Satellite Images Unsupervised Classification Using Two Methods Fast Otsu and K-means

Hameed M. Abduljabar* ***Taghreed A. H. Naji**** ***Amaal J. Hatem****

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Abstract:

Two unsupervised classifiers for optimum multithreshold are presented; fast Otsu and k-means. The unparametric methods produce an efficient procedure to separate the regions (classes) by select optimum levels, either on the gray levels of image histogram (as Otsu classifier), or on the gray levels of image intensities(as k-mean classifier), which are represent threshold values of the classes. In order to compare between the experimental results of these classifiers, the computation time is recorded and the needed iterations for k-means classifier to converge with optimum classes centers. The variation in the recorded computation time for k-means classifier is discussed.

Key words: Fast Otsu, k-means, unsupervised classification, multithresholding.

Introduction:

Satellite image classification is one of the final goals in the remote sensing; where the relationship between pixels is investigated in order to cluster the pixels into certain classes. In some cases, it is useful to have the computer sort out which pixels have similar characteristics (e.g., spectra) rather than to try to force the pixels into a class based on our culturally driven sense of their similarities. This is done using an unsupervised classifier.

The resultant classes will be indicative of the natural spectral clusters in the data. They may or may not correspond to land cover or material classes as we normally think of them. Because of this limitation, unsupervised classification is often used as a preprocessor for other algorithms. For example, when attempting to locate training regions for supervised classification, it is often useful to know where natural spectral groupings occur [1].

Two simple classifiers are usually used; the k-means or iterative self-organizing data (iso-data) [2] and histogram multi-threshold using Otsu algorithm [3], in which the histogram grouped into panes depending on some statistical properties, by using the k-mean algorithm the threshold between certain two panes are affected with tolerance value in the changing in the class's centers.

Materails and Methods:

Sample of Test Sceme:

The scene that used in this study is Al-Ramadi city, which located in Al-Anbar provenience of the Iraq region, and it covers (581.72) km^2 west of Baghdad. Geographic location of AL-Ramadi region had shown in figure 1. The available scene was TM exposure at March 04, 1990, illustrated in figure 2-a, the upper left corner is

*Physics Department,College of Education Ibn Al-Haitham,Baghdad, University, Baghdad/Iraq

lat. 33° 27' 21.44" N, long. 43° 29' 17.91" E and the lower right corner is lat. 33° 14' 14.05" N, long., 43° 44' 36.64" E. This region represents Alluvial Plain; the hot desert climate prevails in the sedimentary plain and the western plateau. It contains some vegetation cover, many soil and rock erosion noticed.

Method:

Since the Otsu algorithm for multi-threshold histogram is time consuming because it is need huge computation, therefore the fast algorithm that proposed by Liao [4] is adopted and applied on the histogram's gray levels of Al-Ramadi image to find the threshold values of the classes, while the algorithm that presented by Seber [2] for the k-means algorithm is adopted and applied on the test image intensity values to find the threshold values between classes. Although the both classifiers are cluster the image into classes, but the main difference between them is; in the fast Otsu classifier it determine the best threshold values between classes (i.e. the maximum and the minimum value for each class) while the k-means classifier after grouping the image into classes it present the centers of the classes, therefore in order to compare the results of k-means with the results of fast Otsu algorithm, the maximum and the minimum values of the classes that obtained using k-means classifier should be calculated since the classes centers is not necessary to be in the middle of each class range.

Results and Discussions:

In order to compare the two classifiers, Al-Ramadi image which has 827×866 pixels with 256 gray level intensities figure 2-a is used. The threshold values for different classes are calculated using two methods and the computation time are recorded (as illustrated in table 1), using 64-bit computer platform of core 2 Due 2.2GHz processer and using MATLAB Ver. 2009a.

It is obvious that the two methods succeed to calculate the optimum values for threshold the images gray level intensities to reach the same best threshold values to separate the required classes, with very close values (maximum difference is1 gray level) as illustrated in table 1. Figure 2-(c, d, e, f) shows the classified test image of Al-Ramadi into four classes using fast Otsu method.

The main difference between the two methods is required computation time; where it is clearly that the k-means algorithm needs huge computation time comparing with the fast Otsu algorithm. Another feature can be noticed in addition to huge computation time which required for the k-means classifier is the variation in the recorded computation time and the number of iterations that needed to converge with the best threshold gray level intensities, this is due to the value of the difference between the selected initial centers values with the optimum centers values of the classes and as shown in table 2. To select initial center values, the range of the gray levels intensities are divided into equal linear difference and selected as initial class centers to generate the start point for the k-means algorithm which is not necessary concede with the optimum class centers, the number of required iterations to reach the optimum class centers has forward relationship with the differences between the initial and the optimum class centers.

