A COMPARISON OF HYPERSPECTRAL DATA AND WORLDVIEW-2 IMAGES TO DETECT IMPERVIOUS SURFACE

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ABSTRACT

One of the most important issues in urban area study during these years is loss of land resources due to rapid expansion and development of urban centers and cities therefore impervious surface (IS) is increased. Thus detection and mapping the impervious surface accurately is one of the important tasks in urban remote sensing. In this study, airborne hyperspectral data and Worldview-2 image were used to classify urban area .The main goal of this study are to compare the hyperspectral data and worldview 2 images and shows the potential of worldview 2 images for detection the impervious surface from the same area. Support vector machine was used as the classification method in both images. The result shows that the hyperspectral data is more accurate for detection of the materials in urban area especially roof type. The overall accuracy is 78% with 0.72 Kappa coefficients but on the other hand the overall accuracy of worldview 2 image is 72% with 0.65 Kappa coefficients. Thus finally based on the result the airborne hyperspectral data is more suitable for detecting the impervious surface in more detail but still there are some limitations. Furthermore the worldview 2 image shows good potential for detection the impervious surface in detail but further works should be done to combine the spectral information with spatial and texture information in order to improve the classification.

Keyword: Urban remote sensing, Impervious surface, Hyperspectral, Worldview-2, classification

INTRODUCTION

Population growth and urban expansion have advanced at an unprecedented pace over the past few decades. Although cities occupy only a very small portion of the Earth's total land surface, almost half of the world population live in urban areas (United Nations 2001). Cities are centers of human activity, because of city booming, urban mapping is becoming significant. The purpose of urban mapping is to accurately describe the figure, structure, geography and relationships of the features in the city .Urban areas are characterized by a large variety of artificial and natural surface materials influencing ecological (Arnold & Gibbons, 1996), climatic and energetic (Oke, 1987) conditions.

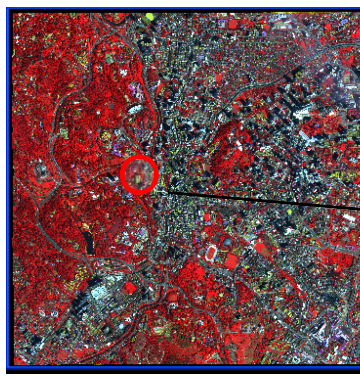
One of the most popular applications of remote sensing in urban area is detection of impervious surface (IS). Impervious surfaces are anthropogenic features through which water cannot infiltrate into the soil, such as roads, driveways, sidewalks, parking lots, rooftops, and so on. In recent years, IS has emerged not only as an indicator of the degree of urbanization, but also a major indicator of urban sustainability. However, accurate impervious surface extraction is still a challenge. Effectiveness of IS in urban land-use classification has not been well addressed (Lu and Weng 2006).One of the most important IS in the urban area is roof of the building. Roof types and conditions can be important information that can be extracted from hyperspectral data (Marino et al 2000) By knowing the roof material types, certain applications can be benefited, such as disaster preparedness (Bhaskaran et al, 2001), solar photovoltaic energy modeling can be carried out by combining hyper spectral and Lidar data (Szykier ,2008) and urban heat island assessment (Ben-Dor 2001).Studies show that imagery of urban areas must have a spatial resolution in the meter to sub-meter range to be useful for many of the different types of applications(Jenson,1999),Thus in this study, two remote sensing images have been used in order to detect the impervious surface especially roof materials which are airborne hyperspectral data and Worldview-2 image from the same area. In order to classify the image the Support vector machine has been used which has given good accuracies when applied to hyperspectral images (Camps-Valls, and Bruzzone, 2005, Fauvel, 2007) based on the literature shows the good results to classify the heterogeneous area.

Furthermore in order to improve the classification accuracy the Lee and Enhance lee filter applied on hyper spectral data (Taherzadeh and Shafri, 2011).

