CONTRAST OF TV-SATELLITE IMAGE EDGES AND QUALITY MEASUREMENT

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Abstract
In this paper the TV-satellite images have been analyzed to estimate their quality by using contrast of image edges method. The edges of the image have the most important image information and details that describe its contents. The contrast of edges has been determined using Michelson formula after modifying it into two different equations based on the mentioned formula. This method has been applied to the TV-Satellite images (same image) from the same channel (Abu Dhabi) of different satellites which are Arabsat, Hotbird, and Nilesat. The results show that the image on Nilesat has the best contrast of edges in the two ways than the images on Arabsat and Hotbird.

Key words: Contrast, Quality Measurement, Main and second diagonal contrast of edges.

Introduction
Since the advent of television in the early 1940s, numerous methods have been used to bring news, sports and other forms of entertainment from the TV studio and the broadcast site to consumers. Cable television began its evolution in the early 1950s with systems designed to bring terrestrial network programming to rural areas in the United States [1].

Digital television has been an anxiously awaited revolution by many since the early 1970s. While the basic methods have been well understood for years, affordable technology to handle the vast quantities of data and the rate at which this data has to be transmitted were not available. Thus audio and video broadcasts have traditionally been relayed as analog signals, even in cases where digital processing has been used at either end of the transmitting or receiving circuit. To serve such professional needs, relatively high cost processing equipment such as standards converters and editing consoles using digital methods were slowly introduced during the past two decades [1].

Satellite TV is playing a major role in the revolution occurring in man-made communications. Satellites and computers have altered everything from business structure to the way children learn and entertain themselves. In particular, dishes that receive audio and video entertainment and information are having a dramatic, global effect from our largest cities to the most separately populated rural areas [1].

So that, there has been an explosive growth in multimedia technology and application in the past several years. Efficient representation of a good image and good image quality estimation are some of the challenges faces. Estimating the quality of the digital image can play variety roles in image processing application [2].

A number of researches have been conducted to study the contrast of image in different ways to estimate its quality, here are number of these studies:

1. Peter J. Bex and Walter Makous 2001: Examined contrast sensitivity and suprathreshold apparent contrast with natural images. The spatial frequency components within single octaves of the images were removed (notch filtered), their phases were randomized, or the polarity of the image was inverted. Of Michelson contrast, root-mean-square (RMS) contrast and band-limited contrast, they discovered that RMS contrast was the best index of detectability. They use contrast detection thresholds and suprathreshold matching function which showed the elevation and loss of spatial frequency dependant contrast for both notch filtering and phase randomize [3].

2. Ayten Noori Husian Al-Biaty 2005:This study was devoted to evaluate image quality depending on computing the image contrast in edge regions, and introduce robust quantitative measures to determine image quality, then estimate the efficiency of the various techniques in image processing applications. In this study they suggested new techniques to calculate image contrast (visibility) and studying it as a function of number of smoothing iterations from using mean filter and a function of gray level resolution [4].

3. WANG Chao and YE Zhong-Fu 2007: They considered the property of human visual system (HVS) and transferred the quantitative perceptual variations from each source image to the result. Using just-noticeable-difference (JND) as measureement, the multiband images perceptual contrast is obtained as a target. They constructed a functional extremum problem to find a single band image, or fusion result, which has the closest perceptual contrast to the target one. Via the variational approach, the Euler-Lagrange equation is derived, and a gradient descent iteration is employed. Experimental results showed that this method is perceptually good [5].

4. Nabeel M. Al Dalawy 2008: This research aimed to study the noise associated with TV images and determined the type of the noise and the relationship between the mean and the standard deviation for regions illumination components of small rotating angles of the antenna. Also this research studied the relationship between the rotating angle of the antenna and the statistical measures which include mean, standard deviation, variance and mean square error (MSE) for three bands RGB and Luminance [6].

5. Ali J. Al Dalawy 2008: He studied the TV-Satellite images of "Al-Hurra" channel broadcasted on Arabsat, Hotbird and Nilesat. These images were the same with respect to the type on the three satellites. Analyzing these images done statistically by finding the statistics distribution and studying the relations between the mean and the standard deviation of the color compound (RGB) and light component (L) for the image as whole and for the extracted homogeneous regions. Also he studied the contrast of image edges depending on sobel operator in limiting the edges and studied the contrast as function for edge finding threshold. He found the Hotbird has the best results [7].

