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Investigation of Optimum Spectral Bands for Urban Area Classification from World View2 (WV2) Satellite Image

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ABSTRACT: Satellite imaging provides not only color images with RGB data but also other information related to invisible bands which is called multi-spectral bands. Images with multi-spectral bands give rich data for features which is useful in description, classification and extraction. The research objective is to investigate the optimum bands for urban area classification from multi-spectral images based on available data. Images from World View2 (WV2) satellite with eight spectral bands in addition to panchromatic image for the captured area are available. This amount of spectral information together with the very high spatial resolution of WV2 imagery provides feature details which is suitable for mapping of land cover. Maximum Likelihood (ML) is a classification technique that is used to classify image of area of study while testing a combination of multi-spectral bands of WV2 satellite image. The proposed research algorithm is based on forming a different set of multiband. Each set is composed of three different bands from input WV2 satellite image. ML classification technique is applied on all sets to extract classified images of study area from all used sets. The assessment of classification results is represented in confusion matrix format and determination of Kappa Coefficients. The research work flow is processed commercial software ENVI(an acronym for "Environment for Visualizing Images"). The preliminary results shows that a set of (Near Infrared (NIR), Green (G) and Costal (C) bands) give accurate classification result for the area of study. Image with NGC bands gives a classification results with overall accuracy 91 % and it is evaluated by Kappa coefficient which is 0.88.

KEYWORDS: Classification; Maximum Likelihood (ML); Aassessment of Classification; Optimum Spectral Bands

I. INTRODUCTION

Satellite images play an important and vital role in providing geographical information for many branches and applications (Urban planning – Agriculture – Military applications - …etc.).Urban area features can be extracted from Satellite image by classifying satellite images by using supervised or unsupervised classification methods[1]. Classification of satellite image can be executed by using full image bands or selected bands based on a classifier technique, band combination and available satellite image[2]. There are various classifiers many classification techniques for classifying can be used with satellite images which includes as Maximum Likelihood Classifier (MLC), Mahalanobis distance classifier, Minimum Distance to means Classifier (MDC), Decision Tree classifier and Artificial Neural Network Classifier (ANN). By performing analysis on 3 different types of classifiers (Maximum Likelihood Classifier - Minimum Distance - Mahalanobis distance classifier) we found that Maximum Likelihood produced the highest accuracy of all types of classifiers a maximum likelihood classification technique gives accurate results with respect to mahalanobis and minimum distance[3]. So to obtain the most out of benefits of such digital data, information extraction, classification approaches are considered with available data [4] and the best classification result was obtained with higher samples per class [5].

A satellite image has three or more spectral bands; Combination of different ranges of the electromagnetic spectrum of bands improves the segmentation and classification of land cover image features. So there are important factors, the economic factor which affects the choosing from multispectral bands and the time that depends on classification procedure .both of them effect on the results of classification [6]. In this paper we use a World View 2 (WV2) satellite image which is 46 cm resolution for panchromatic image and 1.84 m spectral resolution with and 8- multispectral

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bands multispectral imagery is used for investigating an optimum combination from image bands that will give accurate classification results. The high spatial resolution is useful used to distinguish small details of off-terrain objects likes buildings, aircrafts and trees while the high spectral resolution provides detailed information about different details about urban features such as barren, water and roads[7]. The effect of four new bands on land cover classification is evaluated and Results demonstrate that (Coastal blue, Yellow, Red edge and NIR-2) of WV2 increase the overall accuracy [8].

II. AREA OF STUDY

The data was provided by Digital Globe, http://www.digitalglobe.com, the images were captured on April 19th, 2011. The land cover area is a residential area in Ismailia city about 120 Km to the northeast direction from Cairo the capital of EGYPT. The study area is an urban area divided into buildings, roads, vegetation areas, roof steel, barren and water. The current work is study on the on area approximate equal 91 hectares. The projection of the image is UTM, zone36.spheroid and datum of the image is WGS 84. The upper left corner coordinates are (LAT30 35 44.3211 N, LON 32 17 51.0860 E) and lower right corner coordinates of the image (LAT 30 35 16.0068 N, LON 32 18 29.7392 E).

