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A modification to hyper-rectangle supervised classification method for high resolution satellite imagery

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ABSTRACT

Hyper-rectangle (Parallelepiped) supervised classification method is a quick and easy method to implement, with clear definition to each class subspace. Using the training data for each class the limits of the parallelepiped is defined, either by the minimum and maximum pixel values in given class, or by a certain number of standard deviations on either side of the mean of the training data for given class. The pixels lying inside the parallelepipeds are tagged to it.

Although the method looks simple and straight forward, but it's very difficult to grant a robust classification performance. The reason is the presence of serious errors that may take place and affect the robustness of the solution. These errors are coming from the possibility of having one or more than one pixel lying in more than one parallelepiped**,** or fully outside all of them. Basically, theses errors are likely to occur with the more complex feature space.

The proposed modification involves applying this method using only one pair of bands at a time to overcome the problem of finding one pixel in more than one class. The new WorldView-2 eight band data will be used in the assessment and verification of the new approach. Moreover, a significant group of unclassified pixels will be tested, which will be classified in a second step using other spectral characteristics such as NDVI and band rationing. The proposed methodology showed a good result in separating between four main classes namely; vegetation, water, shadow, and man-made objects. Conclusions and recommendations are given with respect to the suitability, accuracy and efficiency of this method.

I. INTRODUCTION

Change detection, urban studies, coastal erosion, environmental monitoring, and agricultural surveys are a few examples where a good classification is needed. For many years, satellite based remote sensing has been a priceless tool for change detection. No other platform can constantly revisit an area, quantify and classify land cover or land use on such a broad scale. Recently, high spatial resolution satellite sensors , such as IKONOS, QuickBird, GeoEye and WorldView, are proving to be a cost-effective alternative to aerial photography, especially, for the acquisition of Land Cover information (Ouma, Tateishi et al. 2010).

Many classification algorithms have been developed to reveal Land use/ Land cover since the launch of ERTS-1 satellite in 1972. There are two broad classes of classification procedure; one is referred to as supervised classification and the other unsupervised classification. The parallelepiped algorithm is a computationally efficient method of the supervised classification type (Richards and Jia 2006).

In this method a parallelepiped-like (i.e., hyper-rectangle) subspace is defined for each class. Using the training data for each class, it will be possible to define the limits of the parallelepiped either by the minimum and maximum pixel values in the given class, or by a certain number of standard deviations on either side of the mean of the training data for the given class (Tso and Mather 2009). The pixels lying inside the parallelepipeds are tagged to this class.

The proposed modification involves as a first step, using only one pair of bands at a time to overcome the problem of finding one pixel in more than one class or overlapping of the parallelepipeds. The new WorldView-2 eight band data will be used in the assessment and verification of the new approach as it fills important gaps in the spectrum, compared to QB, IKONOS or GeoEye, as shown in figure 1. On the other hand, a significant group of pixels will remain unclassified, which will be classified in a second step using other spectral characteristics such as NDVI and band rationing. The proposed methodology showed a good result in separating between four main classes namely; vegetation, water, shadow, and man-made objects.

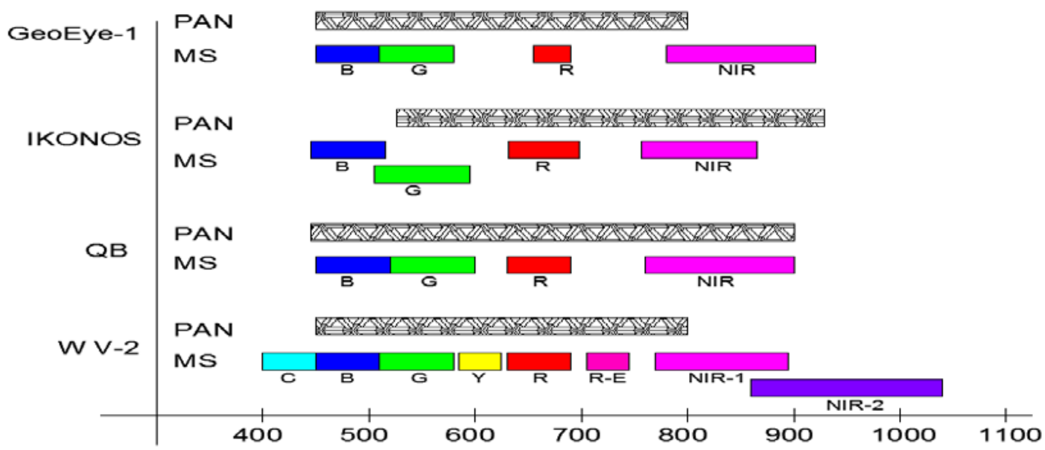

Figure 1 comparison between spectral band coverage of WV-2, QB, IKONOS and GeoEye-1