Edge Detection

Edge detection task is based on one of the discrete differentiation forms, it is the foundation for many application in computer vision. Edge detection is an important task in image processing. It is a main tool in pattern recognition, image segmentation, and scene analysis. An edge is loosely defined as an extended region in the image that undergoes a rapid directional change in intensity [8].

Edge detection algorithms usually detect sharp transitions of intensity and/or color within an image. These transitions are characteristic of object edges. Once edges of an object are detected other processing such as region segmentation, text finding, and object recognition can take place. However, the edges and regions thus generated will probably not only outline material boundaries, but also shadows, and intensity changes across the object [9].

The goal of Edge detection is to locate the pixels in the images that correspond to the edges of the objects seen in the image. This is usually done with a first and/or second derivative measurement followed by a test which marks the pixel as either belonging to an edge or not. The result is a binary image, which contains only the detected edge pixels [10].

Edge detection can be used to find complex object boundaries by making potential edge points corresponding to places in an image where rapid changes in brightness occur. After these points have been marked, they can be merged to form lines and object outlines [11].

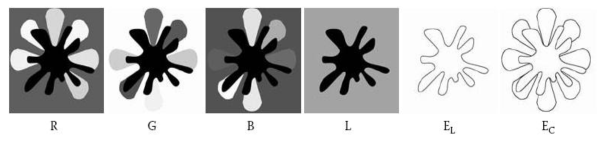


Fig.(1):Test image with its R, G, B channels and the luminance L. EL depicts the edges found utilizing only the luminance, and EC shows the detected edges when the color information is also considered [12].

In many cases, edge detection based only on the intensity of the image may not be sufficient, because no edges will be detected when neighboring objects have different chromaticity but the same luminance (see Fig.(1). Because the capability of distinguishing between different objects is crucial for applications such as object recognition and image segmentation, the additional boundary information provided by color is of great importance. Therefore, there is a strong motivation to develop efficient color edge detectors that provide high-quality edge maps [12].

There are many types of filters could be used as edge detectors (such as Sobel, Preweit, Gradient, and Laplacian filter). The sobel operator is a very well known edge detector. It has been shown to be a good edge detector. In its expanded form, it will deal better with the information contained in color images where the operator is applied to each color plane independently [9].

Sobel operator emphasis regions of high spatial frequency that corresponds to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input image. At least, the operator consists of a pair of 3×3 convolution kernels. The sobel operator therefore resulted in better accuracy [13].

The sobel edge detection masks look for edges in both the horizontal and vertical directions and then combine this information into a single metric. The masks are as follows [11]:

-1	-2	-1
0	0	0
1	2	1

Row Mask

-1	0	1
-2	0	2
-1	0	1

Column Mask

These masks are each convolved with the image. At each pixel location we know have two numbers: s1, corresponding to the result from the row mask, and s2 from the column mask. We use these numbers to compute two metrics, the edge magnitude (G) which is defined as follows [11]:

$$G = Max\left[\left|s_1\right| , \left|s_2\right| \right] \quad .... (1)$$

The edge direction is perpendicular to the edge itself because the direction specified is the direction is gradient, along which the grey levels are changing [11].

Human Visual System (Hvs)

The Human Visual System (HVS) is very complex and able to deal with a huge amount of information. Roughly speaking, it is composed of a receiver with a pre-processor stage, the eye and the retina, a transmission channel, the optic nerve, and a processing engine, the visual cortex. In retina there are three kinds of photo receptors responsible for daily vision, called L-, M-, and S-cones or more simply blue, red, and green cones. They reach their maximum sensitivity at the wavelength corresponding to these basic colors. In recent models of color vision, the color information issued from the cones are combined and transformed into three channels, one achromatic and others chromatic. Achromatic channel or luminance is treated more or less separately from chrominance channel by the HVS [14].

a) Spatial Frequency Resolution

In order to understand the concept of spatial frequency, it is first needed to define exactly what we mean by resolution. Resolution has to do with the ability to separate two adjacent pixels–if we can see two adjacent pixels as being separate, then we can say that we can resolve the two. The spatial frequency concept must include the distance from the viewer to the object as a part of the definition. With a typical television image, we can not resolve the individual pixels unless we get very close, so the distance from the object is important when defining the spatial frequency. We can eliminate the necessity to include distance by defining spatial frequency in terms of cycle per degree, which provides us with a relative measure [11].

b) Brightness Adaptation

The attributes of brightness and lightness are very often interchanged, despite the fact that they have very different definitions. Brightness attribute of a visual sensation according to which an area appears to emit more or less light. Lightness is the brightness of an area judged relative to the brightness of a similarly illuminated area that appears to be white or highly transmitting [15].

