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The Best Delimitation of Earth Features Using Landsat-7 Satellite Composite Images of Al-Mishkhab Subdistrict and Surrounding

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- Landsat
- Optimum Index Factor
- Determinant Covariance Matrix
- Principal Component Analysis

ABCTRACT

The study focuses on the optimum index factor (OIF) and Determinant Covariance methods. Landsat 7 ETM^+ image of Al-Mishkhab subdistrict was used to obtain the optimum results that were explaining earth features. The best result of image composite (OIF) was RGB 345, and determinant covariance was RGB 123 both for cultivated areas, water, and bare soil. In comparison with the two methods, the principal component analysis (PCA) was used in determining the landmarks precisely.

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تحديد المظاهر الأرضية لناحية المشخاب وما يجاورها باستخدام مرئيات لاندسات-٧

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الكلمات المفتاحية:

- لاندسات
- معامل الدليل الأمثل
- محدد مصفوفة التباين
- تحليل المركبات الأساسية

الـــخُـــلاصـــة

تركزت الدراسة حول حساب معامل الدليل الأفضل OIF ومحدد مصفوفة التباين كأسلوبين من أساليب المعالجة الرقمية للمرئيات لناحية المشخاب الواقعة ضمن محافظة النجف الأشرف باستخدام مرئيات قمر لاندسات لأجل الحصول على النتائج الممثلة لأفضل تحديد للمظاهر الأرضية. تم الحصول وفق الدراسة على أفضل مرئية مركبة RGB345 بإستخدام OIF وأفضل مرئية مركبة RGB123 باستخدام محدد مصفوفة التباين حيث تم تحديد أماكن تواجد التربة المحروثة (وكذا المزروعة) والمياه والتربة الجرداء. ولدى مقارنة طريقتي المعالجة بطريقة تحليل المركبات الأساسية PCA فان كفاءة الطريقة الأخيرة تثبت فاعليتها في تمييز المظاهر الأرضية بدقة عالية.

1. Introduction

The images that were obtained from remote sensing satellites in their raw form are often inefficient in terms of detection of geological, hydrological and environmental phenomena and their interpretation precisely (Prost, 2014). So, the necessity to use digital image processing methods for the purpose of producing spectral information so that the interpreter can devise the concepts of these data more effectively (Gupta, 2003). In general, digital image processing methods aim to improve and highlight the spectral information used in land-use applications (Rawa and Kumar, 2015, Yousif and Shneen, 2015, Solomon, and Breckon, 2011).

Some of the colored images require a three-dimensional matrix where the first dimension of the array represents the density (intensity) of the red color, the second dimension represents the intensity of the green color, and the third dimension represents the intensity of blue, which in turn symbolizes as RGB image (Canty, 2008). The representation of images as matrices enables users to work with them and make mathematical calculations and treatments more easily (Jensen,2005).

One of the common processing methods that are performed on these arrays is the method of forming the composite image of more than two images of the same parameter and finding the optimum index factor (OIF). The value of OIF depends on the correlation coefficient and standard deviation (Qaid and Basavarajappa, 2008). From the last two factors, the least correlative bands can be deduced. OIF is a statistical value that can be used to determine the optimal (best) combination of three bands in the satellite images which would be aimed to create a good chromatic installation (Al-Juaidi, et. al., 2003), as well as implementing the covariance matrix determinant method as a competent method concerning results accuracy. In addition to implement the principle component analysis (PCA), which is a special operation uses the eigenvalues for each of the three image components (PCs)(Gao,2009).

2. The Study Area

The research is conducted on Al-Mishkhab Subdistrict and the surrounding within An-Najaf Governorate. The area was compiled from four scenes of Landsat 7 (L7_03 /8/2006/03: 25), which is (168/38, 168/39, 169/38, 169/39). The study area is located between (44° 35 ̄ -44° 30 ̄ E) and (31° 30 ̄ -32° 08.5 ̄ N), (Figure 1). The choice of the area comes from the agricultural nature of the area and the water content due to the vicinity of Euphrates river tributaries.

