Delineation of wetland areas from high resolution
WorldView-2 data by object-based method

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Abstract. Various classification methods are available that can be used to delineate land cover types. Object-based is one of such methods for delineating the land cover from satellite imageries. This paper focuses on the digital image processing aspects of discriminating wetland areas via object-based method using high resolution satellite multispectral WorldView-2 image data taken over part of Penang Island region. This research is an attempt to improve the wetland area delineation in conjunction with a range of classification techniques which can be applied to satellite data with high spatial and spectral resolution such as World View 2. The intent is to determine a suitable approach to delineate and map these wetland areas more appropriately. There are common parameters to take into account that are pivotal in object-based method which are the spatial resolution and the range of spectral channels of the imaging sensor system. The preliminary results of the study showed object-based analysis is capable of delineating wetland region of interest with an accuracy that is acceptable to the required tolerance for land cover classification.

1. Introduction
The Convention Ramsar definition for wetlands is: “Wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs” [1]. Wetlands are determined as an integral part of the global ecosystem that fall somewhere on the environmental spectrum between land and water which presents many ecological services including a diversity of unique habitats flora and fauna. Lately, wetlands are under threat from factors such as dramatic land use changes and land modification. Hence, it is urgent to identify wetland and evaluate its trend of changes in order to conserve and preserve the environment [2,3].

Traditional pixel based digital image classification has been and is still being used for characterization and mapping the spatial extent of forests, urban, coastal, and wetland areas. With the advent of high spatial resolution images, Object-based Image Analysis (OBIA), a recent image analysis approach appears to be more popularly used for the classification of land use/land cover of urban areas [4]. Object-based method considers image classification based on objects such as topologic (neighbourhood, context) and geometric (form, size) information [5]. The object-oriented approach analyzes objects within images as the processing unit instead of using pixels. The segments offer not only object-oriented spectral characteristics, but also geometric and structural information [6].

Advancement of geospatial technology and the increasing need for more products with greater accuracy for the users resulting in Data Providers such as DigitalGlobe to undertake and expand the capabilities of their sensors, hence, we have to-date the WorldView-2 [7]. WorldView-2 satellite is a DigitalGlobe’s second generation satellite, launched on 8th October 2009, enabling a collection of nearly 1 million km² of high-resolution imagery per day and offering average revisit times of 1.1 days around the globe with the capability of capturing 0.50 m panchromatic imagery and 1.84 m resolution with 8 – band multispectral imagery [8,9]. The new additional bands in WorldView-2 are Coastal...
Blue, Yellow, Red-Edge and NearIR-2 bands and was acclaimed by the manufacturer that overall classification accuracy could be increased up to 30% [10]. But of course, the classification method one chosen should also be giving some weightage on the assessment of the accuracy of the classification. The improved characteristics depicted in Worldview-2 has opened a new dimension for works on feature extraction, which include delineation of wetland regions by utilizing the imagery.

Hence, the aim of this research is an attempt to improve the wetland area delineation in conjunction with a range of classification techniques, which can be applied to satellite data with high spatial and spectral resolution via World View 2. Basically, the study intends to highlight how well could high spatial resolution data Worldview-2 data segment the features.

2. Study Area and Dataset

2.1. Area of study

Penang Island is located in the northwest of Malaysia within latitudes 5° 12’ 00” – 5° 30, 00” N and longitudes 100° 09’ 00”– 100° 26’ 00”E (Figure 1) within 292 km² of the area. Penang experiences a year-round equatorial climate which is warm and sunny, along with rainfall. The land use of the study area mainly consists of built-up areas, natural forests and agriculture fields (paddy fields, vegetable fields and crop land) and also with the water areas (ocean and rivers).

![Figure 1](image1.png)

**Figure 1**: Location of the study area and multispectral bands of the Worldview-2.

2.2. Dataset

The remotely sensed data used is World View-2 from DigitalGlobe taken on 29th May 2011 with 16 bit radiometric resolution and consists of 8 bands at a spatial resolution of 2m x 2m, and one band panchromatic band at a spatial resolution of 0.50m x 0.50m with zero cloud cover. WorldView-2 is the first commercial high-resolution satellite to provide 8 spectral sensors in the visible to near-infrared range [11].

3. Methodology

3.1 Pre-Processing

The fusion of panchromatic with multispectral images of WorldView-2 scenes was done using the Hypersperical Color Space method with resampling techniques of Bilinear Interpolation, resulting in an image with 0.50 m spatial resolution in ERDAS IMAGINE 2011 (Figure 2 (c)). According to [12], Hyperspherical Color Space Pan Sharpening was designed specifically with WorldView-2 in mind and is a new feature in ERDAS IMAGINE 2011 works with any multispectral data containing 3 bands and more.

![Figure 2](image2.png)

**Figure 2**: (a) Multispectral original image, (b) Panchromatic original image, (c) HCS image.
3.2 Image Segmentation

The fused image obtained was used in image segmentation. The pixels were first grouped into segments. This could be done according to their spectral similarity and other criteria (shape, area, and position) that is more meaningful. At the beginning of segmentation process the heterogeneity criterion is thresholded by the user. This is done by choosing a scale factor and by fixing the weights of the color and shape criteria, and the smoothness as well as compactness criteria [13]. Shape define the weight the shape criterion should have when segmentation the image. The higher the value, the lower the influence of color on the segmentation process. Meanwhile, compactness define weight the compactness criterion. The higher the value, the compact image objects may be. The dataset in this study was segmented using three different scale parameters algorithm (30,60, and 300) in multiresolution segmentation algorithm in order to provide a range of classification scales for iterative accuracy assessment while all other parameters were held constant (shape: 0.1 and compactness: 0.5). Figure 3 shows examples of the segmentation results at different scale parameters.