In images we observe many brightness levels, and the vision system can adapt to a wide range. However, it has been experimentally determined that we can detect only about 20 changes in brightness in a small area within a complex image. But, for an entire image due to the brightness adaptation that our vision system exhibits. For gray levels in a digital image, we need at least 7 bits/pixel (2^7=128) [11].

The gray scale intensity or brightness is calculated from the following eq. [16]:

$$I = 0.299R + 0.587G + 0.114B \quad \text{.................... (2)}$$

Where I is the intensity (Luminance) and R, G, B are the RGB color coordinated.

c) Contrast And Contrast Sensitivity

Contrast is relative measure of intensity of a stimulus, as compared to its surroundings (It is dimensionless). In psychophysical studies, the typical measure of contrast between two intensities I_{Max} and I_{Min} (I_{Max} being brighter) is the Michelson contrast [17]:

$$Ct = \frac{I_{Max} - I_{Min}}{I_{Max} + I_{Min}} \quad \text{...................... (3)}$$

Contrast provides the primary dimension for the definition of most objects in natural environment. Some objects are brighter than their backgrounds (Positive contrast), whereas others are darker (negative contrast), appearing as backlit objects, shadows, or the myriad of objects that reflect less light than their background. [18]

Contrast sensitivity, which is simply the reciprocal of the contrast, is the typical measure used by psychophysical gauge human visual performance [17]. The Contrast Sensitivity Function (CSF) describes the pattern sensitivity of the Human Visual System (HVS) as a function of contrast and spatial frequency [19].

High contrast images have large regions of dark and light regions. Images with good contrast have a good representation of all luminance intensities. As the contrast of an image increase, the viewer perceives an increase in detail. This is purely a perception as the amount of information in the image does not increase. Our perception is sensitive to luminance contrast rather than absolute luminance intensities, Fig. (2) shows this [20]:

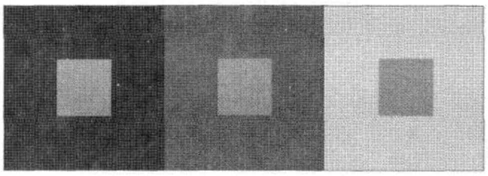


Fig.(2): Example of simultaneous Contrast [20].

An image with low contrast has a histogram are either concentrated on the right, left, or in the middle of the gray scale [21]. The components of the histogram in the high contrast image cover a board range of the gray scale and, further that the distribution of pixel is not too far from uniform, with very few vertical lines being much higher than the others. Intuitively, it is reasonable to conclude that an image whose pixels tend to occupy the entire range of possible gray levels and, in addition, tend to be distributed uniformly, will have an appearance of high contrast and will exhibit a large variety of graytones, Fig.(3) shows the histograms of high and low contrast [21].

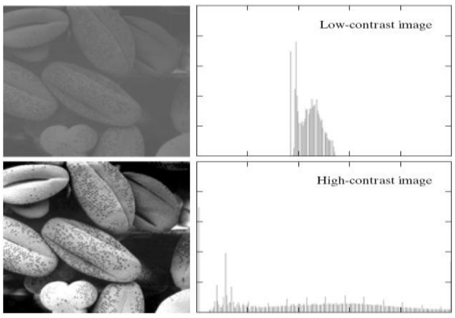


Fig. (3): Two images of low and high contrast and their corresponding histograms [21].

