. are often used in conventional methods because of their advantages including resolution, both radiometric and spatial. However, the disadvantage of the optical data is cloud effect. In areas frequently covered by clouds, it becomes a considerable problem to obtain cloud free satellite images for land cover mapping. In contrast, microwave remote sensing data is not affected by cloud but only affected by the relief. There are several major benefits and limitations of medium–resolution optical and radar imagery in general [2]. Therefore, the combination of radar and optical remote sensing data in land cover mapping is necessary to be studied in order to combine the advantages of the two different images.

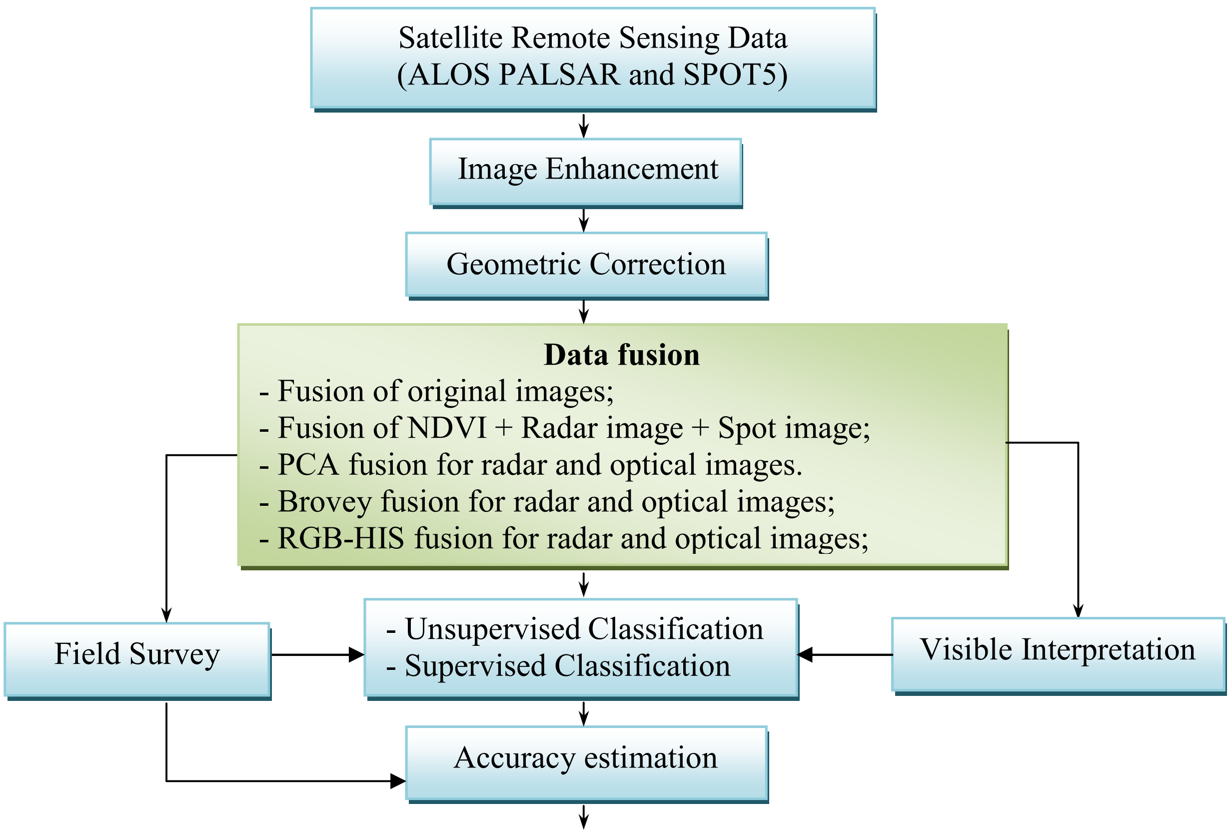
The method used in this paper is fusion technique. The fusion of the different data was done before the classification step. Information from fusion data is then used to add to the lacking information in the cloudy areas on the optical image. The objective of this study is to develop a fusion technique that can be used to create land cover map jointly from microwave and optical remote sensing data. In order to reach the objective, the processing of the data includes the application of various filters, of data fusion methods, of classification of optical data and fusion data and finally, the land cover map is established. From the study, we found that the information from radar image may be used to add to the absent information under cloud on the optical image because the microwave image has the ability to penetrate the cloud.