A. *WV2 SATELLITE IMAGE:*

In 2009 Digital Globe launched the WorldView-2 satellite which is the first commercial high-resolution satellite that provides eight spectral bands. **Error! Reference source not found.** is showing the advantages of WV2 satellite comparing with other satellites, Quick Bird, IKONOS and WorldView-1[9].

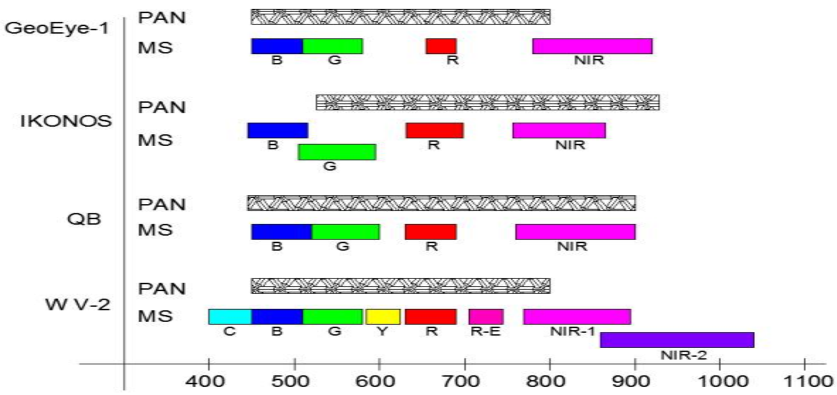

Fig.1.Different spectrum band width of 4 satellites

B. *MULTI BANDS SPECIFICATIONS:*

WorldView-2 satellite provides four new unique spectral bands that give additional information for different features, Coastal blue, Yellow, Red edge and NIR-2 [7]. Coastal blue band supports vegetation identification and analysis and water penetration characteristics, and it is used to investigate atmospheric correction techniques. Yellow band is used to identify" yellow-ness" related to characteristics of targets, and it is important for vegetation applications. Also, yellow band assists in developing"true-color" hue correction for human vision representation. Red edge band is used to analyze vegetative condition directly related to plant health revealed through chlorophyll production. NIR-2 band overlaps the NIR-1 band but is less affected by atmospheric influence and it supports vegetation analysis and biomass studies [10].

C. *INPUT IMAGE:*

The image from WV2 IS fused which contains eight layers (Red(R), Green (G), Blue (b), Near Infrared (NIR1), Near Infrared (NIR2), Yellow (Y) and Costal (C)).the spatial resolution is 0.5 meters which useful used to distinguish small details as shown in **Error! Reference source not found.**.

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Fig.2. Input Image of Area of Studycontains eight layers with the spatial resolution is 0.5 meters

III.PROPOSED ALGORITHM RESEARCH ALGORITHM

This research work concentrated on choosing optimum combination of spectral bands from wv2 satellites image for classifying images features to six classes using Maximum Likelihood classification algorithms. Whereas the most application of the remotely-sensed images is for mainly land-cover classification, for the purpose of applications like monitoring the forest and agricultural areas, mapping urban. The information extraction approach developed consists of the following steps. First, original high resolution panchromatic image 0,5m is fused with the low resolution multispectral imagery 2m to generate8-spectral bands with a resolution of 0.50 m by "HP Resolution Merge" techniques using ERDAS_IMAGINE . The process involves a convolution using a High Pass Filter (HPF) on the high resolution data, then combining this with the lower resolution multispectral data. The result of these techniques excellent details and a realistic representation of original multispectral scene colors,then subset fused image into five MS images with different three combinations of bands to obtain MS images (NGC, NGB, RGC, RGB and RYB). Then we defined spectral signatures to each class through ROI. We defined samples per class in MLC techniques using ENVI to classify land cover. All evaluations or measures of effectiveness of classified images in research were performed using an assessment matrix (confusion), an overall accuracy, a user and producer accuracy by class .Resulting in classifications that were evaluated through the overall accuracy index enabling the determination of the better combination from wv-2 imagery bands.

