Iraqi Journal of Physics, 2016 *Vol.14, No.31, PP. 81-88*

Adaptive digital technique for discriminating between shadow and water bodies in the high resolution satellite imagery

Alaa Soud Mahdi[1], Anaam Kadhim Hadi[2]

[1]Remote Sensing Department, College of Science, Baghdad University

[2]Directorate of Materials Research, Ministry of Sciences and Technology

E-mail: anamkhadi@scbaghdad.edu.iq

Abstract

This research presents a new algorithm for classification the shadow and water bodies for high-resolution satellite images (4-meter) of Baghdad city, have been modulated the equations of the color space components C1-C2-C3. Have been using the color space component C3 (blue) for discriminating the shadow, and has been used C1 (red) to detect the water bodies (river). The new technique was successfully tested on many images of the Google earth and Ikonos. Experimental results show that this algorithm effective to detect all the types of the shadows with color, and also detects the water bodies in another color. The benefit of this new technique to discriminate between the shadows and water in fast Matlab program.

Key words

Remote Sensing Images, Shadow and Water Detection, Classification of High Resolution Images and Recognizing Patterns.

Article info.

Received: Jun. 2016
Accepted: Jun. 2016
Published: Dec. 2016

تـكييف التـقنيات الرقميـة للـ تمييز بين الظـل و المسـطحات المائيـة لصـور الاقمار الصناعيـة عاليـة الدقـة

علاء سعود مهدي[1]، أنعام كاظم هادي[2]

[1]قسم التحسس النائي، كلية العلوم، جامعة بغداد

[2]دائرة بحوث المواد، وزارة العلوم والتكنولوجيا

الخلاصة

هذا البـحث يعرض خوارزميـة جديـدة لتصـنيف مناطـق الظـل والمياه لصـور الاقمار الصناعيـه العاليـة الدقـة (4-متر) لمدينة بغداد، وقـد تم تعـديل المعادلات لمركبات الفضاء اللـوني C1-C2-C3. اسـتخدمت مركبـة الفضاء اللونـي حزمة محددة من لـون C3 (الزرقاء) لتمييز منطقـة الظـل، اسـتخدمت حزمة الفضاء اللونـي فرقــة محـددة من لـون C1 (الحمراء) لتمييـز المسـطحات المائيـه (النهر)، وهـذه التقنيـة الرقميـة الجـديدة تم اختبارها بنجـاح على العـديد من صور Google earth و Ikonos وقد اظهـرت النتـائج العمليـه ان هـذه الخوارزميـة فعالـة للكشـف عن كل أنـواع الظلال مع اللون، و أيضا بالكشـف عن الماء في لون آخر. والفائـدة من هـذه التقنيـه الجديدة هو للتمييز بين الظلال والمياه في برنامج سـريع بلغـة الـ Matlab.

Introduction

The shadows are physical phenomena observed in most natural scenes [1]. Shadows in images lead to undesirable problems on image analysis. Moreover, shadows imply a geometric relationship between objects, light source, and viewpoint. That is why much attention has been paid to the area of shadow detection and removal over the past decades. The shadow can be divided into two major classes (self-shadow and cast shadow). A self-shadow occurs in the portion of an object that is not illuminated by direct light. A cast shadow is the area projected by the object in the direction of direct light [2]. The cast shadow is usually further divided into two parts, umbra and penumbra [3]. The umbra represents the shadow region where the primary light source is completely obscured, whereas the penumbra is the region around the edge of a shadow where the light source is only partially obscured. Spatial detail offered by images of Ikonos and Quickbird, will make the interpretation of imagery produces by these sensors new challenges, particularly in urban areas [2]. Because of the high spatial resolution of the images, pixels are smaller than the urban objects that need to be distinguished. Another limitation of high resolution optical imagery is the lower spectral resolution, the small number of spectral bands that are available usually blue, green, red, and near infrared obstructs the separation of classes on the basis of spectral information.