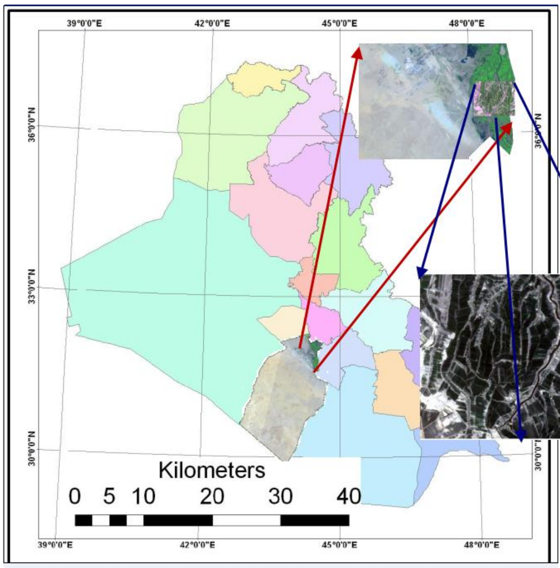

Figure (1): Map of Iraq showing the location of the city of Mashkhab in An-Najaf governorate.

3. SOFTWARE USED

1. ERDAS IMAGINE 8.4, which is a program dealing with images. In the study, Erdas was used to export image bands and the application of eigenvalue relationship of principal component analysis. The program also is used to change the pixel values for Band 6_1 and 6_2 to correspond with the rest of the bands of Landsat 7

2. ENVI 4.7 is another program that is used for image processing. In the study, ENVI was used as a supporting program to conduct the research and to show the results of the integration.

3. Excel was used at the third stage of work to calculate mathematical relationships and manipulation.

4. The Theoretical Approach

The raw data in its basic form is inefficient because the distribution of information amongst the bands in an irregular manner, varying from one band to another, as well as the ability of the human eye to distinguish between relatively close gray levels. Therefore, interpreters often resort to the use of digital processing methods for the purpose of effectively highlighting spectral information. The processing methods can be divided into the following (El-Hassan, 2007):

1. Single processing for one image such as spectral optimization and calculation of contrast ratio as well as creating histograms.
2. The processing of two images such as adding, subtraction, multiplication and band rationing.
3. The processing of more than two images, which is applied in this study. It includes:

A) The composition of the RGB composite image, that is, calculating the optimum index factor (OIF), which is a general processing can be calculate from the following relationship (Chavez et al.,1980).

$$OIF = \frac{\sum_{i=1}^{3} Stdv_i}{ABS \sum_{i=1}^{3} Corr_i}$$

where

is the total standard deviation of the three bands $\sum_{i=1}^{3} \mathrm{Stdv_i}$

$\mathrm{ABS} \sum_{i=1}^{3} \mathrm{Corr_i}$ is the absolute value of the correlation coefficient

The correlation coefficient is extracted from the Covariance contrast ratio, which was extracted using ENVI program.

B) Special processing includes the principal component analysis method where the eigenvalues for each of the three bands must be extracted, and for each eigenvalue there are three eigenvectors. The calculations represent the compensation of these values using the processing programs to obtain a better image using the relationship (Beauchemln and Fung, 2001):

$$SE = \sqrt[2]{eb_x * eb_y * eb_z}$$

Where eb_x, eb_y, eb_z are eigenvalues of the three bands

C) Find covariance matrix determinant for the three bands according to the relationship below (Beauchemln and Fung, 2001).

$$\begin{pmatrix} \mathrm{b_{xx}} & \mathrm{b_{xy}} & \mathrm{b_{xz}} \\ \mathrm{b_{yx}} & \mathrm{b_{yy}} & \mathrm{b_{yz}} \\ \mathrm{b_{zx}} & \mathrm{b_{zy}} & \mathrm{b_{zz}} \end{pmatrix} DC = DET$$

Where b_{xy}, b_{xz} ...., b_{zy} are the values of the variance between two bands of three bands

5. PRACTICAL RESULTS

The RGB123 image of the study area is as follows (Figure 2).

