A THEMATIC MAP FOR UPM, ENGINEERING CAMPUS PRODUCED BY OBJECT-BASED CLASSIFICATION METHOD

Bahareh Kalantar[1], Maruwan S.A.B Amazeeq[1], Shattri Bin Mansor[1], J. L. van Genderen[2]

[1] Department of Civil Engineering, Faculty of Engineering, University Putra Malaysia, 43400, Serdang, Selangor Darul Ehsan, Malaysia,
2 Department of Earth Observation Science, Faculty of Geoinformation Science and Earth Observation(ITC), University of Twente, P.O.Box 217,7500 AE Enschede, The Netherlands.

Email: Bahare_kgh@yahoo.com

KEY WORDS: Thematic maps, object-based image analysis, support vector machine, worldview-2.

ABSTRACT: Thematic maps generated by image classification process are useful for numerous geospatial applications such as urban planning, natural disasters, site selection, and change detection. This study proposed a classification workflow based on object-based analysis for producing thematic maps from Worldview-2 satellite data. The image was segmented by multiresolution segmentation algorithm in eCognition software and image objects were classified by support vector machine. Results indicate that the propose method is suitable for thematic map creation. The overall accuracy achieved in this study was 89.9% and the kappa was 0.86. Findings indicate the usefulness of the object-based image analysis for very high-resolution image processing and producing thematic maps at small and medium scales. Future works should focus on optimization of parameters required by algorithms and improving the segmentation results.

1. INTRODUCTION

Thematic maps generated by image classification process are useful for numerous geospatial applications such as urban planning, natural disasters, site selection, and change detection. Thematic maps can be produced by using remote sensing data and classification techniques. In terms of data, there are wide ranges of datasets that can be used. In general, they can be grouped into satellite-based or airborne-based, another classification can be based on type of the sensor, optical or active sensor, and other classifications could be based on resolution, low resolution, and high resolution. Worldview-2 is one of the optical satellite remote sensing that captures very high resolution (1 m). This data has great potential to extract fine details of information about a study area. However, the very high-resolution images require robust image processing and classification technique. Object-based image analysis or OBIA is one of the most powerful classification method that is very suitable for high-resolution images. In this method, in addition to spectral information, spatial, texture, and contextual information also can be incorporated into the classification process. In other words, this technique processes the images like human brain and knowledge can be used for information extraction. These advantages make this technique outperform per-pixel based classification methods. Therefore, in the current study, OBIA was used to produce a thematic map for UPM engineering campus using Worldview-2 satellite image.

There are several studies used OBIA for image classification and thematic map production. For example, Petropoulos et al. (2012) compared support vector machines (SVM) and object-based classification was used for obtaining land-use/cover from Hyperion hyperspectral imagery. Results indicated that OBIA outperformed the pixel-based SVM classification approach. In another study, Aguilar et al. (2013) combined GeoEye-1 and Worldview-2 for object-based classification in urban environments. Results of their study indicated that GeoEye-1 image produced better results than Worldview-2 image. In addition, SVM was used for object-based building extraction from very high-resolution images by Benarchid and Raissouni (2013). Their method has been applied on a suburban area in Tetuan city (Morocco) and 83.76% of existing buildings have been extracted by only using color features. More recently, a study by Kavzoglu et al. (2015) combined OBIA and rotation forest algorithm for classifying very-high-resolution WorldView-2 image. The classification results confirmed that integration of ancillary data increased the classification accuracy in comparison to using solely spectral bands of WorldView-2. While rotation forest algorithm and SVM generally produced similar results, they outperformed the rotation forest algorithm. Accuracies of object-based approach differ depending on the nature of landscape and type of images used for analysis. However, it is proven and as indicated by previous studies discussed above are outperform per-pixel based approaches.