Class heterogeneity and spectral confusion among classes also hamper the image processing. Another problem the shadows cause's of confusion on image, also causes dark building, in high resolution image the shadow and water are often difficult to distinguish[1]. In Present work distinguished between the types of shadow cast of shadow and non shadow; also distinguish between the shadow and water bodies, by applying the new technique depends the modulation the equations for nonlinear transformation C1-C2-C3 components. That proposed new algorithm to get the new equations CC1-CC2-CC3 which are representing the subtractive color equations CMY that give satisfying results after applying the propose spatial filters the purpose of filtering is to smooth the image. This is done to reduce noise and improve the visual quality of the image. Often, smoothing is referred to as filtering, here filtering is very useful in detecting edges. The equations of subtractive color are very useful to increase the colors in high resolution image to classification the shadow and water in different colors.

Shadow concept

The shadows are physical phenomena, are occurring when the scattering light is reflected by any block or at targets, and appear in the image during bright daylight or under strong lighting condition and any sources of illumination. The shadow is always classified as an object which is normally connected together with the object. The patterns of shadow rely on the size of objects and the angles of lighting source. Shadows of remote sensing images are formed due to the fact that sunlight is blocked by some ground scene which may cause the loss of part or all of the information of the shadow areas. The shadow provides important information about the shape of illuminated surface and occurs when an object totally or partially occludes directly from the light source [1]. Generally, the shadow is divided in two parts: 1-self shadow which is a part of the shadow on the main objects where if not illuminated by light. 2-Cast shadow which is the object's shadow on the background [2] as shown in Fig. 1.

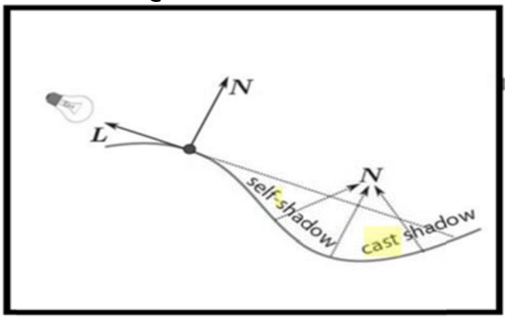


Fig. 1: The types of shadow self shadow and cast shadow, L: Direction of light, N: Is the unit surface normal [3].

Basically, cast shadow itself is divided in two umbra and penumbra. The umbra corresponds to the area where the light is totally absorbed by the object, whereas the penumbra is an area of shadow where light is partially blocked. See Fig. 2 show an example of image types of shadow. The image is segmented into the sunshine, penumbra and umbra regions, the lighting; the color of the umbra region is always darker than the penumbra color's. Self shadows usually have higher intensity values than cast shadows, because they receive more secondary light from near objects. Umbra and penumbra are other two sub categories of shadows which must also be considered.

Umbra represents a shadow region where the primary source of light is completely obscured. Penumbra is the region around the edge of a shadow where the light source is only partially obscured, or where secondary sources of light illuminate it with low intensity [3]. See Fig. 2 illustrates the type of shadow.

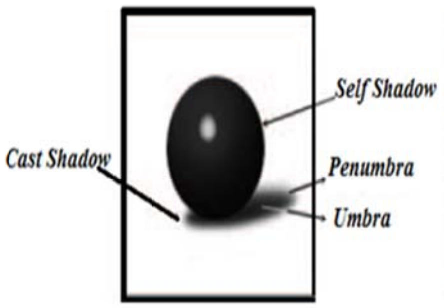


Fig. 2: Types of shadow [4].

Shadow detection

The shadow detection method based on principal modulation equation forms the *C1-C2-C3* components to detect the shadow and water bodies. As well as most the searches, the color of the shadow and water are the same color, in this work was distinguish between them in different colors by employing the second differential edge detection method operator, separate the original color image of the three bands, red, green and blue then find the maximum value for *C3* band to determine the values of normalization equation [5]. Shown these Eqs. (1, 2, 3) below

$$C1=\arctan(R/Max\,(G, B)) \quad (1)$$
$$C2=\arctan(G/Max(R, B)) \quad (2)$$
$$C3=\arctan(B/Max(R,G)) \quad (3)$$

In current work the Eqs. (1, 2, 3) have been modulated to make the classification object like shadow and water bodies. The *C*1*C*2*C*3 color space is a scale model between the three *RGB* components in *RGB*-space, the three color components of which vary clearly with the surface reflection and the sensor [6].

