# Satellite image enhancement using histogram hyperbolization

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**Abstract**

One of the most important quality factors in satellite images comes from its contrast. Contrast enhancement is frequently referred to as one of the most important issues in image processing. Image histogram is a powerful engineering tool to portray information of an image. In this paper a Landsat ETM+ image was analyzed to find out the power of histogram hyperbolization in detecting and delimiting different features in the scene. A visual basic program is designed and implemented on the spectral bands of the satellite image. The results were combined in color composites using ERDAS Imagine Ver. 9.2. Most conventional contrast enhancement algorithms usually fail to provide detailed contrast information in the dark and bright areas of remotely sensed images. The test results indicate that the proposed method provide better contrast image than the conventional enhancement methods.

## I. Introduction

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. If the source of degradation is known, one calls the process image restoration[1]. Image Enhancement techniques are instigated for making satellite imageries more informative and helping to achieve the goal of image interpretation. The term enhancement is used to mean the alteration of the appearance of an image in such a way that the information contained in that image is more readily interpreted visually in terms of a particular need. The image enhancement techniques are applied either to single-band images or separately to the individual bands of a multiband image set. This operation seeks to improve the appearance of image data as a way of assisting in visual interpretation and analysis. Image enhancement techniques improve the subjective quality of the picture, by intensifying image characteristics. The goal is to emphasize certain image features for analysis, image display, or to increase their usefulness. Examples include contrast and edge enhancement, noise filtering, and sharpening[2]. Image enhancement seeks to make the image look better and be more easily interpreted, and can either be radiometric or geometric. Radiometric enhancement is designed to improve the contrast and colour balance in an image while geometric enhancement seeks to make spatial features such as edges more apparent[3]. Radiometric enhancements include contrast stretching, histogram matching, band ratio, band arithmetic and principal component analysis. Radiometric enhancement makes extensive use of the image histograms so it is important to understand what the image histogram is and how it is used. An image histogram is a bar graph of DNs against pixel frequency (number of times that particular grey scale value occurs in the image) is termed an image histogram. The histogram represents a probability distribution function that tells us the chance of finding a pixel with a certain DNs in an image[1]. The histogram has many uses in radiometric correction but can also give clues as to the nature of the image we are analyzing. Each image band has its own unique histogram although the converse is not necessarily true. Histograms do not give any indication of the spatial distribution of the DNs but merely give an indication of their spectral distribution. Image histograms are very useful for determining the spectral distribution of the DNs in an image.

The principal objective of enhancement techniques is to process the image so that the result is more suitable than its original[1]. Image enhancement are algorithms which were applied to remotely sensed data to improve the appearnce of an image for human visual analysis, or occasionally for subsequent machine analysis[4]. Image enhancement is useful in feature extraction, image analysis, and visual information . The enhancement process itself does not increase the inherent information content in the data but it simply emphasizes cretain specified image characteristics. Enhancement algorithms are, generally, interactive and application- dependent[5]. Image enhancement techniques, such as contrast streching which maps each gray level into another gray level by a perdetermined transformation.An example is the histogram equalization method, is which the input gray levels are mapped so that the output gray level distributionis uniform. This has method been found to be a powerfull technique for improving low contrast images[6]. Other enhancement techniques perform local neighborhood operations as in convolution, transform operation as in the discrete fourier transform, and other operation as in pseudo-coloring where a gray – level image is mapped into a color image by assigning different colors to different features[7].

*II. The Histogram Hyperbolization*

It consists of a memoryless nonlinear, space-invariant transformation of the pixel brightness values. This transformation is based upon the histogram of the picture to be processed and the nature of human brightness perception. Contrast is generally defined as the relative difference between light and dark areas of a picture because the visibility by such relative differences, it is often possible to enhance the intelligibility of pictures by an appropriate transformation J(I) of the pixel brightness values **I(X,Y). T**his is especially true when images occupy a small portion of the available dynamic range. when the pixel brightness values of an image are subjected to a memory less, space – invariant transformation J (I), the empirical probability density function P(I) is modified as follows[8]:

$$p(J) = \frac{d}{dJ}\int_{\mathrm{Im}in}^{I(J)} p(I) d(I) \qquad (1)$$

where

*I(J)* is inverse of *J (I).*

The above equation represents the continues case, which is discussed first for simplicity. Also and without loss of generality, it is assumed that I is normalized to the range 0 <= I <= 1.