II Hyper-rectangle (Parallelepiped) supervised classification method

In this method a hyper-rectangle (i.e. parallelepiped-like) subspace is defined for each class. Using the training data for each class, the limits of the parallelepiped subspace can be defined either by the minimum and maximum pixel values in the given class, or by a certain number of standard deviations on either side of the mean of the training data for the given class (Tso and Mather 2009).

The pixels lying inside the parallelepipeds are tagged to this class. Figure depicts this criterion in cases of two-dimensional feature space.

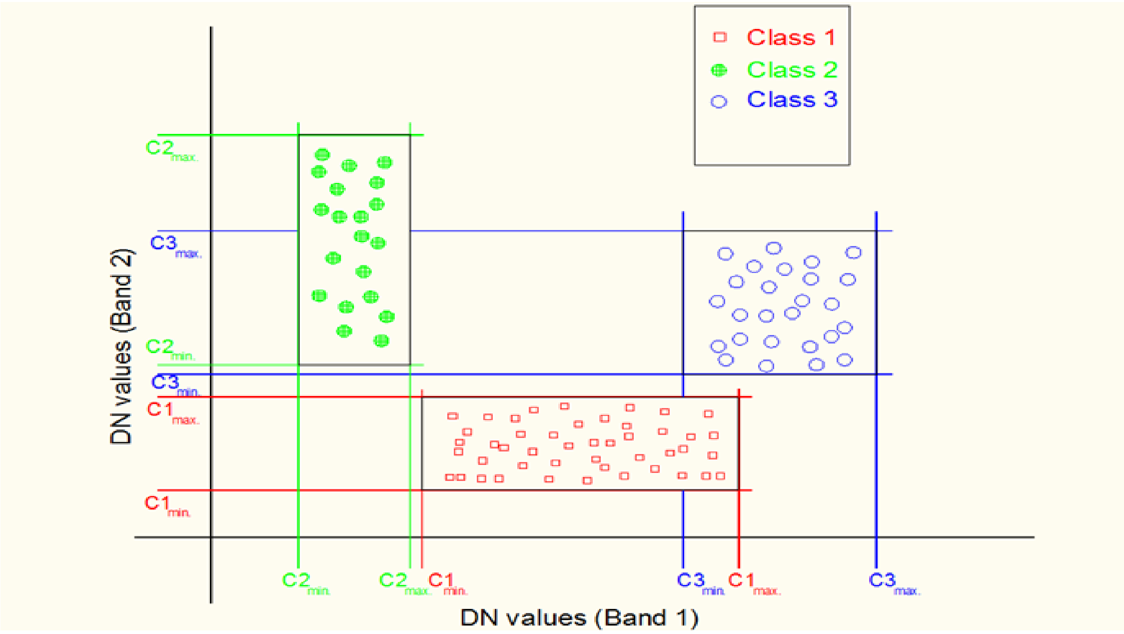

Figure 2 Implementation of the parallelepiped classification method for three classes using two spectral bands, after (Tso and Mather 2009)

Although this method is quick and easy to implement it is very difficult to grant a robust classification performance as a result of serious errors that may take place. These errors are originated from the possibility of having one or more pixels lying in more than one parallelepiped, or outside all parallelepipeds. Essentially, these errors are likely to occur with more complex feature space (Tso and Mather 2009). The proposed modification involves applying this method using only one pair of bands at a time to overcome the problem of finding one pixel in more than one class. On the other hand, many un-classified pixels will exist which will be classified later using another spectral characteristic.

III. DATA AND METHOD

In addition to the large-scale collection capacity of WorldView-2's it has a high spatial and spectral resolution. This satellite is able to capture 46 cm panchromatic imagery and 1.84 m spectral resolution with 8-band multispectral imagery. The high spatial resolution facilitate the differentiation of fine details, like vehicles, shallow reefs and individual trees, and the high spectral resolution provides detailed information on such diverse areas as the quality of the road surfaces, the depth of the ocean, and the health of plants, (Globe 2009).