The shadow detection algorithms can evaluate by applying the Eq. (3), of the blue space coloring C3 component which is representing the sky color caused by Rayleigh scattering, therefore it is suitable to detect the shadow [6,7]. The modulation equations are as follows:

$$CC1=1-\arctan\,(R/\max\,(G, B) \quad (4)$$

$$CC2=1-\arctan\,(G/\max\,(R, B)) \quad (5)$$

$$CC3=1-\arctan\,(B/\max\,(R, G) \quad (6)$$

From the above equations the maximum (G,B)≈1, maximum (R,B)≈1 maximum (R,G)≈1, therefore the Eqs.(4, 5, 6) become

$$CC1= 1-R \quad (7)$$
$$CC2= 1-G \quad (8)$$
$$CC3= 1-B \quad (9)$$

The propose Eqs. (7, 8, 9) represented the CMY subtractive color model. In additive color (Red + Green +Blue)=1, the proposed equation of CC1 represents the (Cyan) color = (Green + Blue), the equation CC2 represents the (Magenta) color = (Red +Blue), and the equation CC3 represents the (yellow) color = (Blue + Green).

In additive color (Red + Green + Blue) =1, requites this in Eqs. (7, 8, 9) to get the equations:

$$CC1=R+G+B-R= G+B = Cyan \quad (10)$$

$$CC2=R+G+B-G=R+B = Magenta \quad (11)$$

$CC3=R+G+B\text{-}B=R+G=Yellow$ (12)

The normalization equation as follows [8]:

$$d(x,y) = \frac{[src(x,y) - Min(CC3) * 255]}{Max(CC3) - Min(CC3)} \quad (13)$$

where, *Src* (x, y) the gray value of the pixel position (x,y) of the original imaged (x, y), the grayscale value in pixel position *(x, y)* after normalization, and min *(src)*, max (src) denote the minimum and maximum gray value in the original image respectively.

Methodology and results

The spatial detection has been applied to detect the shadow and river or any water bodies for high-resolution images. The proposed algorithm applies color analysis, for the water detection and approximate segmentation the river shape. The approach has been tested with high resolution color images, which extracted from Google earth images suitable of the algorithm has been contrasted with a visual localization of the river entailed in a given area, and shadow, these are the steps of the program.

Step (1) Load the original image of Baghdad city in Fig. 3a. Compute the minimum and maximum RGB, apply the Eqs. (4, 5, 6) to obtain the (CC1-CC2-CC3) components. See the results in Fig. 3 (b, c, d).

Step (2) Apply the Eq. (13) to normalize CC3 to get results in Fig. 3e.

Step (3) Apply the automatic threshold on Fig. 3e, for first condition and using 3x3 or 5x5 mask to get the image in Fig. 4a.

Step (4) Use the first filter=1/8*[-1 -1 -1, -1 8 -1, -1 -1 -1] on output from step 3 to then apply a second condition to get the image in Fig. 4b.

Step (5) Apply the automatic threshold, for the second condition.

ep (6) Use the second filter=1/8*[1 1 1, 1 -8 1, 1 1 1] on output from step 4 then apply a second threshold to get the image in Fig. 4c.