2. METHODOLOGY

Ca Mau peninsula [8] is located in the Mekong Delta, southern Vietnam, geographical coordinates: 8°30' to 9°33' N, 104°43' to 105°24' E. Ca Mau area is chosen as case study as it is characterized by frequent cloud cover and heterogeneous land cover.

The SPOT 5 multi-spectral image (273-332, dated 05 January 2011, resolution 10m) and the ALOS PALSAR image (PASL15010010515445911011110292B, dated 10 January 2010; spatial resolution of 12.5 m, HH polarization and L band) were acquired over the study area. These data were processed with Envi4.5 and ArcGIS10.0 software. The topographic map of Ca Mau province with the scale 1/50,000 in 2004 supplied by Vietnam Natural resources and Environment Corporation was used for image geometric correction to the VN-2000 coordination system. A land use map in 2010 of the study area was also used for validation and accuracy analysis of the classification results.

The main steps of data fusion of ALOS PALSAR and SPOT5 images for land cover mapping and accuracy estimation are shown on Figure 1.



Land Cover Map

Figure 1: Combination of ALOS PALSAR and SPOT5 images for land cover mapping

Digital image processing steps in the Figure 1 are described more detail below.

**** ALOS PALSAR image enhancement***

Microwave image enhancement is a very important step in the progress of digital image processing for land cover mapping. Radar image reflects clearly the structure of relief because of its oblique imaging geometry (side-looking). Radar image are made up of digital numbers characterizing the intensity of the back-scattered energy for each individual pixel. The contrasted the back-scatter from different objects enables them to be visually discriminated. In term of statistic, the numeric value (absolute value) of pixels can be estimated by mean and the changing (relative value) by standard deviation. For speckle reduction, microwave data needs to be filtered by various filters.

For SAR images, Lee, Frost, Gamma-MAP have been shown to be adequate filters [1], [4]. These were applied to reduce the noise and enhance the image quality. Lee filter, as well as Gamma filter, has been developed as standard filter for radar image processing. Figure 2 illustrates the effective Lee filter size 5x5 pixels for area with intense back-scattering. The noise has also been significantly reduced thanks to the filter.

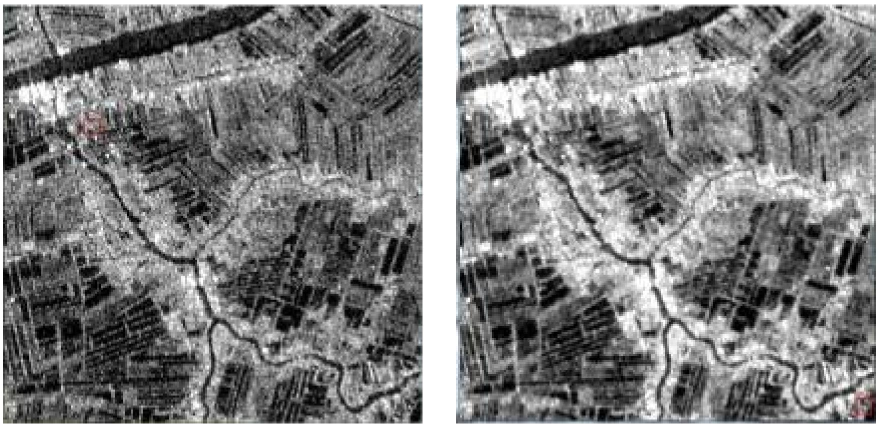


Figure 2: Radar image (left) and its filtered image (right) using Lee filter (5x5)

**** Geometric Correction***

The topographic map is utilized for geometric correction to the VN-2000 coordinate system of the optical and microwave images with the allowed accuracy (<1 pixel).