The basic idea underling histogram hyperbolization is to seek a function J (I) such that all perceived brightness levels of the processed image are equiprobable because the perception of brightness is a nonlinear function of light intensity, this goal is not achieved by histogram equalization. In order to specify an appropriate transformation, we need an expression for the perception of brightness for which about half a dozen formulas have been proposed . The difficulty is that brightness perception depends upon viewing conditions such as target size, background illumination, etc.Which are unpredictable in pictures, and has been arbitrarily chosen here to express the perceived brightness Bas:

$$B = \log(J + c)$$

And the constant c is the adjusted experimentally ( normalization is not necessary here ) .

Letting

$$B_{\max} = \log(1 + c)$$

$$B_{\min} = \log c_2$$

And requiring that B be equally distributed,

$$p(B) = \frac{1}{B_{\max} - B_{\min}}$$

To find that the desired density function

$$p(J)=\frac{d}{dJ}\int_{B\min}^{B(J)}\frac{1}{B_{\max}-B_{\min}}dB=\frac{1}{(J+c)\log(1+1/c)} \qquad (2)$$

Has a hyperbolic from. Because the effect of the parameter c is some
what obscure a more convenient parameter is defined, namely, the slope s of P (J) at the origin J = 0

$$s=\frac{d}{dJ}\bigg|_{J=0}=\frac{-1}{e^2\log(1+1/c)^2} \qquad (3)$$

The desired function *J* (*I*) can now be determined by observing that ( see equations( 1 ) and ( 2 ) ).