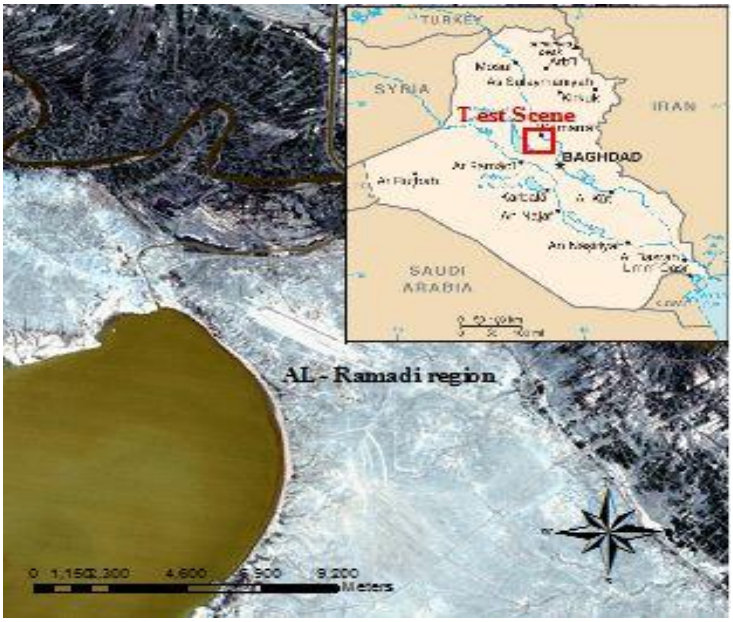


Figure 1 Test Image of Al-Ramadi Depicted its Location in Iraq

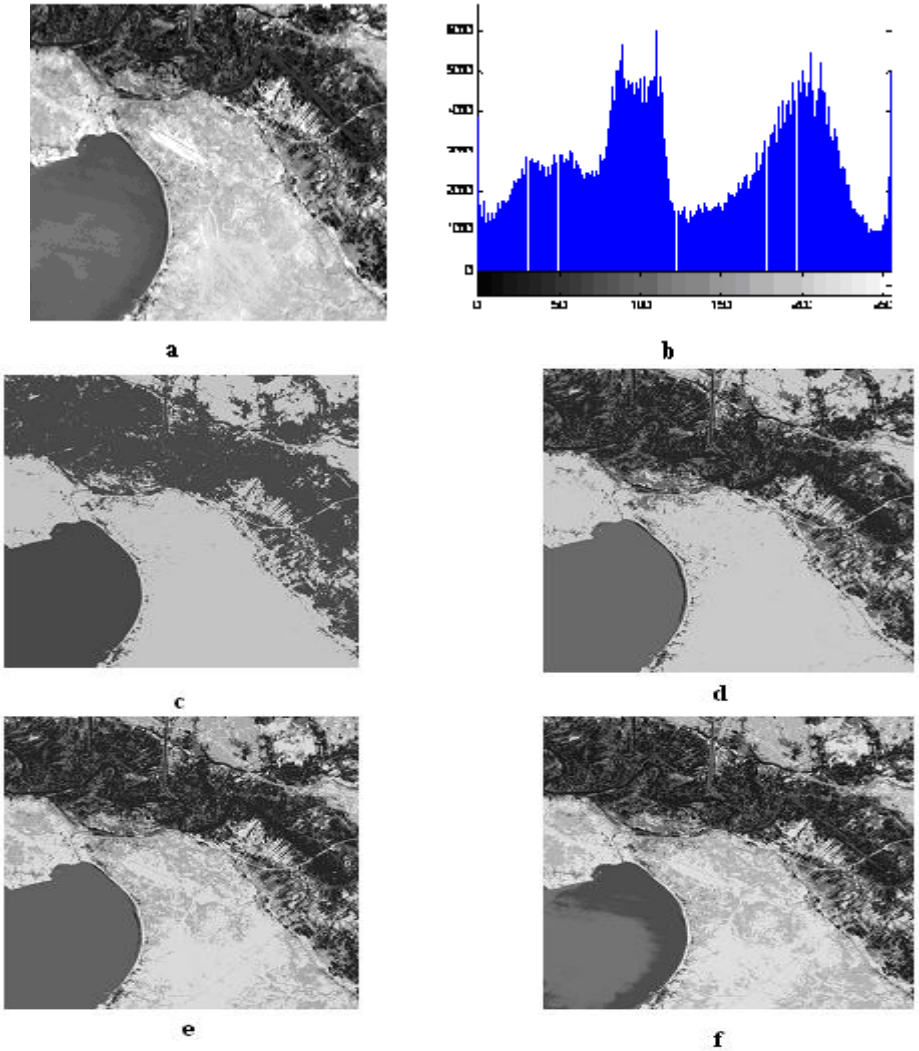
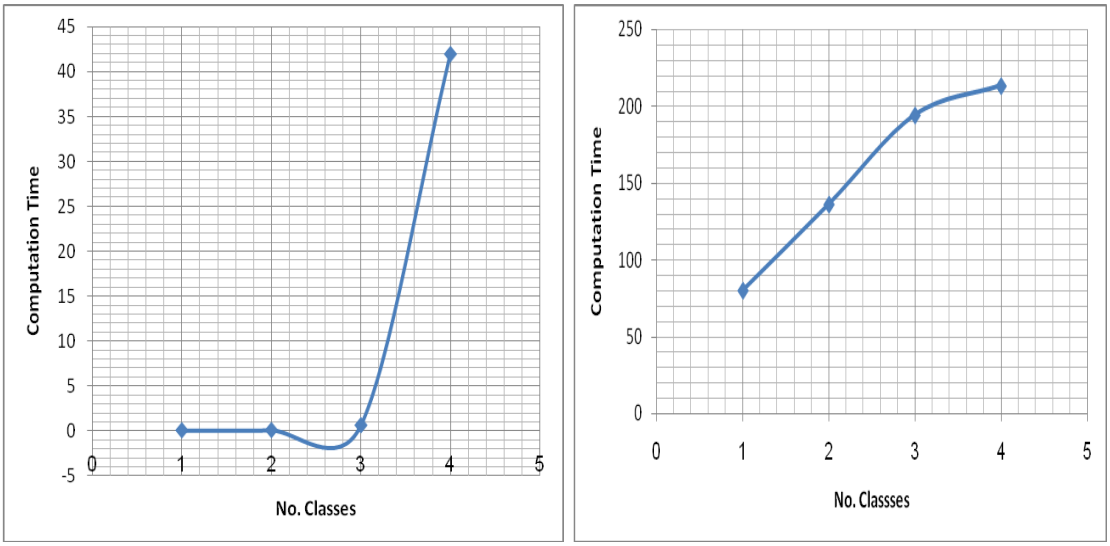