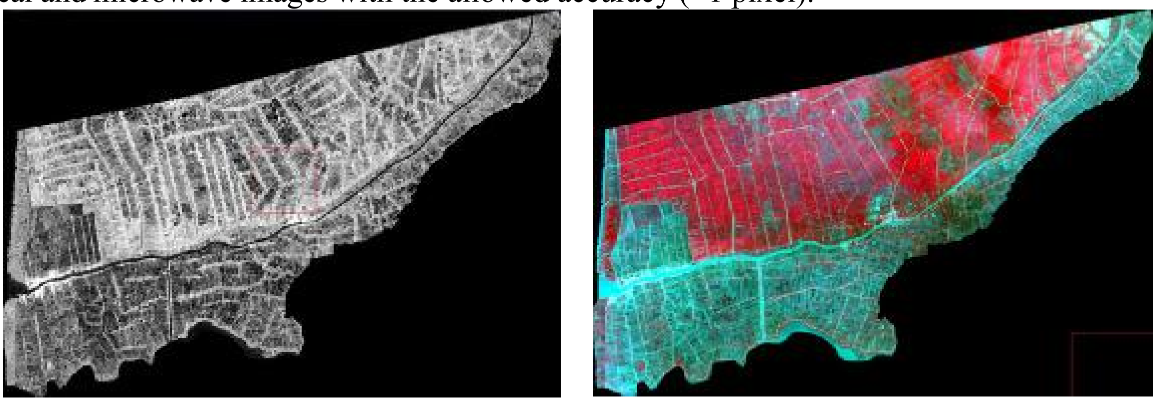


Figure 3: ALOS PALSAR (left) and SPOT5 images (right) after geo-referencing

**** Data Fusion***

Fusion technique was applied to integrate information from the optical image (SPOT5) and the radar image (ALOS PALSAR). This technique allows to create one or many new channels containing information from input channels. Each channel has its specific characteristic for interpretation. There currently exist many types of fusion of radar and optical satellite images. In this study, several types of data fusion were applied: fusion of original images, fusion of NDVI + Radar image + Spot images, Brovey fusion for radar and optical images, RGB-HIS fusion for radar and optical images; PCA fusion for radar and optical images, [5]. In the fusion images, land cover objects can be separated quite easily (Figure 4.).

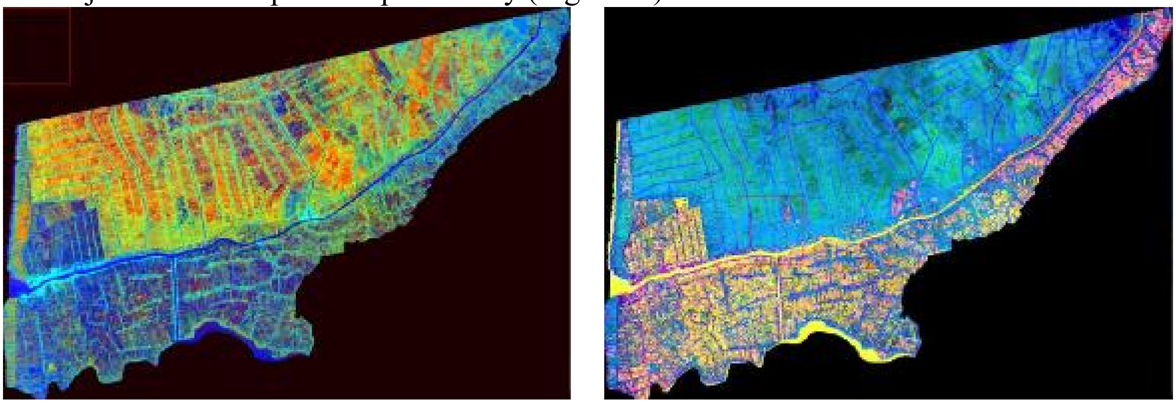


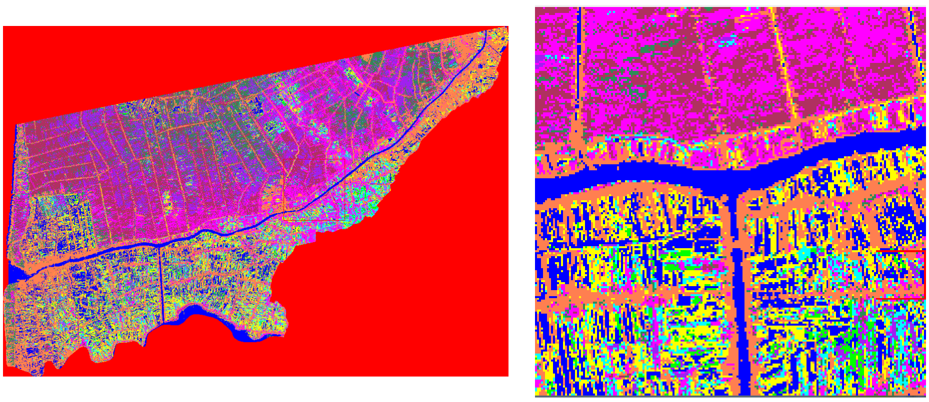
Figure 4: Examples of data fusion: NDVI + Radar image + Spot image (left) and RGB – HSV (right)