The proposed algorithm starts with a preprocessing step involves image sub setting and image sharpening using color normalized method, then training data selection is accomplished against 5 classes namely; vegetation, water, bright surfaces, shadow and roads. A crucial step is to choose the appropriate bands for each class which is summarized in table 1. For each class the minimum and maximum boundary, of its parallelepiped, is calculated for the selected bands, the traditional parallelepiped algorithm is then applied. Using two bands only at a time ensure that there are no overlapping pixels, i.e. pixels lies in more than one class, which is the main advantage of this modification, but a significant group of unclassified pixels will exist. The next step is to classify this group of pixels to their proper classes.

Table 1 Decision rule for each class

No.	class	Used bands
1	Vegetation	Red and NIR-2
2	Water	Red edge , NIR-1and NIR-2
3	Bright surfaces	NIR-1 and Green
4	Shadows	Red and NIR-2
5	Roads	Red edge, Yellow and Coastal blue

A careful study of the spectral profiles, figures 3,4 and 5, of the 8-bands of the WorldView-2 data will lead to the contribution of the new bands into classification. NDVI was used to test this contribution and the results are summarized in table 2.

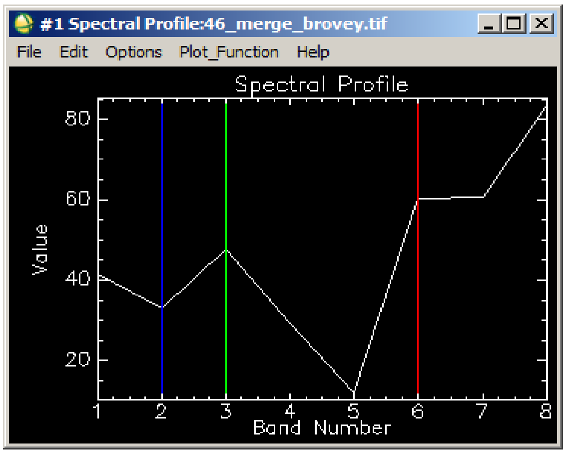

Figure 3 Vegetation spectral profile

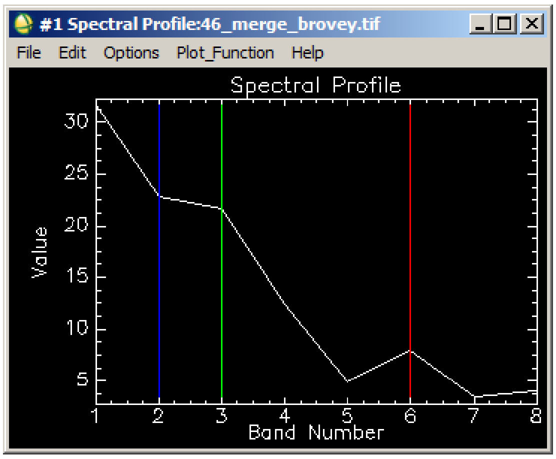

Figure 4 Water spectral profile

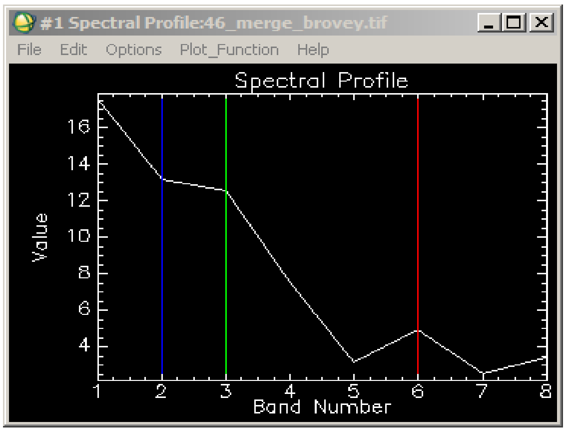

Figure 4 Shadow spectral profile

Table 2 contribution of the new bands into classification

NDVI ratio	Contribution
Red/NIR1	stand water - shadow
Red edge/Red	Manmade objects
Red edge/NIR2	Stand water
NIR1/Red	Vegetation
C/NIR2	Stand water

The next section will show the outcome of the complete algorithm steps which indicates a remarkable increase in the quality of classification which can be visually recognized.