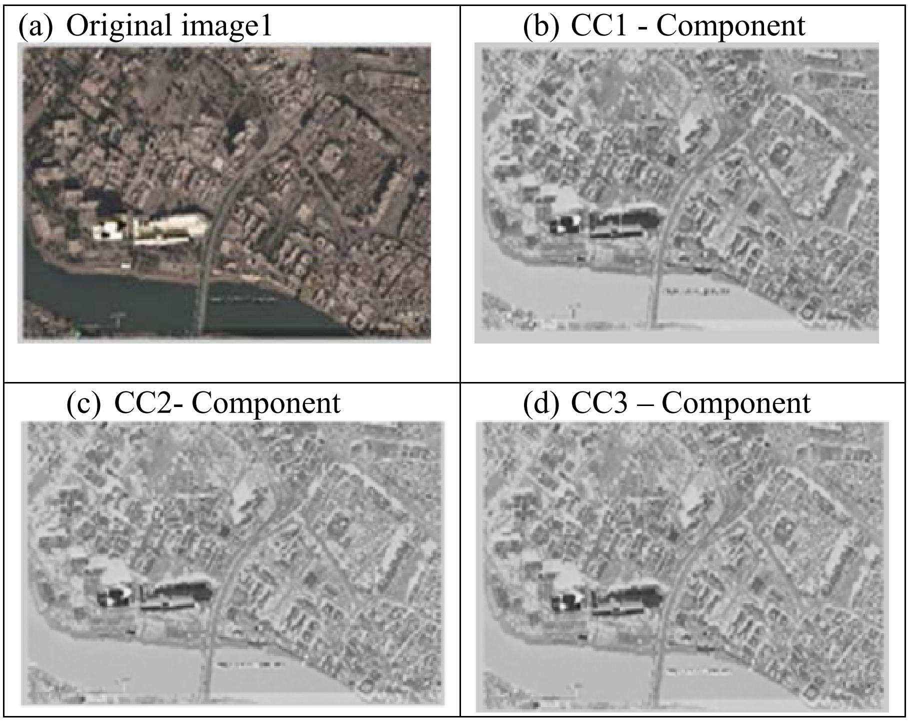
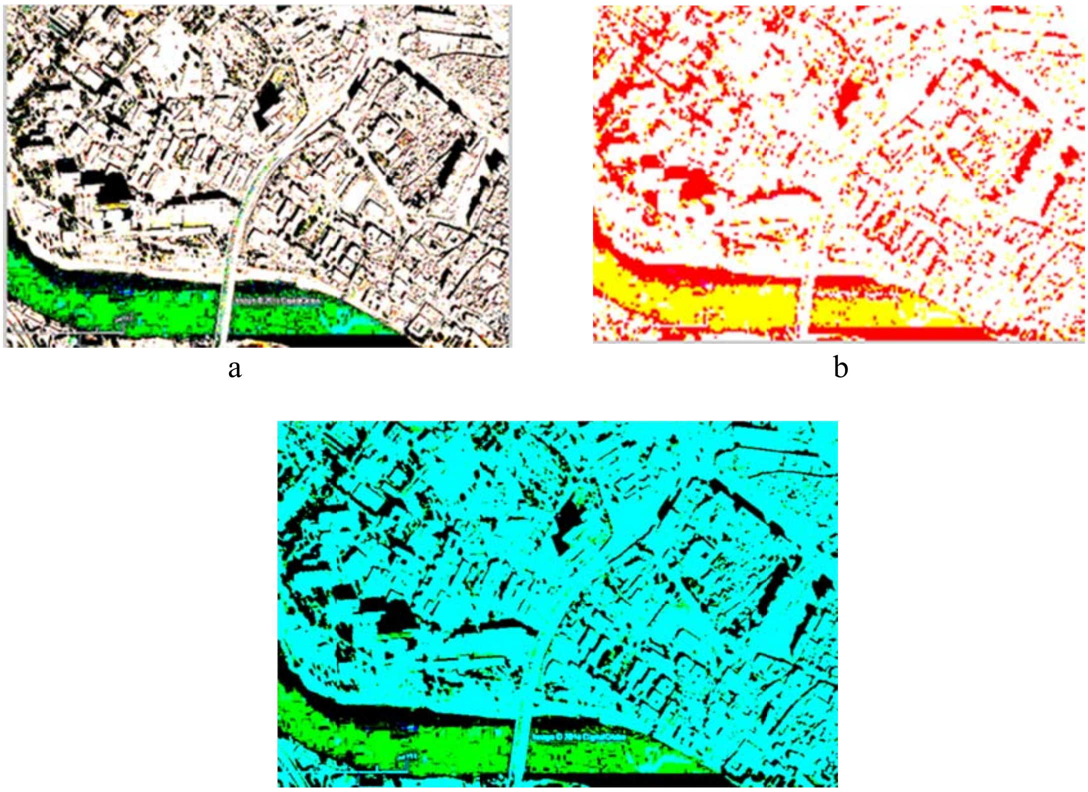


Fig. 3: (a) original Image 1, (b, c, d) CC1-CC2-CC3 components.