**** Classification***

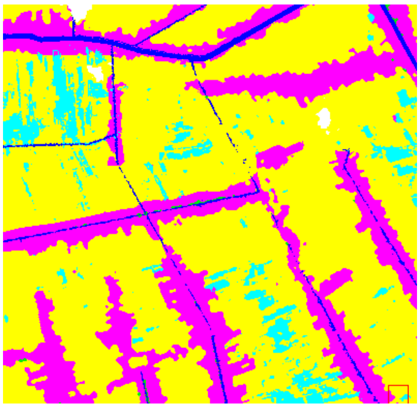
Unsupervised Classification of Data Fusion: It can be seen as a traditional method of digital image processing. Digital image can be classified into a specified number of classes into a but the natural character of the classes is unknown. In the study, fusion images were used for classification. Clustering is a grouping of data with similar characteristics. The results are shown in Figure 5.

Supervised Classification of Spot Image and Data Fusion: The SPOT and fusion images were classified by using supervised classification method. In supervised classification, considering the differences of spectral features between different objects in each Spot band and each fusion data, the maximum likelihood method was applied in order to separate different categories of land cover. The difference of spectral features of land cover is clear. For separating the different types of land cover, besides using spectral characters, the information from field survey and land use map are required as calibration and validation data. This study used the land use map for validation the results of fusion classification. The results are shown in Figure 5.

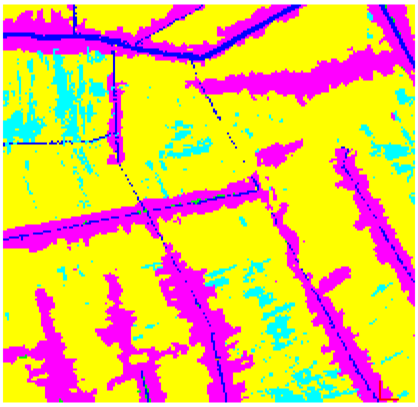
3. RESULT AND DISCUSSION



Land cover classified image using unsupervised classification from fusion image – Ca Mau area



Land cover classified image using supervised classification from Spot image – Ca Mau area



Land cover classified image using supervised classification from fusion image - Ca Mau area

Figure 5: Land cover classification using unsupervised and supervised classification from Spot and fusion images (white color: cloud)

- Accuracy estimation of supervised classification of the fusion images is shown in Table 2 - with the overall accuracy and Kappa coefficient are 96.6% and 0.96, respectively.

Table 2: Overall accuracy of fusion image classification results

Types	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Total	User. Acc (%)
Paddy rice (1)	840	0	3	4	0	0	0	0	847	99.1
Fruit trees (2)	0	552	0	10	0	4	0	0	566	97.5
Aquaculture (3)	0	3	643	0	7	0	4	0	657	97.9
Settlement, built up area (4)	21	40	13	420	5	0	0	0	499	84.2
Mangrove forest (5)	0	0	0	0	460	0	0	0	460	100
Water body (6)	0	1	1	3	0	478	1	0	484	98.8
Bare land (7)	0	0	0	0	9	0	191	0	200	95.5
Others (8)	0	0	0	0	0	0	0	96	96	100
Total	1422	918	766	843	1177	1176	75		13979	
Prod. Acc (%)	97.6	92.6	97.4	96.1	95.6	99.2	97.4	100		
Overall Accuracy	(3680/3809) = 96.6%									
Kappa Coefficient	0.960									

- Finally, ArcGIS software was used to edit and establish the land cover map as presented in Figure 6.