Figure 3: Segmentation results with different scale parameters
(a) WV-2 image, (b) Scale parameter 30, (c) Scale parameter 60, (d) Scale parameter 300

Figure 3 (b) shows the segmentation result at scale parameter of 30. Many image objects at this scale correspond to individual tree crowns for forest, crop land and vegetation, as well as other spatial objects including the roofs of buildings, water (ocean and river) and the ground sizes of most image objects at scale parameter 30 are smaller. In contrast, at scale parameter of 300 in Figure 3 (d) shows that image objects produced correspond too coarser units of spatial features. Image segmentation objects shown in Figure 3 (c) at scale parameter of 60 shows the most suitable scale to match polygons for the land cover classes. Noted that difference segmentation scale does affect the classification result. Using small segmentation scale (i.e 30) for a large coverage of study area, will result lower accuracy of classification due to misclassification. However, using large segmentation scale (i.e 300) for a small study area coverage resulted different features in the image will be merged into one feature class with
lower classification accuracy.

3.3 Segment-Based Classification
A classification-based segmentation was performed to fuse all the similar objects that were assigned. In the object-based image classification, each segmented image object needs to be labelled with a proper class name. Some image objects in this study were relatively easy to be labelled based on the spectral properties, but others are difficult to be determined only by the spectral properties without considering other contextual information such as relative sizes, shape and texture. The classification of individual objects utilized the Nearest Neighborhood decision rules determined according to feature class of the objects. This classification results involved of trial and error process.

4. Result and Discussion
The analysis found that object-based classification using scale parameter of 60 produced the best result of wetland delineation compared to scale 30 and 300 in Figure 4 (b). This was due to a clear delineation of water bodies as well as sandy beaches and mangrove forest. The study of classification process found that about 100 polygons of the sample features able to produce the best result of land use classification which focus given to wetland areas.

![Figure 4](image_url)

**Figure 4:** Classification results with different scale parameters
(a) Classification of scale parameter 30, (b) Classification of scale parameter 60, (c) Classification of scale parameter 300, (d) Class name

The object-based classification was based into seven categories which are built-up areas, crop land, mangrove forest, open land, sandy beaches, vegetation and water bodies. Total area in meter square of wetland delineated from object-based method shown in graph (Figure 5). Approximately about 510703.486 meter\(^2\) of wetland areas were derived at the scale parameter of 60. At scale parameter of 30, total area of wetland areas is about 546651.728 m\(^2\) and at scale parameter of 300, total area of...
wetland areas is around 553646.794 m². The result shows that the mapping of wetland areas was improved using WorldView-2 data of 0.5m resolution through object-based classification method.

As stated earlier, the study tries to determine suitable approach to delineate the part of Penang Island wetland areas through the high resolution imagery of the WorldView-2 and utilization of object-based classification method. The object-based segmentation scale parameter of 60 proved to best segmentation scale to delineate wetland of the study area. The fined classification results showed that wetland areas were delineated accordingly. In summary, combination of spectral and spatial resolution allows improvement of separation among physical characteristics or target class for land cover maps.

5. Conclusion
The aim of this study was to determine suitable approach to delineate and map the wetland areas using object-based classification of WorldView-2 imagery. The use of E-Cognition software for object – based image classification, and the decision tree that enabled a fast classification from improved image attributes, using the class hierarchy with Nearest Neighborhood Classification algorithm, allowing the separability of class wetland areas in conjunction with GIS. By the combination of spatial and spectral resolutions allows the improvement of separation among the physical characteristics of
targets features to be mapped, resulting in finer details and precision of land cover maps.

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References
[1] Davis T J, Blasco D, I U for Conservation of Nature and N R R C Bureau 2013 The Ramsar Convention Manual: A Guide to the Convention on Wetlands (Ramsar, Iran, 1971) 6th ed Ramsar Convention Bureau
[2] Habiba U 2011 Remote sensing & GIS based spatio-temporal change analysis of wetland in Dhaka city, Bangladesh Journal of Water Resource and Protection 3 781–787
[3] Gao P, Trettin C C and Ghoshal S 2012 Object-oriented segmentation and classification of wetlands within the Khlong-la-Lithuny a catchment Lesotho, Africa 1–6
[4] Blaschke T 2003 Object-based contextual image classification built on image segmentation vol 00 no C 113–119
[5] Kux H J H and Souza U D V 2012 Object-based image analysis of worldview-2 satellite data for the classification of mangrove areas in the city of Sao Luis, Maranhao State, Brazil vol I no September 95–100
[6] Li L and Shu N 2010 Object-oriented classification of high-resolution remote sensing image using structural feature 2212–2215
[7] Lee K R, Kim A M, Olsen C R and Kruse F A 2011 Using worldview-2 to determine bottom-type and bathymetry SPIE Defense, Security, and Sensing 80300D– 80300D
[8] Paper W 2010 The benefits of the 8 spectral bands of worldview-2 no March
[9] Ribeiro B M G and Fonseca L M G 2012 Evaluation of worldview-2 imagery for urban land cover mapping using the interimage system 206–210
[10] Zhou X, Tamas J, Chen C and Verone M W 2012 Urban land cover mapping based on object oriented classification using worldview 2 satellite remote sensing images International Scientific Conference on Sustainable Development & Ecological Footprint vol 2
[11] Globe D 2009 Digital globe constellation of WorldView-2
[12] Padwick C, Scientist P, Deskevich M, Pacifici F and Smallwood S 2010 Worldview-2 pan-sharpening
[13] Wojtaszek M V and Ronczyk L 2012 Object-based classification of urban land cover extraction using high spatial resolution imagery International Scientific Footprint, Ecological