(e)

Fig. 3: (e) CC3 Component after normalized.



a b

c

Fig. 4: (a, b, c) Classification image 1.

Step (7) Load the Ikonos original image in Fig. 5a, repeat the previous steps to obtain the results in Fig. 5.

Can applying the previous steps on the image of Ikonos (4 meter) to get the results in Fig. 5.

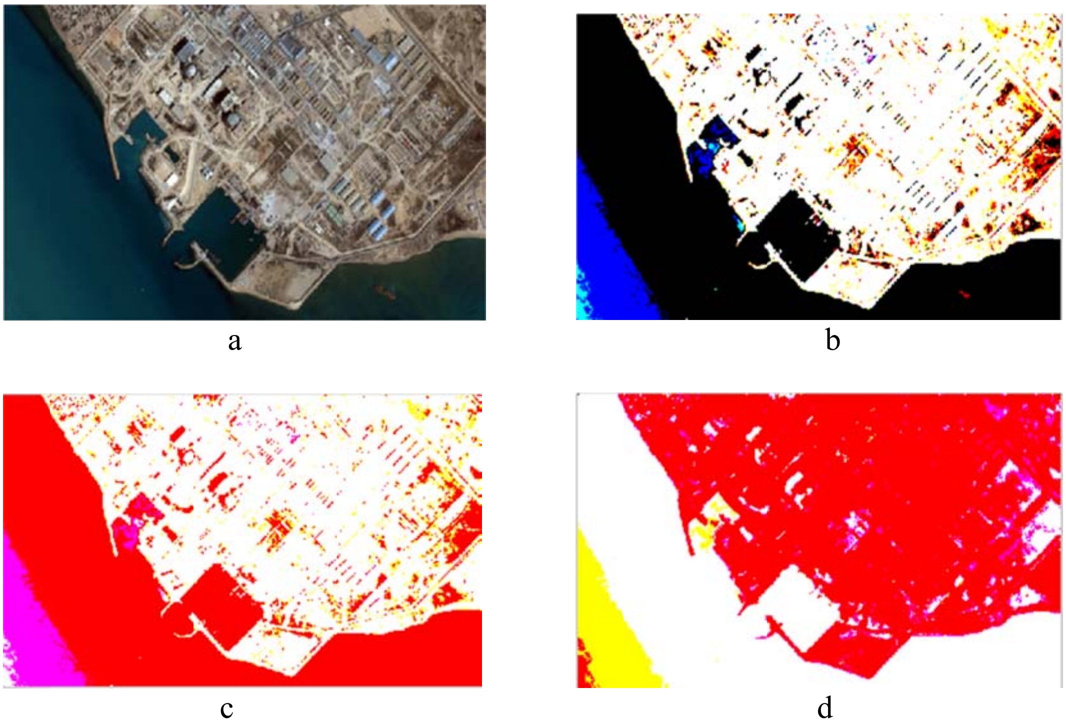


Fig. 5: (a) original image 2, (b, c, d) classification image 2.