MATERIAL AND METHOD

Study Area

The test site was chosen in some part of Kuala Lumpur which contains a mixture of historical and modern buildings. In this study the AISA Eagle airborne hyperspectral sensor and Worldview-2 image were used which the former collected the data in 128 bands from 400 to 1000 nm with approximately 5 nm spectral resolution with 1 m spatial resolution.(figure 2) and the latter collect the data in 8 bands with 0.68 meter spatial resolution(pan sharpening).



Worldview-2

Hyper spectral data

Categorization of Urban Material

Based on our images, the test site was categorized for classification of different materials in the study area. To do this, field survey has been conducted and finally 9 classes were defined in order to generate ground truth map.

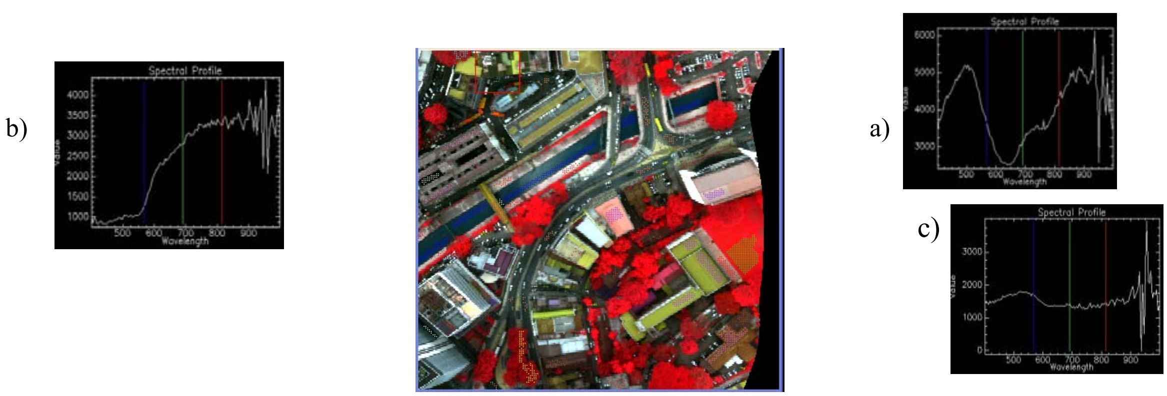


Figure 1. Spectral reflectance of different materials a) Zinc roof b) Clay roof c) Tarmac.

Preprocessing

Before processing the data, atmospheric and geometric corrections were applied on our images. Due to the lack of some meteorological parameters during the data acquisition using the advance atmospheric correction method is difficult task. The Quick Atmospheric Correction extension (QUAC) was used on hyperspectral data and for

Woeildview-2 image, IAR Reflectance calibration (Internal Average Relative Reflectance) was used to normalize images to a scene average spectrum which is available in ENVI 4.7 software.

Processing

In this section in order to classify the HRS and Wordview-2 images for the extraction of the impervious surface the Lee filter was applied on the hyperspectral data and then the result of it was used as input data of SVM.

In order to classify the images with using SVM classification method the training data are needed which in this study the training data and testing data were provided based on the field survey.

Table 1. Training and testing pixels

Classes	Training	Testing
water	238	509
grass	763	1530
Polycarbonate roof	165	206
tarmac	201	732
Zinc roof	341	5033
Clay roof	388	9700
Shadow	286	970
Asbestos Roof	244	2204
Cement	399	1890

Support Vector Machine

Base on the literature the SVM classification method shows good results to classify the heterogeneous urban area. thus in this study the SVM classification method was used. The SVM represents a group of theoretically superior machine learning algorithms. The SVM employs optimization algorithms to locate the optimal boundaries between classes. Statistically, the optimal boundaries should be generalized to unseen samples with least errors among all possible boundaries separating the classes, therefore minimizing the confusion between classes. In this study the redial basis function (RBF) SVM kernel used which is available in ENVI 4.7 software.

Applying Lee Filter on HRS data

The Lee filters were used to smooth noisy (speckled) data that have an intensity related to the image scene and that also have an additive and/or multiplicative component. Lee filtering is a standard deviation based (sigma) filter that filters data based on statistics calculated within individual filter windows. Unlike a typical low-pass smoothing filter, the Lee filter and other similar sigma filters preserve image sharpness and detail while suppressing noise. The pixel being filtered is replaced by a value calculated using the surrounding pixels.