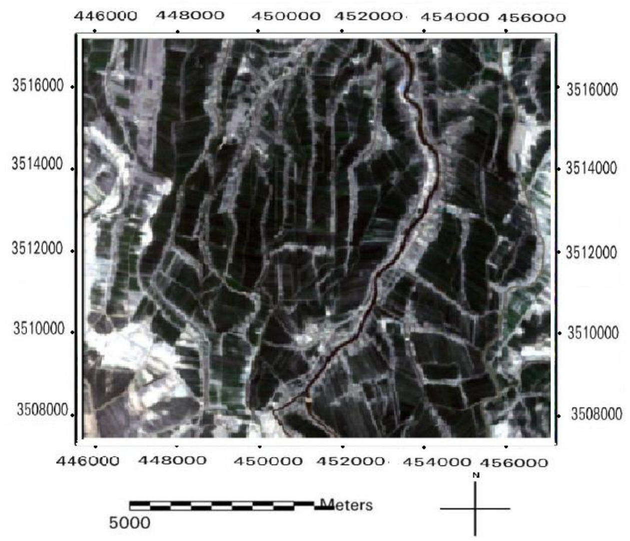

Figure 2: shows the RGB123 image of the study area.

A- Calculation of OIF

The results were obtained by converting the standard deviation value and the correlation matrix. The OIF relationship between them obtained from ENVI 4.7 and Excel, and extracting the values for each of the three combinations of bands (Table 1).

Table1: shows the values of OIF for the study area.

RGB	Sum stdv	Sum corr	OIF
345	49.52	1.62	30.63
348	41.72	1.41	29.54

458	39.30	1.34	29.41
457	47.98	1.64	29.32
478	40.18	1.39	28.90
347	50.39	1.77	28.49
247	42.66	1.70	25.11
248	33.99	1.40	24.32
134	41.95	1.74	24.07
147	40.42	1.70	23.83
148	31.74	1.39	22.84
378	45.81	2.16	21.16
358	44.93	2.20	20.40
278	38.08	2.19	17.39
138	37.37	2.20	16.99
258	37.20	2.23	16.68
178	35.83	2.16	16.60
235	47.41	2.87	16.54
237	48.29	2.92	16.51
257	45.88	2.87	15.99
135	45.17	2.84	15.90
158	34.95	2.20	15.90
137	46.05	2.90	15.87
157	43.63	2.84	15.35
123	39.85	2.96	13.47
127	38.32	2.89	13.24
125	37.44	2.84	13.19
128	29.64	2.25	13.18

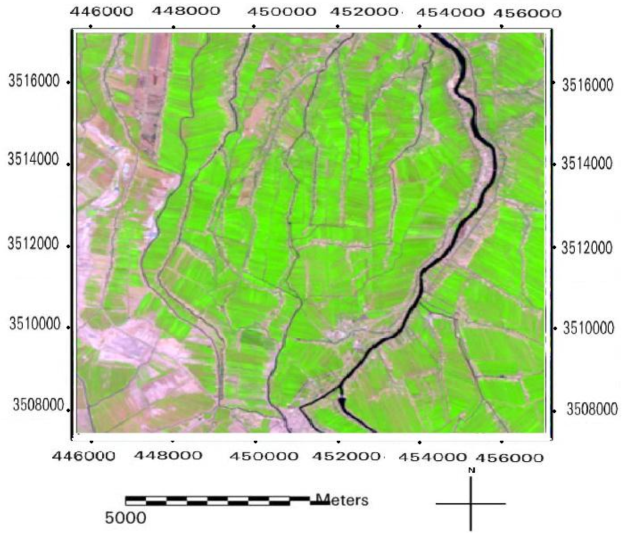

Figure 3: shows the colour composite RGB345 image of the study area using Erdas Imagine 8.4.