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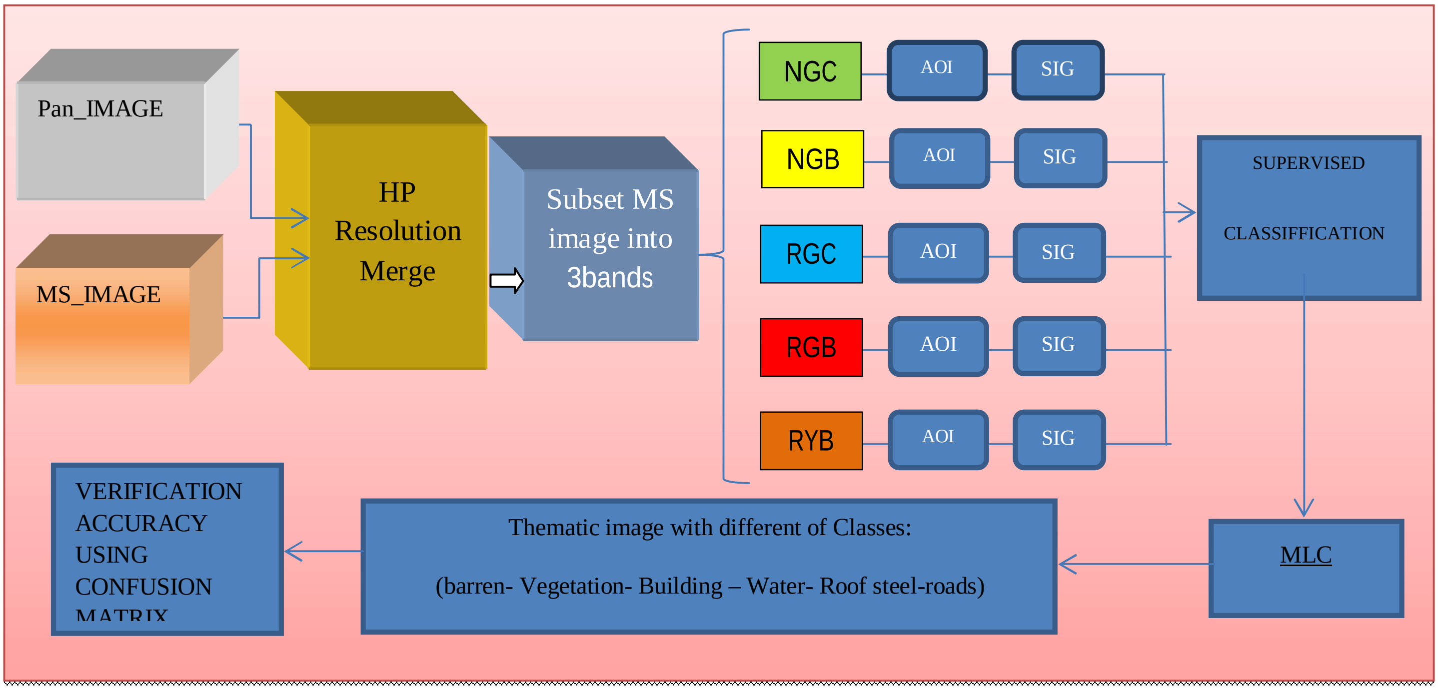

Fig.3. the procedures that were applied in experiment by fused image and then subset fused image into five MS images with different three combinations of bands thendefined spectral signatures to each class through ROI finally classify image using MLC techniques and assessment results (3) describes the procedures that were applied in experiment.

IV. SPECTRAL BANDS COMBINATIONS AND CLASSIFICATION RESULTS

A. CLASSIFICATION IMAGES SPECTRAL BANDS COMBINATIONS

In Our research subset fused image which contain 8 bands into five MS images with different three combinations of bands to obtain MS images (NGC, NGB, RGC, RGB and RYB) so we produced 5 classifications and the results indicate that with a three different combination of bands. **Error! Reference source not found.** illustrates the output of classified images with six classes in each combination of different bands.