IV. RESULTS AND ANALYSIS

Considering the classification results using Maximum Likelihood Classifier, MLC, are the reference data, which will be compared by the new proposed modified parallelepiped method and the traditional parallelepiped method. There was a remarkable enhancement in the classification especially in shadow and bright surfaces classes. This enhancement of accuracy was attributed to more than 20% of the pixels were set to unclassified category in the traditional method and were set to their proper classes using the proposed modified method.

Figure 2 shows the area of study, while figure 3 shows the classification result using the proposed modified method, and figure 4 shows the classification result using traditional parallelepiped method. The black pixels of figure 3 represent unclassified areas which were classified correctly in the proposed method.

V. CONCLUSION

In this research paper a modified parallelepiped-like method for supervised classification for high resolution satellite imagery was introduced and compared with the most reliable supervised classification technique, MLC, and the results showed a visually remarkable enhancement in the classification results.

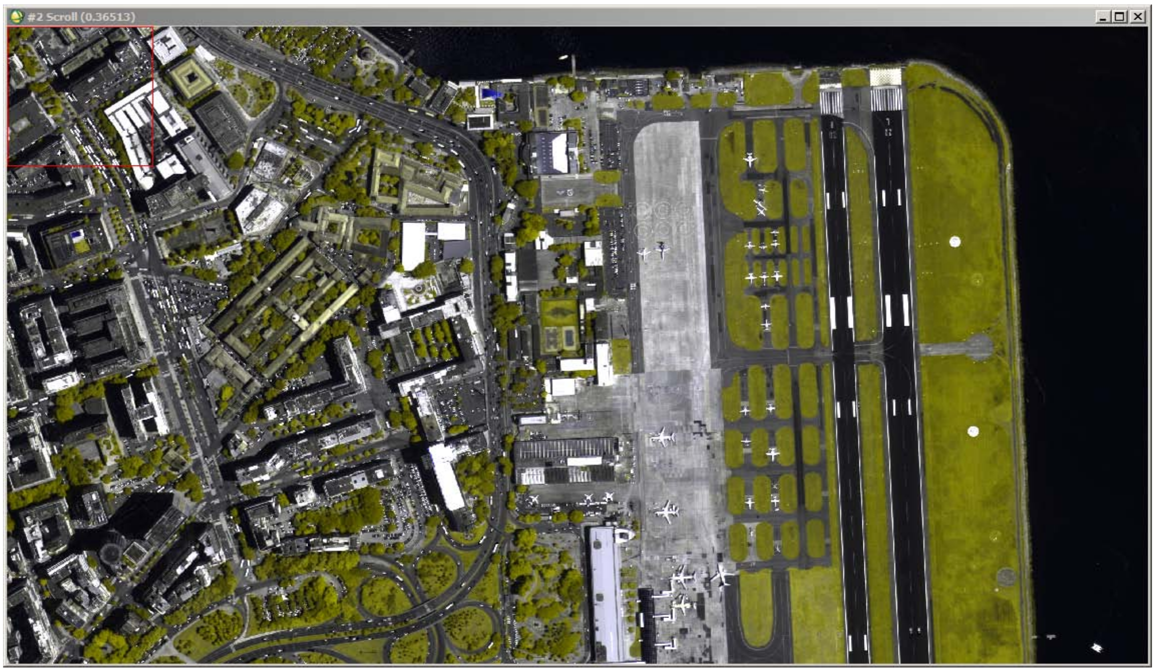

Figure 2 Area of study

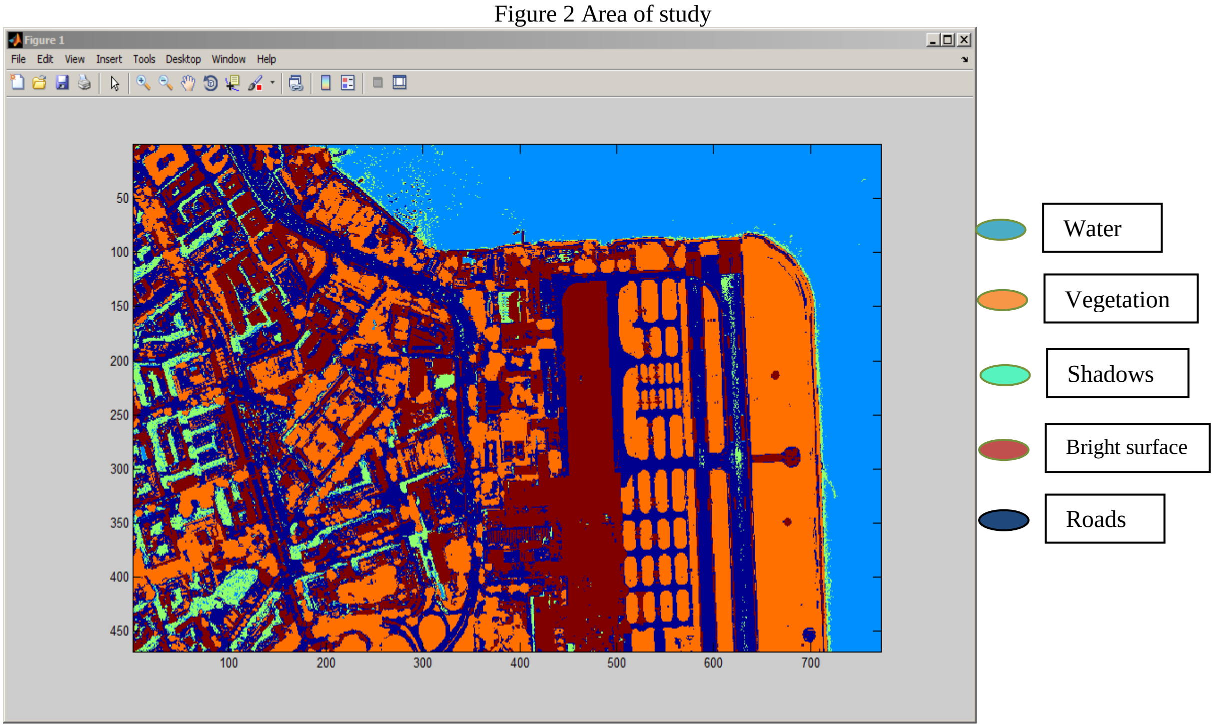

Figure 3 Classification results of the proposed modified parallelepiped method

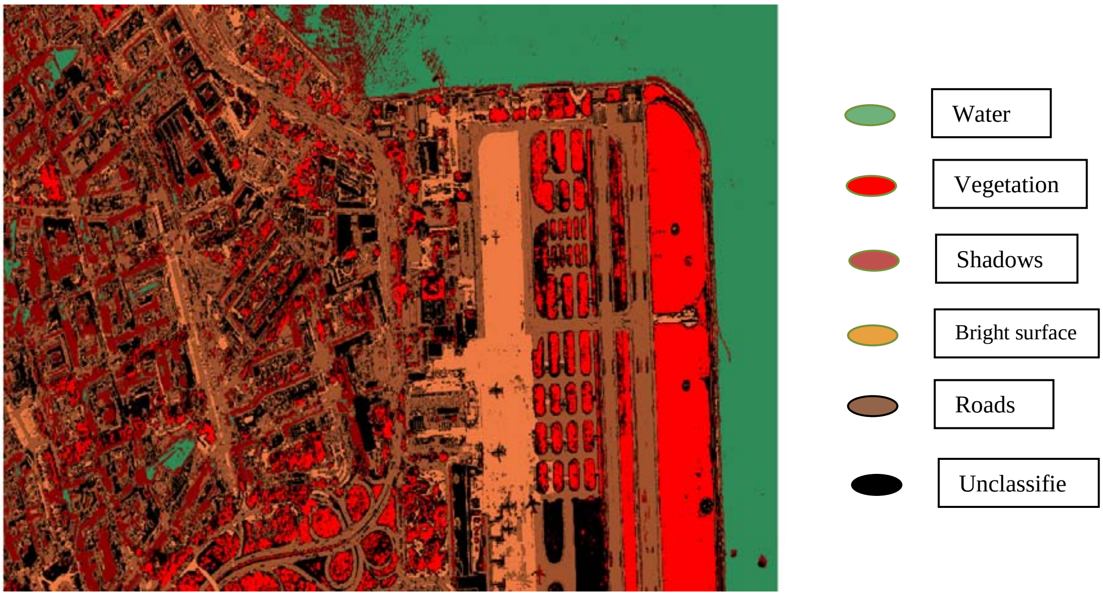

Figure 4 Classification results of the traditional parallelepiped method.

V. REFRENCES

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