Accuracy Assessment

Generally, classification accuracy refers to the extent of correspondence between the remotely sensed data and reference information(Congalton ,1991).Pixel-based training/test samples were defined as regions of interest (ROIs) using the ENVI function of defining training areas on both of images. Confusion Matrix uses to evaluate the classification accuracy for hyperspectral data. ENVI software use to calculate a confusion matrix using ground truth for regions of interest (ROIs**).**

RESULT AND DISCUSSION

The results of SVM classification of hyperspectral with applying the Lee filter is shown in figure 2. The overall accuracy of HRS data is 78% with Kappa coefficient 0.72and the table 2. Shows the classification accuracy for each class. On the other hand the Worldview-2 classification result (figure 3) shows the overall accuracy is 72% with Kappa coefficient 0.65.table 3 shows the classification accuracy for each class.

Figure 2. Classification of hyperspectral data after Lee filter.

Table 2. Classification accuracy of HRS data

Class	Prod. Accuracy (%)	User Accuracy (%)
Water	100.00	100
cement	98.84	49.48
polycarbonate	92.90	84.86
Asbestos	94	33
Zinc	51.15	100.00
Clay	96.00	100.00
tarmac	95.16	77.21
Vegetation	95.99	99.70
Shadows	91.00	88.74

The HRS result shows that most of the impervious surface such as roof materials and tarmac were detected well but some misclassification and error still exist in this classification result. Some misclassification between some classes such as Asbestos roof vs. Clay roof, Cement vs. tarmac which is related to the spectral similarity of some materials in this heterogonous urban area. On the other hand the displacement of the high rise building and the body of them caused some misclassification and error appeared in this result.

Figure 3. Worldview-2 image classification result.

Table 3. Classifcation accuracy of Worldview-2 image

Class	Prod. Accuracy (%)	User Accuracy (%)
Water	100.00	81.41
cement	64.39	40.28
polycarbonate	24.8	77
Zinc	68.81	99
Clay	71.10	98.08
tarmac	67.21	44.44
Vegetation	100	93.12
Shadows	98	80
Asbestos	80	35.54

The classification result of Worldview-2 image shows that some roof materials such as Zinc clay and asbestos roof material detected well and it can be seen clearly in some part of classification result (fig.3) but in some part of image some misclassification and confusion between these classes appeared. One of the source of error in this classification is, existence of shadows that it can be seen clearly in most part of the image that cause some materials did not detect at all for instance the road which is made with tarmac material does not detect very well due to cover by shadows and some materials which underneath of shadows did not detect. On the other hand spectral similarity of some of these materials caused to have some misclassification and confusion between some impervious surface materials is related to lack of sufficient spectral resolution of these types of data. It should be noted regarding to some misclassification in these result was related to the illumination direction and building geometry.

CONCLUSION

In this study has tried to do the comparison between two very high resolution imagery remote sensing (VHR) data. Airborne hyperspectral data and Worldview-2 image have been used in order to extract the impervious surface in heterogeneous urban area. Field survey has been conducted to categorize nine urban classes such as different roof materials, vegetation and water body .In order to extract the impervious surface the SVM classification method has been used which shows the good result in classify the complex urban area. The results show that the hyperspectral data is more accurate than Worldview-2 image with overall accuracy 78% and 72% respectively.

In order to compare between these types of data, in general the disadvantage of HRS is data acquisition is more expensive and limitation in coverage area compared to the Worldview-2 image. In detail HRS data shows the good result in term of detection of most impervious surface in urban area but still some misclassification exist due to spectral similarity between some roof materials ,Cement and Tarmac and etc. On the other hand the Worldview-2 image shows the good potential to detect the impervious surface especially the roof material detected well .Totally in order to classify and extract the IS of VHR imagery using the spectral base only classification method is not suitable due to misclassification and confusion between some materials and furthermore separation of each building in heterogeneous should be a difficult task in urban remote sensing. Further work should be done to combine the spectral, spatial and texture information and utilized them which are inherent in the VHR images.

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