B. CLASSIFICATION RESULTS

Maximum Likelihood decision rule is based on the probability that a pixel belongs to a particular class. The basic equation assumes that these probabilities are equal for all classes, and that the input bands have normal distributions as in equation (1): [11]

$$D = \ln(a_c)-[0.5\ln(|Cov_c|)]-[0.5(X-M_c)T(Cov^{-1})(X-M_c)] \quad \text{eq. (1)}$$

Where:
D = weighted distance (likelihood),c = a particular class,X = measurement vector of the candidate pixel, Mc =mean vector of the sample of class c,a_c =percent probability that any candidate pixel is a member ofclass c,(Defaults to 1.0, or is entered from a priori knowledge),Cov_c = covariance matrix of the pixels in the sample of class c,$|Cov_c|$ = determinant of Covariance (matrix algebra),$Covc^{-1}$ = inverse of Covariance (matrix algebra) ln = natural logarithm function = transposition function (matrix algebra).

C. STATISTICAL CLASSIFICATION ASSESSMENT

Accuracy assessment of the MLC classification was calculated by means of confusion matrix (sometimes called error matrix), which compute the relationship betweenresults of a classification and the corresponding reference data

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(ground truth) .We obtain from accuracy assessment report that contains producer and user accuracies, an overall accuracy, kappa coefficient . where Overall Accuracy is calculated by summing the number of pixels classified correctly and dividing by the total number of pixels, Producer's accuracy is calculated by dividing total number of correct pixels in a class by the total number of pixels of that class as considered from the reference data(ground truth) to measure correctly classification of reference data, User's accuracyis calculated by dividing the total numberof correct pixels in a class by thetotal number of pixels that were classified in that class corresponds to measure probability of pixel classified on the thematic image actually representsthat class on the ground and kappa coefficient is another method for measuring accuracy of classification which is calculated by subtracting Chance agreement incorporates off-diagonal from Observed accuracy determined by diagonal in error matrix and divided by subtracting Chance agreement from one[12].We calculate accuracy assessment of each classified image in Envi software and define the area of interest (AOI) OF each class as reference data. .The highest values of accuracy are obtained with (N, G, C) combination of layers, and the better classification achieved the value of overall accuracy of 91.5741% and kappa coefficient 0.8846 with the Maximum Likelihood techniques. In terms of combination of bands, NGC showed the best results. The NGB combination of bands also gives suitable values, although these were lower than those from NGC.As for, The RYB combination of bands these results were significantly lower than the other combination of bands, as can be seen in