2. MATERIAL AND METHOD

Figure 1 shows the overall method used in the current study for producing a thematic map for UPM using object-based classification technique. The process starts by collecting three different data types namely Worldview-2 satellite image, Google maps, and Open Street Maps.Worldview-2 satellite image is used for image classification whereas the other datasets are used as supplementary data that support the final thematic map and for accuracy assessment. The, the Worldview-2 image was pre-processed in three steps. First, the image is geometrically corrected based on Google maps. Then, radiometric calibration is applied on the image for converting the digital numbers into radiance. After that, the processed image is atmospherically corrected by dark object subtraction method. Once the image is pre-processed, a classification scheme is then prepared containing of several land cover classes. Based on the classification scheme, training and testing data are collected from the Worldview-2 image-using region of interests. Image segmentation is then applied to generate image objects. Image objects are then classified using SVM method. Finally, the thematic map of UPM is produced and roads are overlaid which is extracted from Open Street Map.

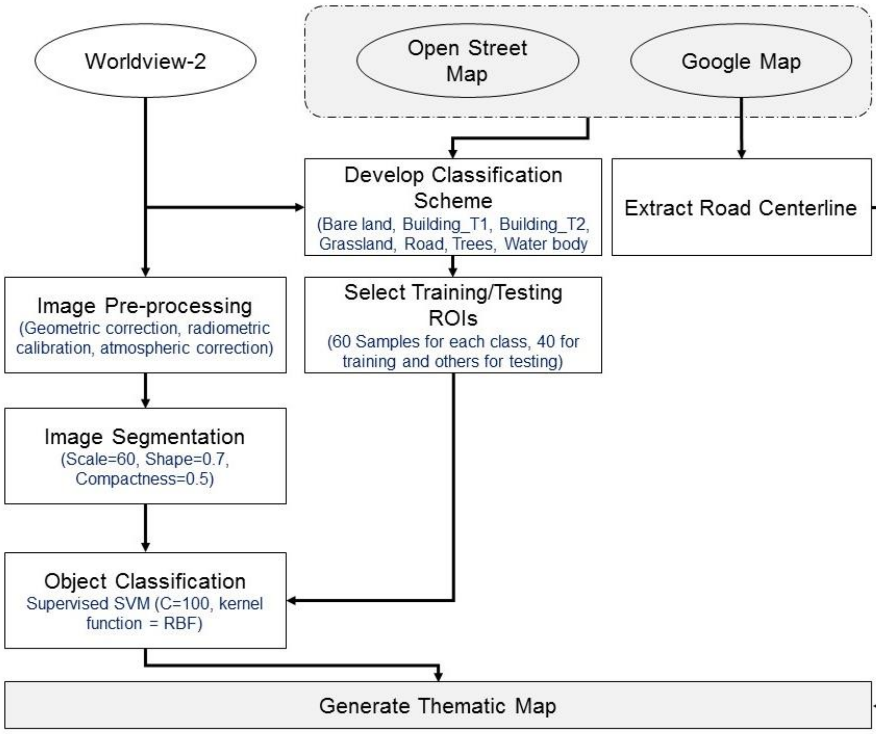

Figure 1. Overall classification workflow applied in this study for thematic map production.

2.1 Study Area and Dataset

A WorldView-2 satellite image that was acquired on January 23, 2010, was used to conduct the proposed methodology (Figure 2). WorldView-2 contains a panchromatic band with 0.5 m spatial resolution and eight multispectral bands [coastal, blue, green, yellow, red, red edge, near infrared1 (NIR1), and near infrared2 (NIR2)] of 2 m pixels. The improved spectral resolution and fine pixel size of WorldView-2 provide a wealth of details for image analysis and feature discrimination.

The Universiti Putra Malaysia (UPM) campus is used as the study site. The study area contains several landcover classes namely, roads, bare soil, grassland, trees, water bodies, and different types of buildings. Several spectral indices were used to reduce the spectral heterogeneity of urban surface materials. Previous studies introduced different spectral indices and highlighted the potential of WorldView-2 bands in improving the classification of various landcovers and other urban features.