$$p(J)=\frac{1}{(J+c)\log(1+1/c)}=\frac{d}{dJ}\int_0^{I(J)}p(I)d(I) \qquad (4)$$

Integrating both sides with respect to *J*, to obtain

$$I(J)=F_{I^{-1}}\frac{\log(1+J/c)}{\log(1+1/c)} \qquad (5)$$

where $F^{-1}$ is the inverse of the cumulative distribution

$$F_I=\int_0^I p(I)d(I) \qquad (6)$$

$$J(I)=c(\exp[\log\ 1+1/c\int_0^I p(I)dI]-1) \qquad (7)$$

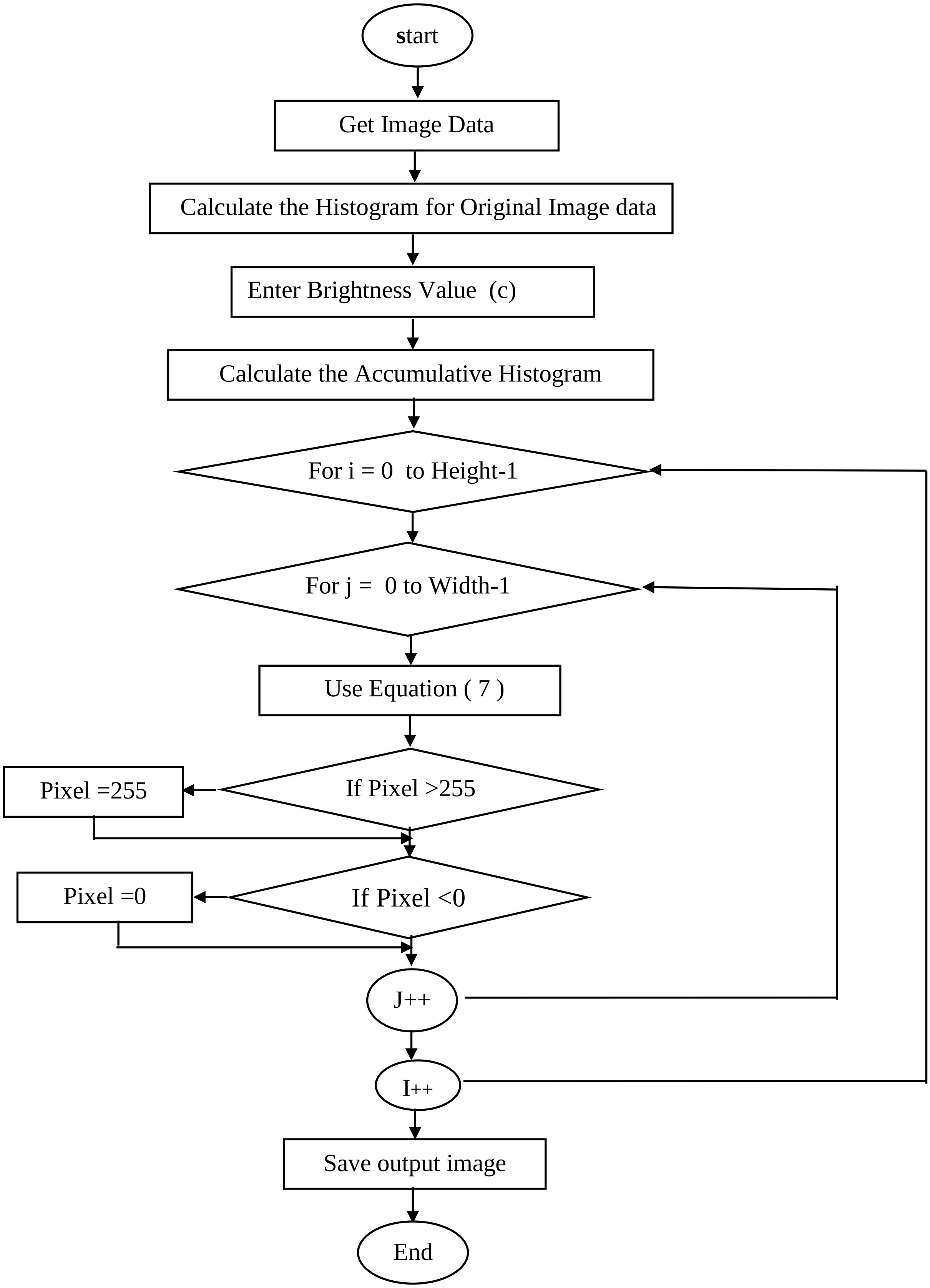



**Figure ( 1 ) Histogram Hyperbolization Flowchart**

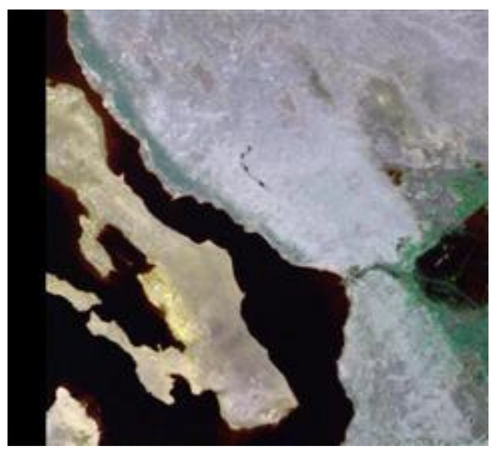
III. Results and discussion:

Figure ( 1 ) represent the flowchart of the visual basic program. Different values of the parameter c have been used , and applied to satellite images. Its effects are shown in the following figures.

The histogram hyperbolization depends on the value of a special variable of the light intensity levels. It gave the satellite image details that is more clear and accurate than the original image.

We analyzed a Landsat image shown in figure(2), and its subset shown in figure (3), to find out which methods of digital image processing give the most useful results for detecting and delimiting different features, by using different values of the controlling parameter c, shown in figures (7),(8),(9),(10),(11), and (12) . The best results were obtained with enhanced colour composites shown in figures (13) and (14), especially when histogram hyperbolization was applied: the features types that were known from the area were clearly visible in the image products, and also previously unknown regional patterns were found . Most conventional contrast enhancement algorithms usually fail to provide detailed contrast information in the dark and bright areas of remotely sensed images.

Figure( 2 ): Landsat Image.



Figure( 3 ): Subset of image.

