TV-Satellite Image Quality Evaluation by Cross-Correlation

Ali A. D. Al-Zuky[*] and Esraa H. Ali[**]
[*]Department of Physics, Al-Mustansiryah University, Baghdad-Iraq.
[**]Department of Computer Science, Al-Nahrain University, Baghdad-Iraq.

Abstract

Cross-Correlation is widely used to match images. In this work, an attempt is made to study the cross-correlation performance on the TV-satellite images. These images were taken from a channel (Abu Dhabi) broadcasts over three satellites (Arabsat, Hotbird, and Nilesat). The aim of this work is to determine the best quality TV-Satellite images on one satellite and compare it with the other satellites. It has been considered the automatic selected regions based on searching for the region that has minimum standard deviation of luminance (σ_{minL}) in the image. The cross-correlation method was computed for the found σ_{minL} block and the block next to it by one pixel. In this method all RGB-L components are calculated. The results indicated that the image on the Nilesat was correlated more than the images on the other satellites.

Keywords: TV-Satellite Image Quality, Cross-Correlation, Automatic Selected Regions.

1. Introduction

In today's audio/visual industry, image quality projection displays is defined by a myriad of individual performance specifications. These include screen brightness, luminance output of the projection, contrast ratio, etc. For the consumer, it can be difficult to make sense of how these all relate to the over-all display image quality. What would be helpful is a single, simple metric for evaluating image quality. Yet it should be noted that image quality is highly subjective. Therefore, the ultimate test of any image quality metric is how well it correlates to perceived image quality [1].

Image quality can be presented as the ability to analyze the image or the clarity degree of the image that the human visual system able to separate and estimate two adjacent objects [2,3]. There are many different methods used to evaluate image quality one of them is used in this study, which it is the cross-correlation method. A literature survey was made on the topic of image quality and cross-correlation which are introduced bellow:

1. In 1995 J. P. Lewis introduced the normalized cross correlation that computed in the spatial domain and showed that unnormalized cross correlation can be efficiently normalized using precomputing integrals of the image over the search window [4].
2. In 1999, S. J. Sangwine and T. A. Ell studied the auto correlation and cross correlation for color or vector images. They presented a definition of correlation applicable to color images, based on quaternion or hyper complex numbers [5].
3. In 2005 A. N. Al-Biaty devoted to evaluate image quality depending on compute 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 she 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 [6].
4. In 2006 R. S. Al-Taweel analyzed the associated noise of the TV-satellite images in digital receiver system statistically and enhanced these images by using different digital filters. These filters were applied using different color spaces such as RGB, HLS and YIQ, and he was able to determine the type of the noise on the TV-Satellite Images [7].
5. In 2008 A. J. Al-Dalawy studied the TV-Satellite images of "Al-Hurra" channel broadcasted on Arabsat, Hotbird and Nilesat. Analyzing these images done statistically by finding the statistical distribution and studying the relations between the mean and the standard

deviation of the RGB-bands and L-components for the image as whole and for the extracted homogeneous regions. Also he studied the contrast of image edges depending on sobel operator for different threshold values. The results indicated that the image on Hotbird has the best quality [8].

2. Cross Correlation Method

The correlation between two signals (cross-correlation) is a standard approach to feature detection [9,10] as well as a component of more sophisticated techniques [11]. Unfortunately the normalized form of correlation (correlation coefficient) does not have a correspondingly simple and efficient frequency domain expression. For this reason normalized cross-correlation has been computed in the spatial domain [10].

Cross-Correlation is a measure of the relation between two or more variables. The measurement scales used should be at least interval scales, but other correlation coefficients are available to handle other types of data. Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of 0.00 represents a lack of correlation i.e. the correlation is 1 in the case of an increasing linear relationship, −1 in the case of a decreasing linear relationship, and some value in between in all other cases, indicating the degree of linear dependence between the variables. The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables. If the variables are independent then the correlation is 0, but the converse is not true because the correlation coefficient detects only linear dependencies between two variables [12], the Corss-Correlation method can be computed according to the equation bellow [13]:

$$Cor = \frac{\left(\sum_{i=1}^{m}\sum_{j=1}^{n}(I_1(i,j)-\mu_{I_1})(I_2(i,j+1)-\mu_{I_2})\right)}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(I_1(i,j)-\mu_{I_1}\right)^2\sum_{i=1}^{m}\sum_{j=1}^{n}\left(I_2(i,j+1)-\mu_{I_2}\right)^2}} \quad \text{..........(1)}$$

The principle use of correlation is for matching. In matching, I(i,j) is an image containing object or region. If it has been to determine whether I contains a particular object or region, then $I_2(i,j)$ let to be that object or region (normally call this image a template). Then if there is a match, the correlation of the two functions will be maximum at the location where I_2 finds a correspondence in I. μ_I is the mean value of the image that containing object or region, while μ_{I2} is the mean value of the particular object or region [14].