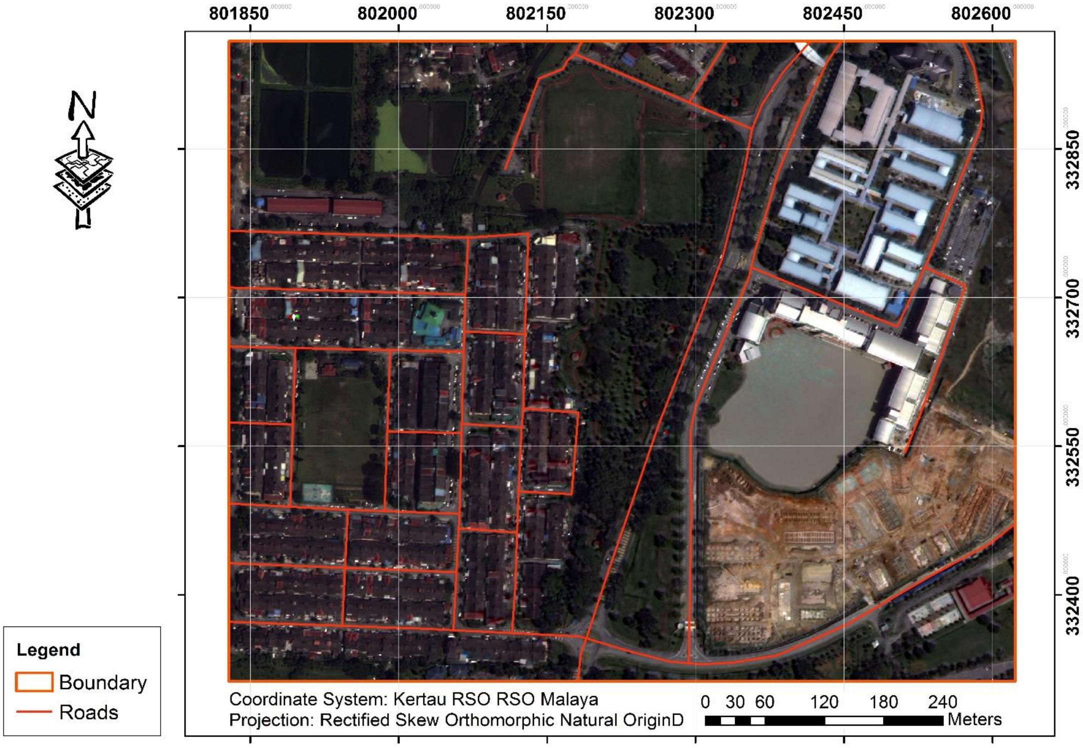

Figure 2. Worldview-2 satellite image used in this study to produce a thematic map for UPM.

2.2 Image Pre-processing

The first step of classification of any remote sensing image is the pre-processing, which reduces errors in the images and subsequently improves the quality of outputs. In this study, first 50 ground control points were collected from Google maps and then used to correct the Worldview-2 satellite image. Once the image was geometrically corrected, its digital numbers were converted into radiance in a process called radiometric calibration. After this process, the processed image was further calibrated to reduce the effects of atmosphere layer. The image was corrected for atmosphere error by dark object (DOS) method. After these steps, the image was ready for processing and classification.

2.3 Image Segmentation

The first step of OBIA is the image segmentation. In this step, an image is segmented to create meaningful image objects. Image segmentation is the process of grouping image pixels into non-overlapped and homogenous groups based on image spectral and spatial characteristics. In this study, a multiresolution segmentation algorithm was applied in eCognition software to create image objects. This algorithm requires several users defined parameters such as scale, shape, and compactness. These parameters were selected by trial and error method. Then, the image was segmented and image objects were created.

2.4 Image Classification

The second step of OBIA is the image classification. In general, there are two types of classification, supervised and unsupervised. The first method requires knowledge about the study area and simply in this method the analyst needs to selected region of interest to guide the classifier for classification. The image analyst, specify the number of classes and label them that are required for the classification and in thematic map. In this study, a method called support vector machine was applied to classify the image objects created in the first step. This method is proven in literature to be an efficient method and produce very good results in urban environments. However, this method requires two parameters called penalty and kernel function. The penalty (C) was set as 100 as it was found to be efficient for the data and study area, whereas the kernel function was set as radial basis function (RBF) based on literature suggestions. Image objects where then classified and a thematic map for the study area was generated.