TV-Satellite Image Analysis System

The foundation idea of this paper is to analyze the TV image using different contrast computing approaches. This paper has considered three same TV-satellite images on different satellites (Arabsat, Hotbird and Nilesat). These images were captured using satellite home receiver of type (strong SRT 4620) which attached to a TV-Tuner card of type (Easy Capture TV). After complete the installation process of the TV-Tuner card that we used it to record number of video clips from three satellites which are Arabsat, Hotbird and Nilesat of the same channel (Abu-Dhabi).

An overview of the developed system architecture in this work is presented in Fig. (4). The steps involved processes are discussed in the following sections.

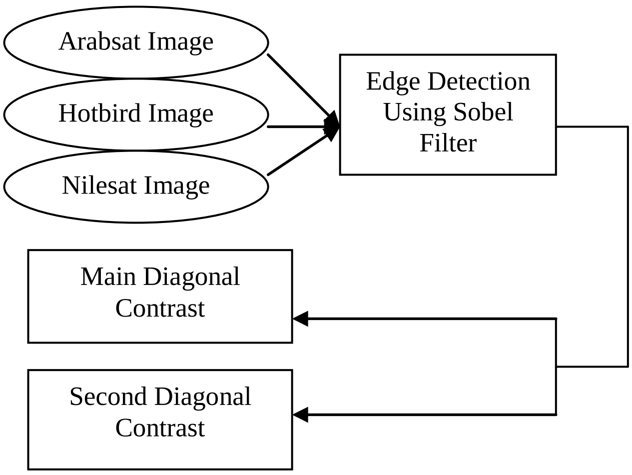


Fig. (4): The System Architecture.

First acquiring the image from the channel of the three satellites which are the same images from the Abu-Dhabi channel, then apply the Sobel edge detector to determine the edges, and then calculate the contrast according to the two different new ways which are, Main and Second diagonal contrast of edges, and do a comparison among the satellite's images to determine the best quality image.

Main And Second Diagonal Contrast Of Edges Method

The main and second diagonal contrast of edges are two new ways of calculating the contrast after modifying the Michelson formula into two different equations. As illustrated in the Fig. (5), the main diagonal contrast is based on taking 3×3 mask window, then calculate the mean of the three pixels over and under the main diagonal of the mask separately (I_{m1}, I_{m2}), then replace them to the equation that illustrated in the mentioned figure. The main diagonal contrast of edges method is calculated according to the number of steps discussed in the following algorithm. First load the TV-image, then apply Sobel filter to determine the edges using threshold value of 30. The following algorithm (1) illustrates the steps of this method.

Algorithm (1): Main Diagonal contrast of edges

Input: Cimg: Image array of RGB-L data.
{Where Ih and Iw are the height and the width of the image}
Edge: Image array of edges of RGB-L data.

Output: Hist: Array of histogram of contrast of edges.
m: Mean of probability of contrast of edges.

Procedure:

n ← 0

Step 1: Take 3×3 mask window over the edge pixel of the original image.

For i *{Where i=2..ih-1}*
i1 ← i-1, i2 ← i+1
For j *{Where j=2..iw-1}*
j1 ← j-1, j2 ← j+1
{Check whether the pixel is an edge or not}
If cimg1(i,j)=255 then

Step 2: Calculate the mean of the pixel values over and under the main diagonal and give those variables name I_{m1} and I_{m2} respectively.

n ← n+1
I_{m1} ← (cimg(i1,j)+cimg(i1,j2)+cimg(i,j2))/3
I_{m2} ← (cimg(i,j1)+cimg(i2,j1)+cimg(i2,j))/3
{Calculate the stretched contrast and the probability of contrast}

$$Cont \leftarrow Round\_Integer(255 \times \frac{|I_{m2} - I_{m1}|}{I_{m2} + I_{m1}})$$

Hist(cont) ← hist(cont)+1
End For i, j
m ← 0
For k {where k=0..255}
gl ← k/255
m ← m+gl*(hist(k)/n)
End For{This method will apply for all RGB-L *components}*

End Procedure

The second diagonal contrast of edges has the same steps except taking the mean of the pixels over and under the second diagonal of the mask window separately. The Fig. (5) will illustrate the two methods with examples.