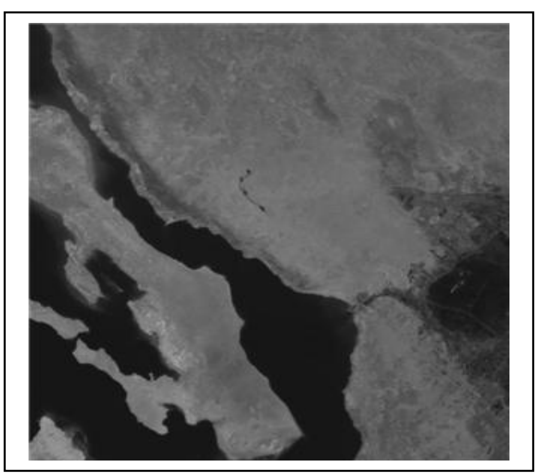
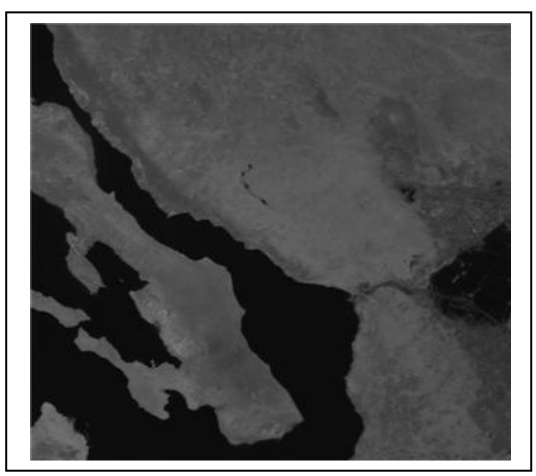
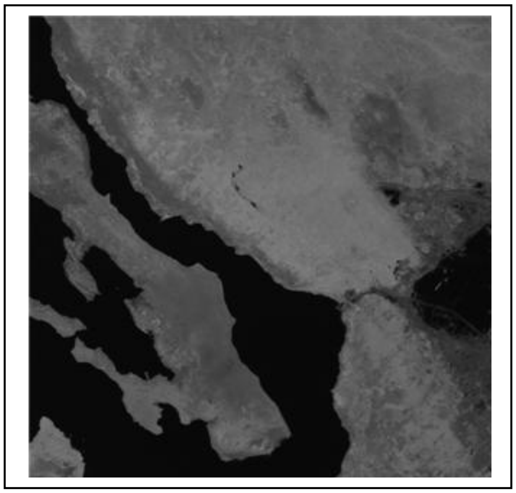


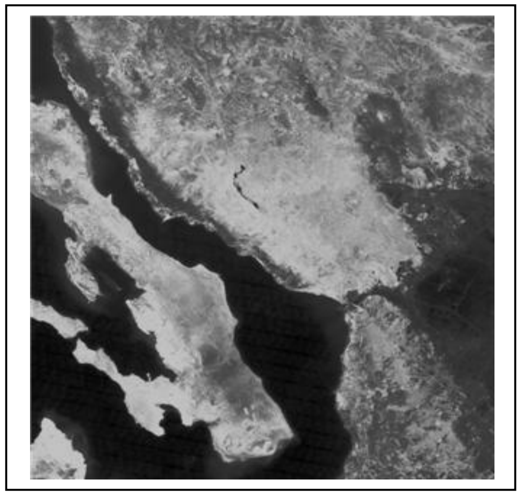
Figure ( 4 ): Band one.



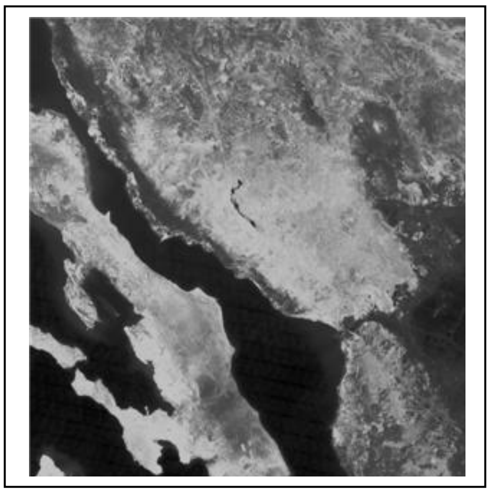
Figure( 5 ): Band two.



Figure( 6 ): Band three.



Figure( 7 ): Band one , c=4.5.



Figure( 8 ): Band one , c=5.5.