Can summarize the above steps for the program in the block diagram below:

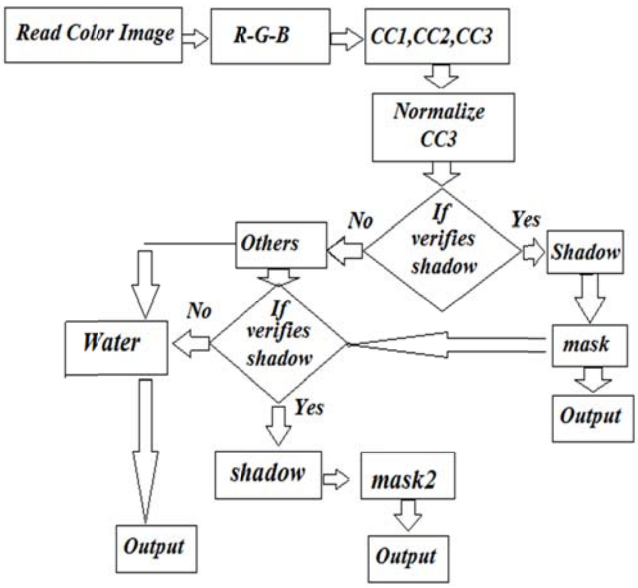


Fig. 6: The block diagram for the a new algorithm.

The assessment of results

The assessment method used here involves mainly three aspects: one is the ratio of the correct shadow date by the algorithm to the truly shadow date called Producers Accuracy (PA), the second is that of the correct shadow date by the algorithm to the detected shadow data called Consumers Accuracy (CA), and the third is that of the detected shadow data to all data called Overall Accuracy (OA) (OA can directly measure the effectiveness of an algorithm). It is defined as follows [9].

$$PA = \frac{TP}{TP + FN} \quad (14)$$

$$CA = \frac{TP}{TP + FP} \quad (15)$$

$$OA = \frac{TP+TN}{TP+FP+TN+FN} \quad (16)$$

The proportion of non-shadow pixels which are erroneously detected as shadow pixels; TN (True Negative) is the proportion of non-shadow pixels which are detected correctly; FN (False Negative). Where, TP (True Positive) is the proportion of shadow pixels which are detected correctly; FP (False Positive) is the proportion of the shadow pixels which are erroneously detected as non-shadow pixels.

Image 4, the analysis of water detection algorithms is shown in Table1. Also the analysis of numerous the shadow detection algorithms is shown in Table 2. The algorithms include the algorithm TP, FN, FP, and TN are obtained in accordance with the referenced original image of the corresponding pixels to the total number of pixels in the image. FP value in our method has a notable reduction and indicates that it reduces the error of the proportion due to detecting the non-shadows as shadows. Analyzing PA, CA and OA value, can conclude that PA values in the images change a little and the other values are all improved. The improvement of OA value directly illustrates the effect of the algorithm.

Table 1: Water assessment.

Water Non-water	TP	TN	FP	FN	PA%	CA%	OA%
Image1 Figure 4-b	112451	477	0.75	0.75	99.99	99.99	99.78
Image2 Figure 5-b	553	328	0.8	0.5	99.99	99.99	99.99

Table 2: Shadow assessment.

Shadow Non shadow	TP	TN	FP	FN	PA%	CA%	OA%
Image1 Figure 4-b	955	717	0.75	0.75	99.99	99.99	99.99
Image2 Figure 5-b	201480	599	0.75	0.5	99.99	99.99	99.99

Conclusions

This is a new algorithm for shadow and river detect, are proposed here using of the normalization of the propose new equations CC3 component to detect the shadow use CC1 to detect the water bodies in different color in Fig.4 a, the shadow is black and the water is green with white background. In Fig. 4b, the shadow is red and the water is yellow with white background, while in Fig. 4c the shadow is black and the water is green with a cyan background. In Fig. 5b, the shadow is black and the water is blue. In Fig. 5c, the shadow is red and the water is magenta. In Fig. 5d, the shadow is white and the water is yellow. Experimental results show that the algorithm detects the shadow more accurately and efficiently, and reduces the error rate of detecting the non-shadows as shadows. Present work could discriminate between shadow and water in many colors, furthermore the method can better eliminate the confusing shadows, thus improving the efficiency of the shadow detection the detection of automatic threshold has presented the good result of shadowing in high-resolution satellite imagery and methods to detect and discrimination all types of shadows in many colors. It was found that the fast, algorithms providing the best classification for shadow and water in the image.

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