Fig. 2 Test Image of Al-Ramadi and its Histogram (a &b), (c) The Classified Image after Implementation Fast Otsu Classifier into two classes, (d) Three classes, (e) Four Classes, (f) Five Classes



a **b**

Fig. 3 Computation Time Curves Counted using (a) Fast Otsu, (b) K-Means Classifiers

Table 1 Threshold Values and Computation Time Recorded using the Two Classifiers

	Thresholds				Time (sec)			
	1	2	3	4	1	2	3	4
Fast Otsu	135	72	68	54	0.031	0.051	0.596	41.932
		154	134	97				
			194	147				
				200				
K-Means	134	72	67	53	79.954 (4-itr)	136.125 (7-itr)	194.306 (10-itr)	213.443 (11-itr)
		153	134	96				
			194	147				
				201				

Table 2 Initial and the Optimum Class Centers for k-means Classifier

	1		2		3		4	
Number of Thresholds	Initial	Optimum	Initial	Optimum	Initial	Optimum	Initial	Optimum
Classes Center Values	0	73.09736	0	39.07272	0	36.69114	0	29.37922
	255	196.2758	128	105.0815	85.6667	98.07407	64.5	78.06621
			255	201.6456	170.3333	170.4147	128	115.1595
					255	218.1046	191.5	179.6666
							255	222.504

Conclusions:

From the obtained result, the following conclusions can be derived:

- The two classifiers successes to cluster the Al-Ramadi image into very close threshold values.
- The fast Otsu classifier is very fast to calculate the threshold values compared with k-mean classifier; therefore it is recommend using the fast Otsu classifier.
- It is seen from figure 3, The computation time for fast Otsu

classifier increase exponentially while the computation time for the k-means is increase with variation manner depending on how close the initial class centers to the optimum values.

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التصنيف الغير موجه للصور الفضائية بأستعمال المصنفين اوتسو السريع والمعدل المتعدد

حميد مجيد عبد الجبار *** ***تغريد عبد الحميد ناجي* ***آمال جبار حاتم ****

*جامعة بغداد/ كلية التربية/ قسم الفيزياء

الخلاصة:

يستعرض البحث استعمال المُصنِفين اوتسو السريع (Fast Otsu) والمعدل المتعدد (K-Means) لأجل إيجاد حد العتبات الأمثل للفصل. قدمت طرائق الفصل الخالية من المتغيرات المساعدة إجراء كفوءً لأجل فصل المناطق (الأصناف) باختيارها مستوى الشدة الأمثل, إما باستخدام مستويات الشدة لمنحني الاحتمالية (Histogram) للصورة (كما في مُصنِف اوتسو), او مستويات الشدة للصورة نفسها (كما في مُصنِف المعدل المتعدد), التي تقدم حدود العتبة للأصناف. للمقارنة بين النتائج العملية لهذين المصنفين, تم تسجيل الوقت المستغرق للتنفيذ وعدد التكرارات المطلوبة للمُصنِف المعدل المتعدد للوصول لمراكز الأصناف المثلى.وقد تمت مناقشة التفاوت في الوقت المسجل للمنصف المعدل المتعدد.