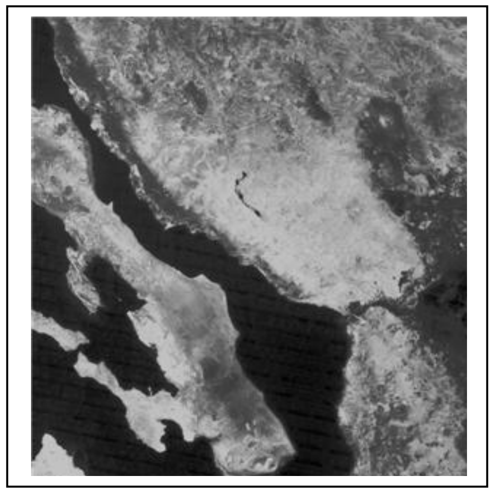
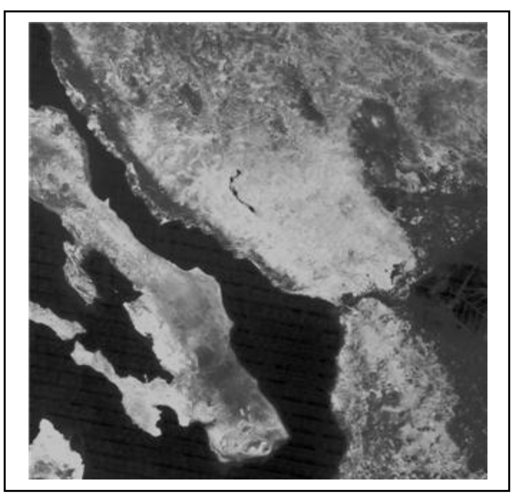
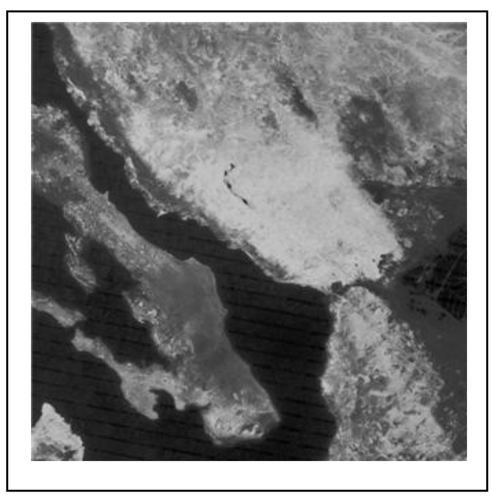


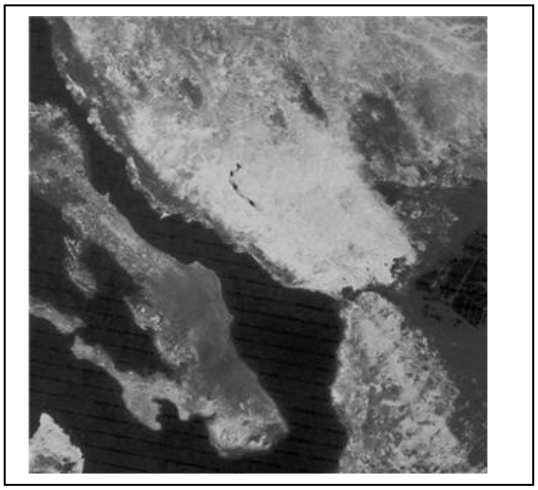
Figure ( 9 ): Band two, c= 4.5.



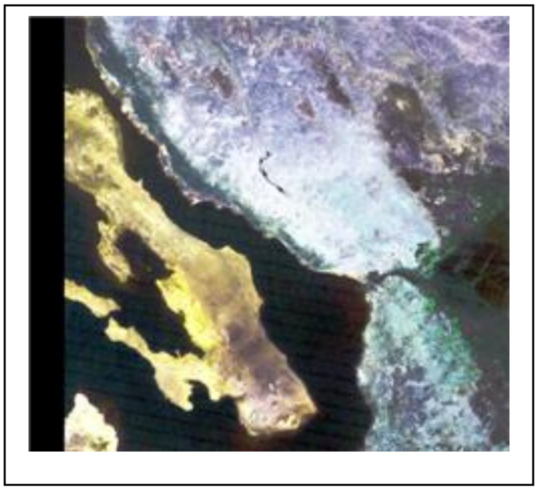
Figure( 10 ): Band two , c=5.5.