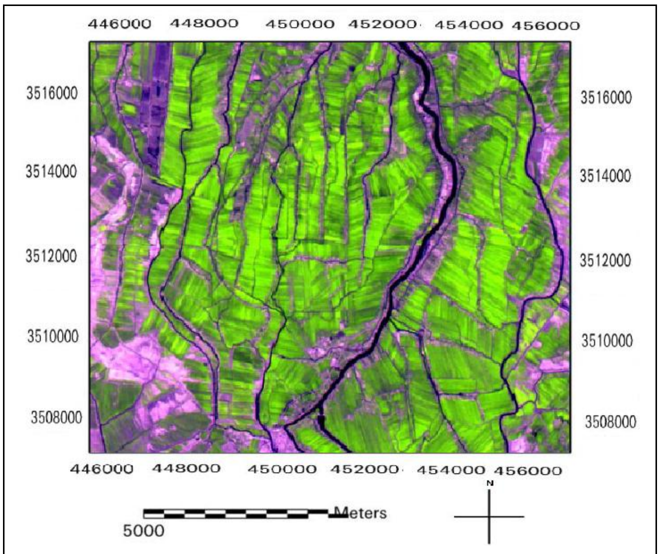

Figure 4: shows the colour composite RGB348 image of the study area using Erdas Imagine 8.4.

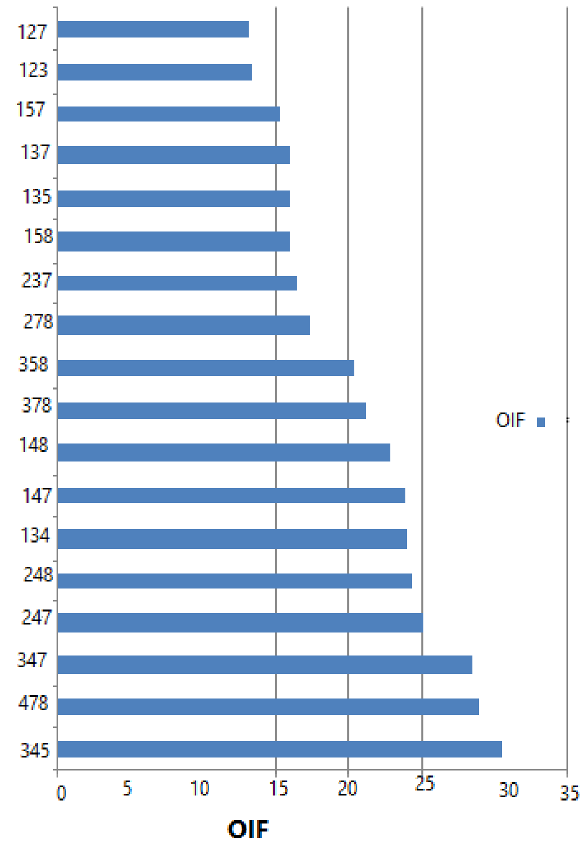

Figure 5: shows diagram of the relationship of OIF and RGB bands

B) Calculate the square root of the multiplication of the eigenvalues of each band The results were taken by converting the eigenvalue in ENVI 4.7 to Erdas Imagine and then to Excel and then extracting the values for each three combinations of bands (Table 2)

Table2: shows the square root of the multiplication of the eigenvalues of each band.

Principal Components	SQRT(e_x*e_y*e_z)	SE
123	4011.00	63.33
124	2516.93	50.17
125	1420.92	37.70
134	1369.29	37.00
135	773.02	27.80
234	551.88	23.49
145	485.08	22.02
127	455.57	21.34
128	386.30	19.65
235	311.56	17.65
137	247.84	15.74
138	210.16	14.50
245	195.50	13.98
147	155.52	12.47
148	131.88	11.48
345	106.36	10.31
237	99.89	9.99
157	87.80	9.37
238	84.70	9.20
158	74.45	8.63
247	62.68	7.92
257	62.68	7.92
248	53.15	7.29
258	53.15	7.29
347	34.10	5.84
348	28.92	5.38
178	23.87	4.89
357	19.25	4.39
358	16.32	4.04
457	12.08	3.48
458	10.24	3.20
278	9.62	3.10
378	5.23	2.29
478	3.28	1.81
578	1.85	1.36