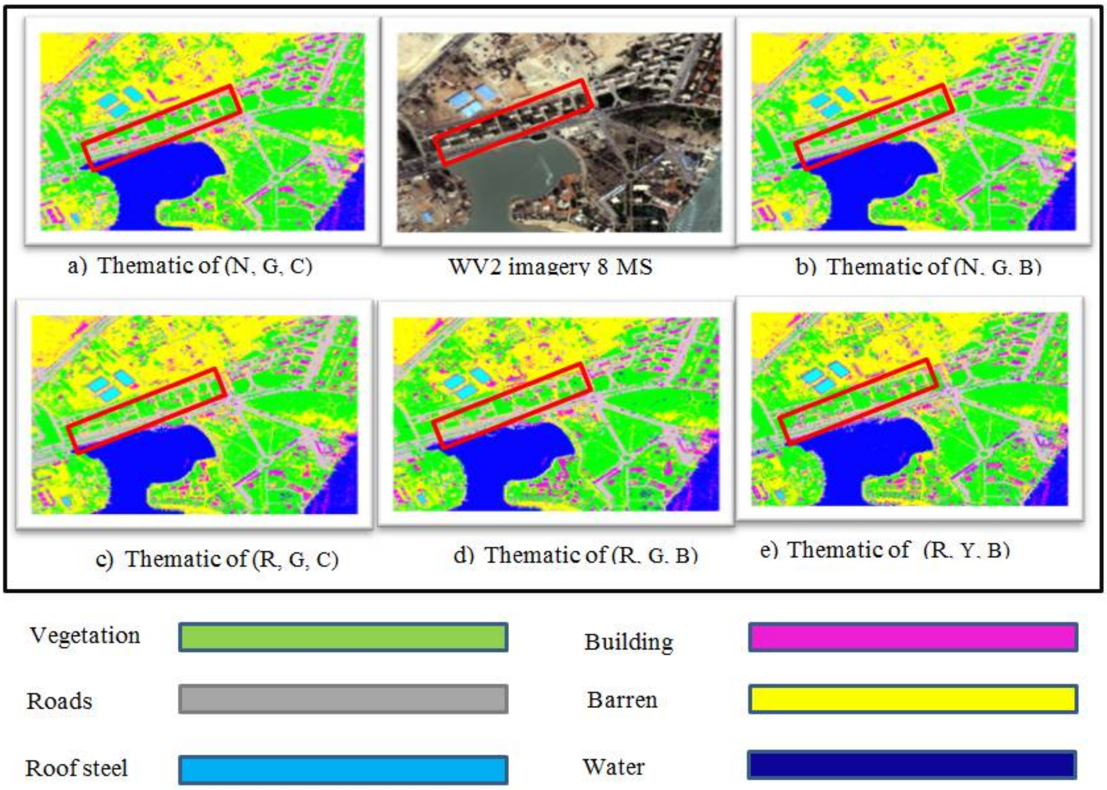

Fig.4. the results of classifications containsthe five thematic imageswhich have six classes(barren- Vegetation- Building – Water- Roof steel-roads) from the multi-layer classification process of different combination and raster input image to area of study

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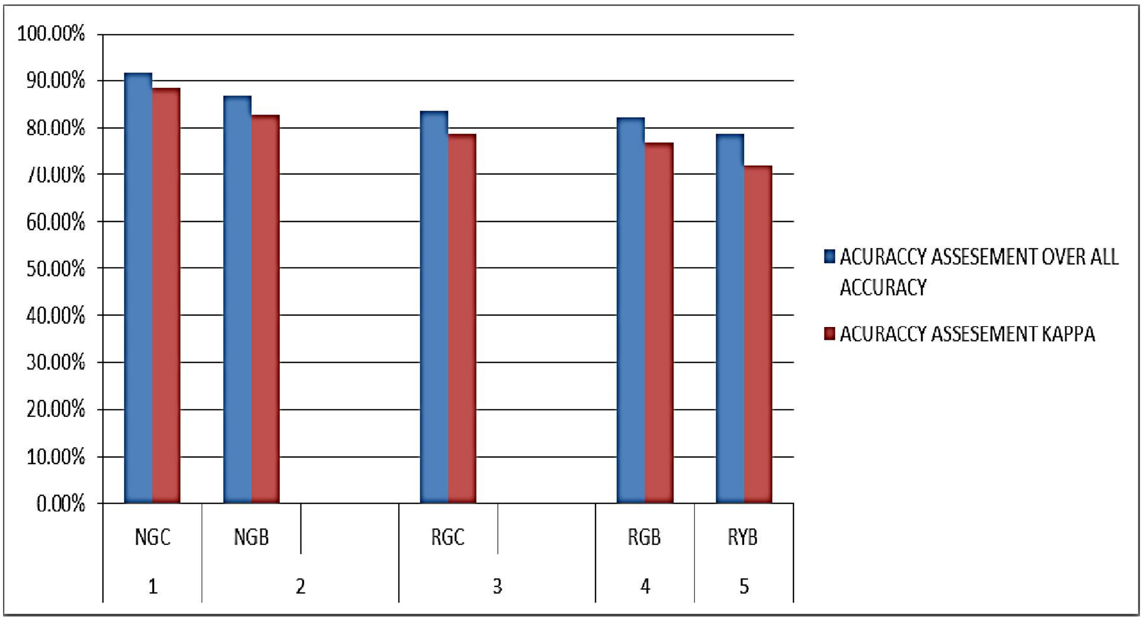

Fig.5. Overall accuracy and kappa coefficient with different combination of bands using Maximum Likelihood algorithms, each combination has two bars to represent assessment results through Overall accuracy(blue bar) and kappa coefficient(red bar) after classification process

We use producer accuracy results which calculated from accuracy assessment to calculate Population correlation between different bands using Population correlation coefficient equation: [11]

$$\rho = \frac{\sigma xy}{(\sigma x\ \sigma y)} \text{eq. (2)}$$

The population correlation coefficient uses σx and σy as the population standard deviations, and σxy as the population covariance. Results of correlation between different combinations of spectral bands for classification the results derived the lowest correlation between combination of NGC and RGB these means NGC combination is very different RGB when it is used in classification.