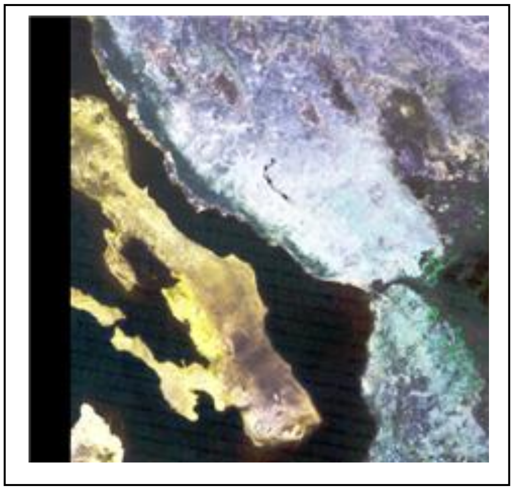
Figure( 11 ): Band three, c=4.5.



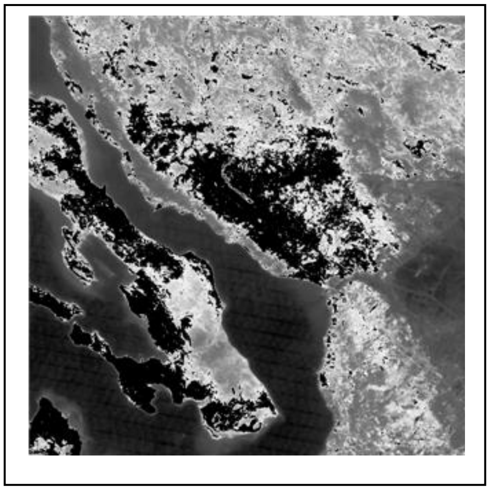
Figure( 12 ): Band three, c=5.5.



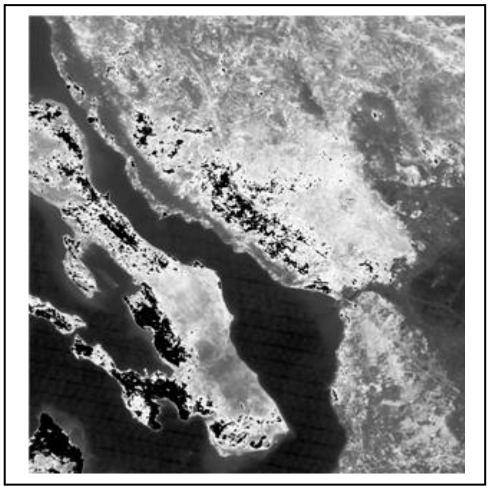
Figure(13): Band combination, c=4.5.



Figure( 14 ): Band combination, c=5.5.



Figure( 15 ): Band one , c=3.5.



Figure( 16 ): Band one , c=4.

The effects of changing the values of the parameter c are also clear in figures (15) and (16). Therefore a special attention is necessary to avoid negative effects when applying the algorithm on satellite images. Distortion on image in these two figures is evident.

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# تحسين الصور الفضائية باستخدام المخطط التكراري الفوقي

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**ملخص**

ان أحد أهم العوامل النوعية للصور الفضائية يأتي من تباين الصورة. يشار الى تحسين التباين غالبا كأحد القضايا المهمة في معالجة الصور. يعتبر المخطط التكراري أداة هندسية فعالة لتصوير معلومات الصورة. تم في البحث تحليل صورة القمر لاندسات لايجاد قوة المخطط التكراري الفوقي و قابليته في كشف وتحديد المعالم المختلفة بالمشهد. صمم برنامج بلغة البيسك المرئي واستخدم على الحزم الطيفية للصورة الفضائية. تم دمج النتائج للحصول على صور مركبة ملونة باستخدام برنامج ايرداس النسخة 9.2. ان معظم خوارزميات تحسين التباين التقليدية تفشل عادة في ايضاح معلومات التباين التفصيلية في المناطق المضلمة و المضيئة لصور التحسس النائي. لقد اثبتت النتائج الاختبارية بان الطريقة المقترحة توفر صورة ذات تباين افضل من طرق التحسين التقليدية.