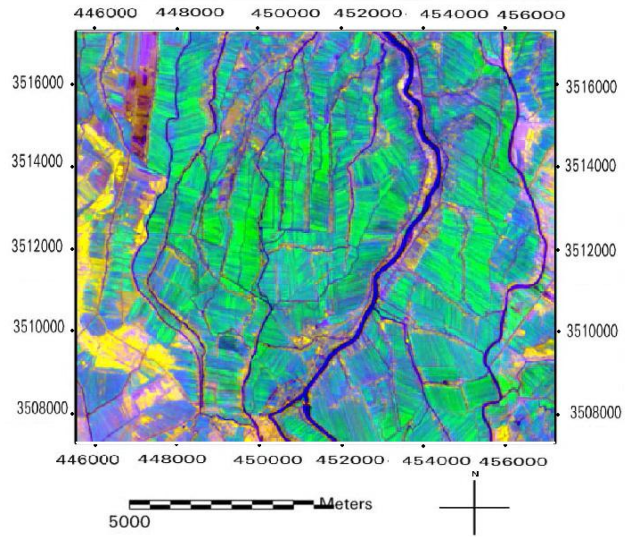

Figure 6: Shows PC123 for the square root of eigenvalues of the study area.

C) Calculation of the Covariance Matrix Determinant:

From the covariance matrix determinant, the values for each of the three bands were calculated separately, for example bands 1, 2 and 3 (Table 3).

Table3: Shows the covariance matrix determinant values for RGB123

Covariance	Band 1	Band 2	Band 3
Band 1	84.83	104.28	173.02
Band 2	104.28	131.19	217.72
Band 3	173.02	217.72	368.09

$DC=DETM_{3*3}=1722.01$

The results were taken from ENVI 4.7 and each of the three bands was transferred to Excel (Table 4)

Table 4: The Covariance Matrix Determinant of RGB of the study area.

Bands	Covariance Matrix Determinant
348	2771316.36
478	2396701.38
458	1960177.44
345	1489495.77
248	941734.23

347	881402.46
358	508677.70
247	501162.65
147	425377.93
457	388150.88
258	217928.96
134	190307.41
158	171177.86
578	153491.43
278	153027.98
234	113490.89
124	40716.98
257	39338.79
135	39014.30
238	37733.69
157	32944.33
235	27049.68
137	19497.60
237	13235.94
128	12044.86
125	9317.05
127	6291.40
123	1722.01

6. Conclusions

1. From Figure 2, RGB123 image which present the true colour composite image of the study area, earth features cannot be distinguished precisely, therefore mathematical methods must be used to simplify the interpretation of landmarks and rely primarily on the display in false colors.

2. The OIF values of RGB bands of 128, 125, 127 are low, that is, the amount of contrast in the image is low. Also, because of the correlation coefficient between these bands is high (approaches to one), these bands lie at the bottom of the Table (4). The RGB bands of 345, 348 (Figures 3 & 4) are also convergent within the highest values, that is, the best merging took place because of the correlation coefficient between these bands is low away from the one. In this case for example, the drainage pattern appears more clearly.

3. Table (2) illustrates the impression of principal components on the clarification of earth features and landmarks within the study area, that is, in PC123 (Figure 6) has the highest value, while the other principal components have lower values. In conclusion, the component 1 specialized in the showing of most features such as water, tributary, wet soils (nearby waters), and vegetation due to the high values of relationship SE they pose, which greatly illustrate areas of agriculture, water and land not planted.

4. The covariance matrix determinant supports optimum index factor in showing RGB348 , but poor in recognizing RGB345, which have the most suitable band composite due to the high OIF, and when displaying the image as in Figure (3), it was found to be more distinctive than RGB123 as in Figure (2), and both methods work on the original bands without changing the original values, i.e., simply making the best mixing of the existing bands.

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