3. EXPERIMENTAL RESULTS

3.1 Results of Image Segmentation

Results of image segmentation are presented in figure 3. This figure shows the image objects created by the segmentation process applied on Worldview-2 satellite image as a first step for classification. This image objects are characterized by several attributes such as mean spectral values of image bands, spatial, shape or geometry, texture, and contextual. These attributes are very useful for differentiation of image objects that belong to different classes. The unique of OBIA method is to make use of these additional attributes as in per-pixel methods only spectral characteristics are utilized. Therefore, it is expected that OBIA better than per-pixel methods. Results indicate the high quality of image segments as the boundary of most of the objects is well defined and extracted. This is also a good indicator for high quality thematic maps.

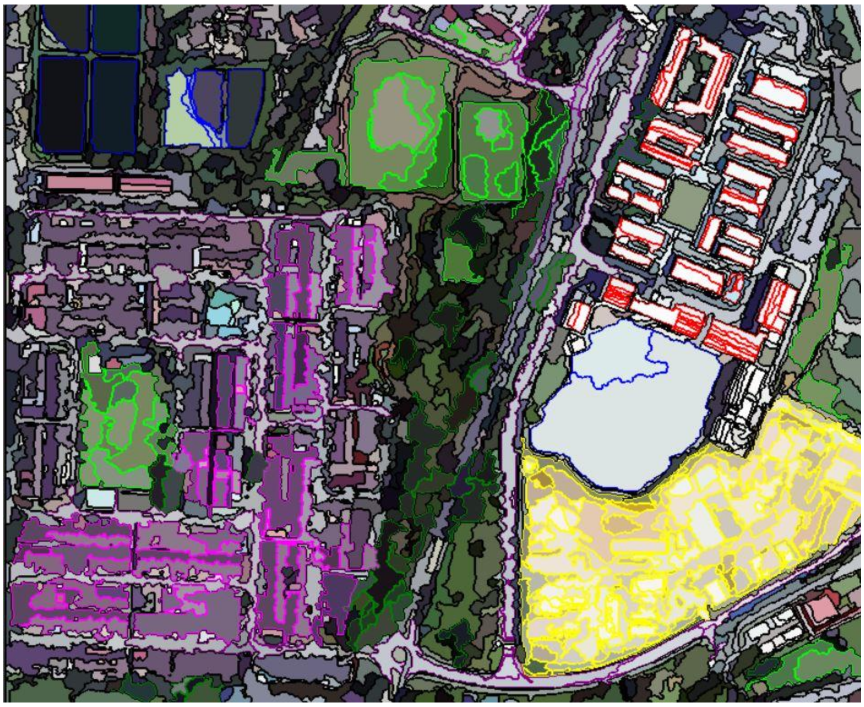

Figure 3. Results of image segmentation.

3.2 Results of Image Classification

SVM classifier was used to generate the thematic map of the study area using the image objects discussed previously. Results of the classification are shown in figure 4. It is worth to note that the thematic map was further processed in ArcGIS to make it ready for end users. Results indicate the high accuracy of classification as most of the image objects are correctly classified. However, some misclassification occurred in trees, buildings, and grassland classes. This is because of shadows affected on the characteristics of the features in the image. The classification map contains of seven classes determined in the initial steps. The robustness of the proposed method is shown as the different types of buildings could be separated in the map. Two types of buildings were identified and separated in the final classification map. This can further be improved by incorporating post-processing steps into the workflow of classification proposed here in this study.