Main Diagonal

89	81	85
84	91	79
97	80	83

Second Diagonal

89	81	85
84	91	79
97	80	83

I_{m1}=(81+85+79)/3=82
I_{m2}=(84+97+80)/3=87

$$Ct_{D1} = \frac{|I_{m2} - I_{m1}|}{I_{m2} + I_{m1}}$$

$$Ct_{D1} = \frac{87-82}{87+82} = 0.03$$

I_{m1}=(89+81+84)/3=85
I_{m2}=(79+80+83)/3=80

$$Ct_{D2} = \frac{|I_{m2} - I_{m1}|}{I_{m2} + I_{m1}}$$

$$Ct_{D2} = \frac{85-81}{85+81} = 0.01$$

Fig. (5) :Shows the mechanism of calculating main and second diagonal contrast of edges.

Results Disscusions And Concolusions

The images used in this study are illustrated in Fig. (6).The Table (1) shows the characteristics of Abu Dhabi channel on the three mentioned satellites.

Table (1)
Shows the characteristics of the (Abu Dhabi) channel.

Satellite	Arabsat	Hotbird	Nilesat
Frequency	11804 GHz	12380 GHz	11747 GHz
Symbol Rate	27500	27500	27500
Polarization	Horizonta	Vertical	Vertical

The Table (2) shows the properties for each of these images after save them as a BMP type.

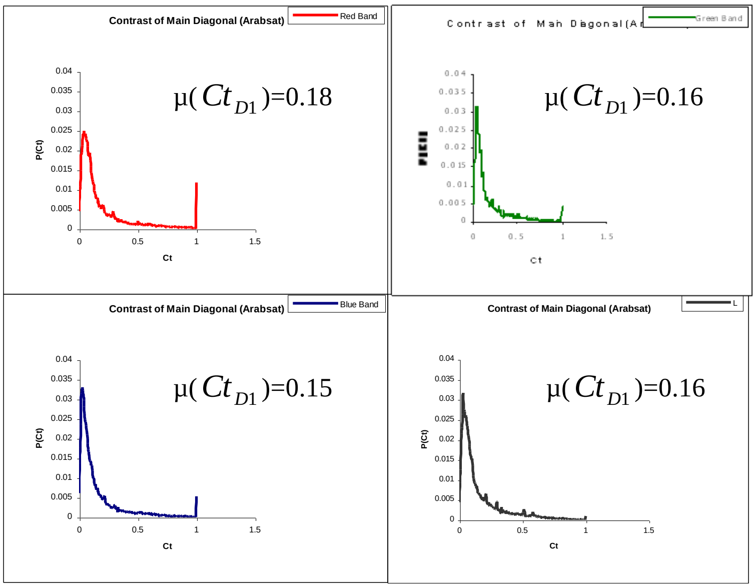
Table (2)
Shows the image properties.

Type of the Image	Bmp Image
Image Size	740 kB
Image Width	640 Pixels
Image Height	395 Pixels
Horizontal Resolution	96 dpi
Vertical Resolution	96 dpi
Bit depth	24

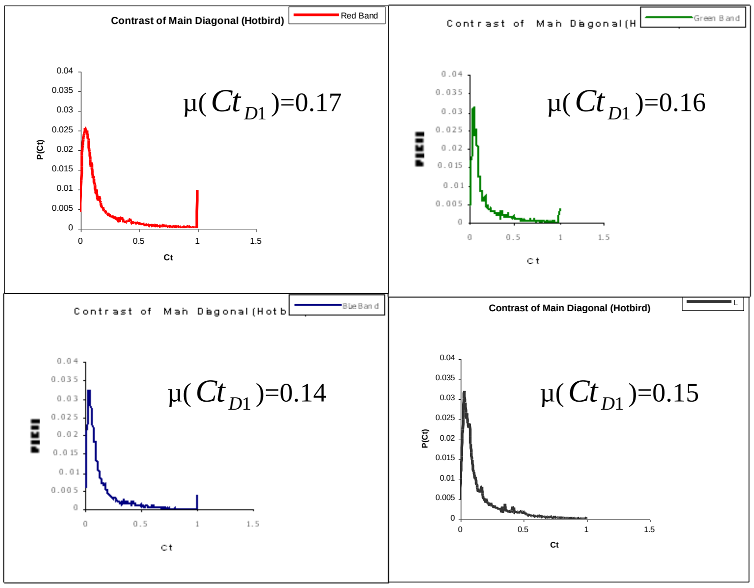
Figs. (7) and (8) present Ct_{D1} and Ct_{D2} (where Ct_{D1} and Ct_{D2} are Main and Second diagonal contrast of edges respectively) for RGBL component of the images on satellites (Arabsat, Hotbird, and Nilesat). The x-axis shows the contrast values that scaled (from 0 (low contrast value) to 1 (high contrast value)). The y-axis shows the probability of Ct_{D1} and Ct_{D2} of image edges. The contrast is calculated according to the Michelson equation (3) after modifying it into two different equations. The contrast is calculated for the image edges, whereas the edges is considered one of the most important features of the image because it contains high details that isolate the object from the background in the image. However, as the edges have high contrast, the image has a good quality. The histograms in both figures illustrate the distribution of the contrast of image edges values for all RGB-L components. It had been found that the indicated histograms contained high probability of contrast values in the low contrast area (where Ct=0..0.2) and low probability of contrast values in the high contrast areas (where Ct=1) which take vertical line shape for all RGB bands. The middle areas of the histograms were flatted with small peaks which indicated for different edge values in the image.