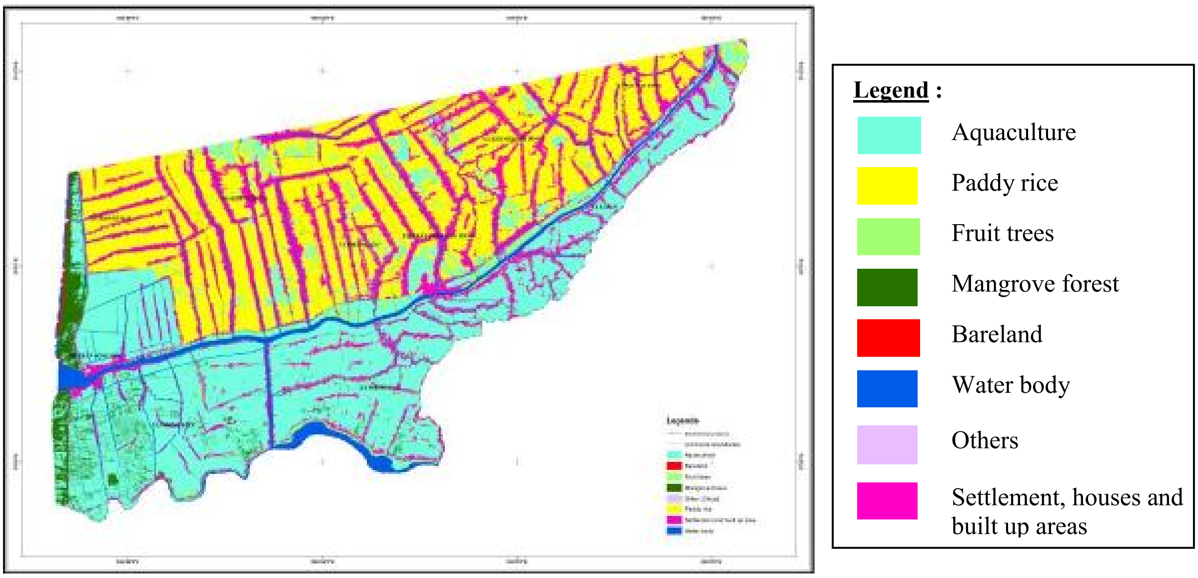


Figure 6: Land cover map from combination ALOS PALSAR and SPOT classification in Ca Mau area

The accuracy of the classified image from the fusion data is estimated based on the information of the existing land use map. Some areas in the SPOT image were covered by cloud so the categories of land cover in those areas are difficult for interpretation. The classification results of the optical image and the fusion images of optical and radar data were used for completing the lacking information. Fusion data processing includes fusion steps, unsupervised classification and supervised classification. At the same time, the optical data were processed through unsupervised and supervised classification. All processing aimed at combining information from radar and optical imagery. Optical imagery with wide spectral range can bring plenty information in terms of land cover while radar imagery can give the adding information that was lacking by effect of cloud on optical imagery. The disadvantage of this method is requiring remote sensing data of the same area and fees to buy optical and also radar images. The final result is a land cover map with 8 different categories from multi-sensor data.

4. CONCLUSIONS

- The combination of radar and optical remote sensing data for land cover mapping is worth to investigate as it enables to combine the advantages of the two different images, especially in areas frequently covered by clouds typical of tropical climate like Vietnam. Radar remote sensing data is not affected by cloud but is sensitive to the relief, in contrast with optical remote sensing data. Radar and optical imageries can be combined successfully in applied studies, for land cover mapping in this case.

- The information given by radar images is useful for monitoring natural resources and protecting the environment, especially in the tropical and cloudy country like Vietnam, and can be used effectively in an integrated information system.

- Image fusion may be considered as an effective method as it enables to extract the needed information from both radar and optical imagery. Fusion data provides much useful information, increased the accuracy of the interpretation, to save time and expense for field survey.

5. ACKNOWLEDGEMENT

We would like to express our gratitude to Vietnam Natural Resources and Environment Corporation who provided the necessary topographic map and land use map and the Vietnam Remote Sensing Center for supporting the SPOT5 image.

We also would like to thank to the METI (Japanese Ministry of Economy, Trade and Industry) and JAXA (Japan Aerospace Exploration Agency) retain ownership of the original ALOS PALSAR data, which were distributed by Earth Remote Sensing Data Analysis Center.

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