Table 1 illustrates results of producer's accuracy for different combination of spectral bands and table (2) shown the results of correlation. We can derive that the highest results of each class in different combination using producer's accuracy In the NGC combination bands then NGB as shown

Table 1: Producer Accuracyto evaluate correctly classification of reference data from six classes in each combination of bands which obtain From accuracy assessment

Class	NGC	NGB	RGC	RGB	RYB
VEGETATION	98.57 %	94.36 %	88.33%	83.53%	85.19%
WATER	95.76%	99.45%	97.69%	98.11%	96.33%
BUILDING	78.80%	63.04 %	71.75%	60.03%	57.73%
ROOFSTEEL	99.75 %	96.35 %	88.31%	88.78 %	88.15%
BARREN	78.80%	83.37 %	78.51%	86.47%	78.31%
ROADS	88.30%	80.76%	78.21%	69.76%	62.77%

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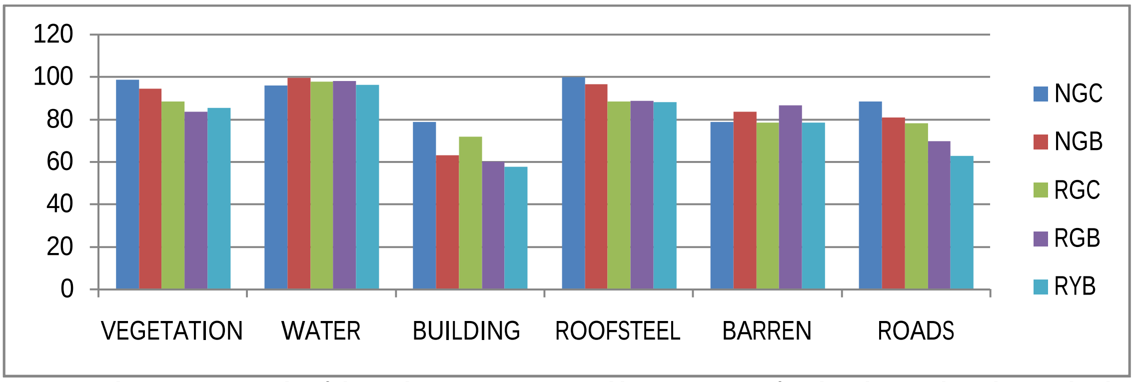

Fig.6. Represent producer accuracy results of classes (barren- Vegetation- Building – Water- Roof steel-roads) in each combination bands in graph to illustrates the most highest results through NGC combinations(blue bar)

Table 2: Correlation between different combinations of spectral bands for classification the results to illustrates relations between combinations of spectral bands when used to classify land cover

	NGC	NGB	RGC	RGB	RYB
NGC	1				
NGB	0.843174328	1			
RGC	0.820380882	0.931581387	1		
RGB	0.589339719	0.915101204	0.931712	1	
RYB	0.717574887	0.9365414	0.962341	0.976272	1

V. CONCLUSION

The recently available WorldView2 (WV2) imagery provides four new spectral bands (Coastal blue, Yellow, Red edge and NIR-2) in addition to the four standard spectral bands (Red, Blue, Green, NIR-1). This great amount of spectral information together with the very high spatial resolution of WV2 imagery provides details that are useful for production accurate mapping of land cover. The current research work proved that NGC combinations of MS bands using maximum likelihood classification technique is considered as an optimum spectral combination that can be used from WV2 imagery where overall accuracy was 91.5741% and kappa coefficient was 0.8846which is accurate classification results for urban areas.

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