The shapes of the histograms of the two figures are almost the same and the mean of contrast almost equal. In this method the histograms and the mean of Ct_{D1} and Ct_{D2} indicated that the Nilesat has the best contrast than Arabsat and Hotbird.

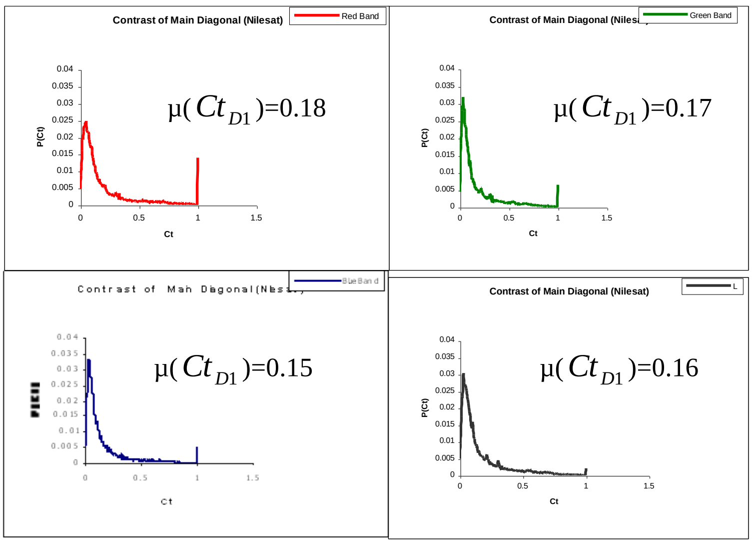
Fig. (6): Presents the images on the three satellites used in edge detection.