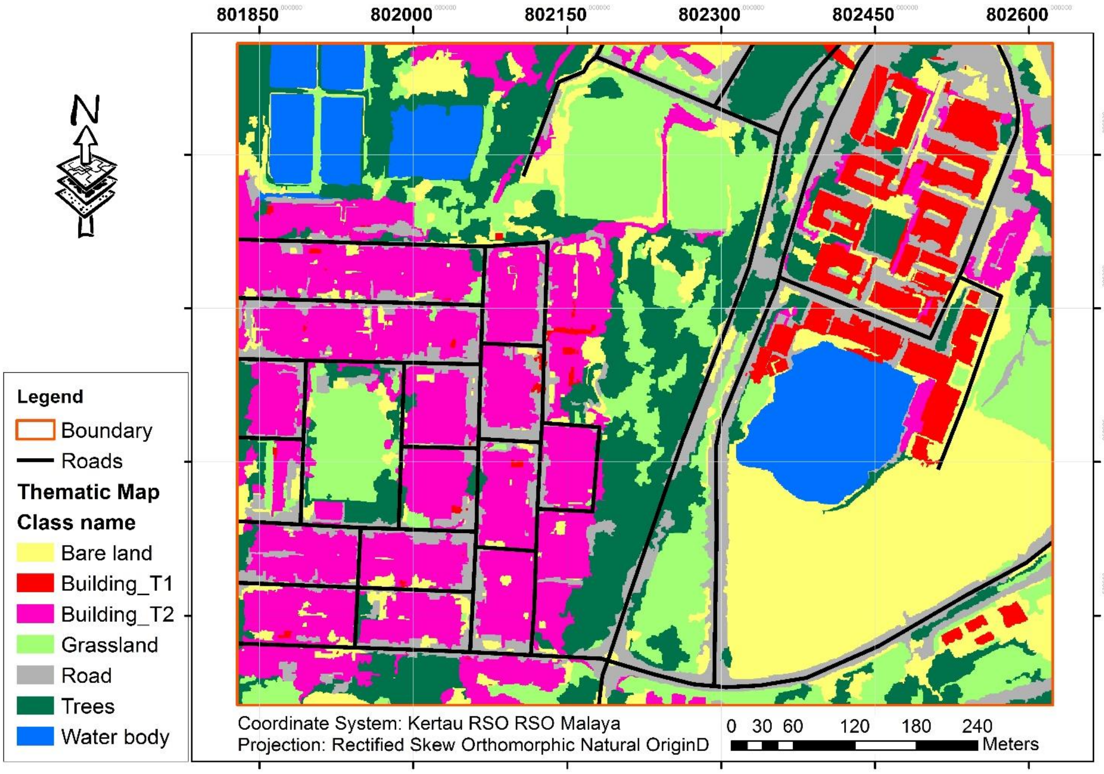

Figure 4. Thematic map of UPM produced with the proposed method based on Worldview-2 image.

3.3 Accuracy Assessment

To evaluate the result of classification, we calculated the confusion matrix based on some testing regions identified based on Google maps of the study area. Results of the accuracy assessment are summarized in table 1. Overall accuracy of the classification is 89.8% whereas the kappa coefficient is 0.86. Most of the classes are extracted accurately, user accuracy indicate that the highest accuracy obtained for bare lands, while the lowest accuracy belongs to water body. These statistics could not be realistic as they totally depend on the testing regions determined by the analyst and could be biased. Therefore, qualitative assessment is also an important indicator for accuracy of classification.

Table 1 Accuracy assessment of thematic map produced by OBIA method.

User class/ Sample	Bare land	Water body	Grassland	Trees	Road	Building_T1	Building_T2	Sum
Confusion matrix								
Bare land	138	0	0	0	0	0	0	138
Water body	0	11	1	0	2	2	0	16
Grassland	4	0	30	2	0	0	0	36
Trees	1	0	1	31	0	0	0	33
Road	13	0	0	0	38	0	2	53
Building_T1	0	0	0	0	0	65	0	65
Building_T2	11	0	0	1	1	0	48	61
Unclassified	0	0	0	0	0	0	0	0
Sum	167	11	32	34	41	67	50	
Accuracy								
Producer	0.826	1	0.937	0.911	0.926	0.970	0.96	
User	1	0.687	0.833	0.939	0.717	1	0.786	
Hellden	0.905	0.814	0.882	0.925	0.808	0.984	0.864	
Short	0.826	0.687	0.789	0.861	0.678	0.970	0.762	
KIA per Class	0.7355	1	0.931	0.903	0.915	0.964	0.952	
Totals								
Overall Accuracy	0.898							
KIA	0.869							

4. CONCLUSION

This study proposed an object-based classification workflow for Worldview-2 data. First, the image was pre-processed, and supplementary data from Google maps and Open Street Maps were gathered. These supplementary data were used to enhance the results of thematic map of the study area and they used for selecting training and testing samples. After that, the image was segmented and classified by SVM method. Finally, a thematic map was produced for the study area in ArcGIS software. The thematic map was also validated and results indicated the robustness of the method as the overall accuracy was over 85%. Findings suggest that OBIA is a suitable method for producing thematic maps using very high-resolution images. Future works should focus on optimization of parameters and enhancing results of segmentation.

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