Arabsat

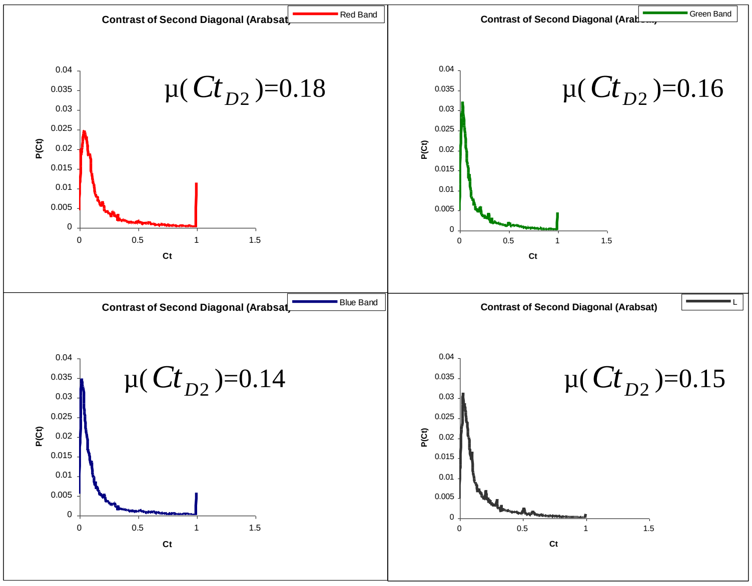


Hotbird

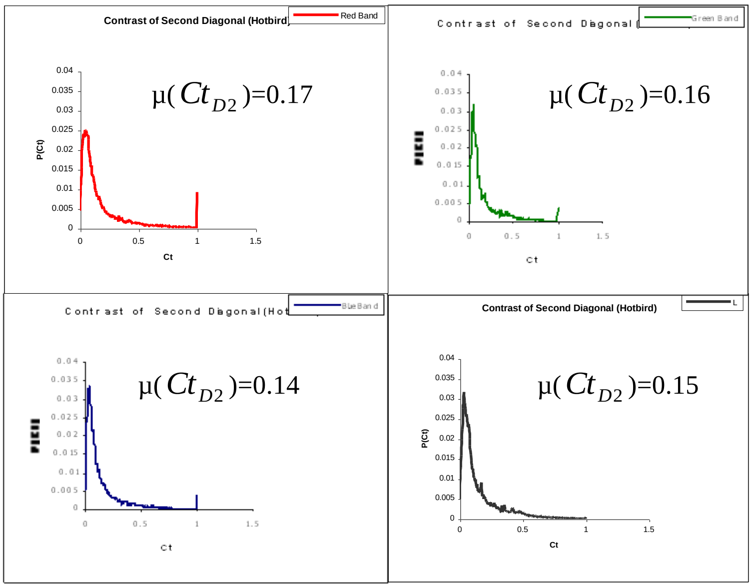


Nilesat

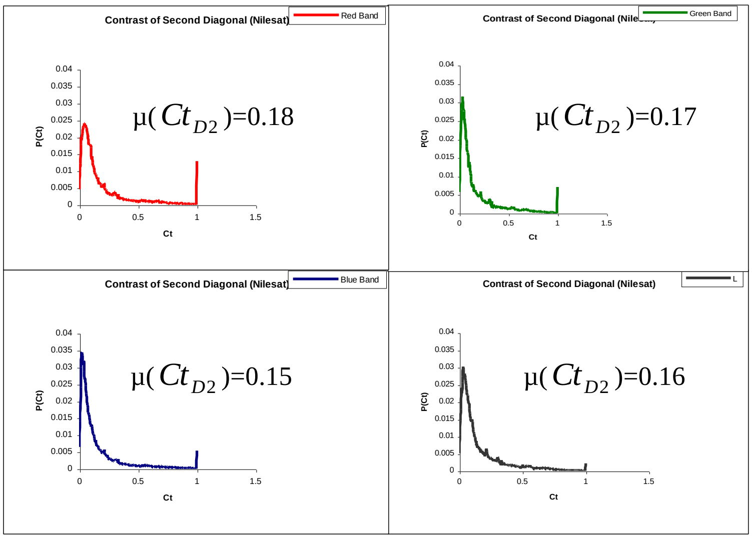
Fig. (7): Ct_{D1} ***for RGBL components by using threshold 30 for Arabsat, Hotbird and Nilesat .***



Arabsat



Hotbird



Nilesat

Fig. (8): Ct_{D2} ***for RGBL components by using threshold 30 for Arabsat, Hotbird and Nilesat .***

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الخلاصة

في هذا البحث تم دراسة وتحليل الصور التلفزيونية الفضائية لتثمين جودتها باستخدام طريقة التباين على حافات الصورة. ان حافات الصورة تعتبر من اهم المعلومات والتفاصيل التي تصف محتويات الصورة. ان تباين الحافات قد تم حسابه باستخدام معادلة مايكلسون. حيث تم تحوير هذه المعادلة الى معادلتين لتحديد طريقتين مختلفتين لحساب التباين للحافات. هذه المعادلتين قد تم تطبيقهما على حافات الصور التلفزيونية الفضائية للحزم اللونية الثلاث (RGB) بالاضافة الى مركبة الاضاءة (L). هذه الصور التلفزيونية الفضائية (نفس الصورة) قد تم التقاطها من قناة ابو ظبي الفضائية على ثلاث اقمار مختلفة (عرب سات، هوت بيرد ونايل سات). لقد بينت النتائج ان الصورة على النايل سات قد اعطت افضل تباين للحافات لكلا الطريقتين اكثر من الصور على العرب سات والهوت بيرد.