3.Cross-Correlation-Implementation procedure

The fundamental idea of this work is to analyze the TV-Satellite images using Cross-Correlation method. Fig.(1) shows the main work stages, it consists of two main stages:

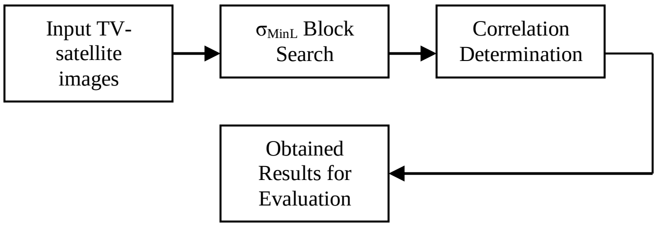

Fig.(1) Shows the main work stages.

1. σ_{MinL} Block Search Stage: in this stage the input is the colored TV-satellite image. A procedure was proposed to search for the block that has minimum standard deviation of Luminance (σ_{MinL}) value. The found region of the image considered to be homogeneous region and that would help to determine the correlation for the block has no image edges on it. The starting top left point of the block will be saved to be an input to the second stage. The block size determined at the beginning of the procedure, also considered as input to the second stage of this work.
2. Correlation Determination Stage: in this stage the input is the starting top left point and the size of the found block. The correlation will be computed to the found block and the block next to it by one pixel for all RGB-L components. The results are used to determine the best quality image among the images on the satellites (Arabsat, Hotbird and Nilesat).

Algorithm (1) illustrates the implementation steps of the two discussed stages.

Pseudo code list (1) Image Correlation of automatic selection

```
Input
  Cimg: Image array of RGB-L data.
  {Where Ih and Iw are the height and the width of the image}
  Sblock: Selected block size.
Output
  Cor: Correlation between the two blocks.
Variables
  Ss, std1: Standard derivation.
  m1: mean of the moved window.
Procedure
Step 1: Input the size of the sliding window, the proposed size in this study is 30×30 from the loaded image.
  Std1 ⟵ 10000   {Initial value for comparison}
  Bsz1 ⟵ bsz-1
  For i    Step 4   {Where i=60..ih}
     i1 ⟵ i+bsz1
  For j   Step4   {Where j=1..iw}
     j1 ⟵ j+bsz1
     m1 ⟵ 0,  Sm1 ⟵ 0
              If i1 > ih then exit for
     if j1 > iw then exit for
      For ii, jj   {Where ii=i..i1,  jj=j..j1}
     m1 ⟵ m1+cimg(ii, jj)
     sm1 ⟵ sm1+(cimg(ii, jj)^2)
  end for i, j
Step 2: Calculate the σ of the sliding window.
     m1 ⟵ m1/n
     ss1 ⟵ sqrt((sm_1/n) - m_1^2)
Step 3: Check if the σ has the minimum value, if it is so then save the values of the σ and the starting points of the blocks in the parameters and go to the next block, which is away from the previous block about four pixels, else take the next block to calculate the σ, and so on until we find the last minimum value of σ for L component.
     If ss1 <= std1 then
Step 4: After finding σMin of L of the block, as mentioned in the previous step the σMin value and the starting points of the block (x,y) have saved, that can be later used to calculate the correlation.
     Std1 ⟵ ss1
     x ⟵ ii – bsz
     y ⟵ jj – bsz
   end if
end for i, j
Step 5: Start to calculate the correlation for the found block. Where x2 and x1 are the last point of the found block.
   x2 ⟵ x + Bsz1
   y2 ⟵ y + Bsz1
   m1 ⟵ 0,  m2 ⟵ 0
Step 6: Calculate the mean for all RGB-L components of the found block and the overlapped block which shifted by one pixel, where the found and the overlapped blocks have the same size.
  n ⟵ (Sblock*Sblock)
   For i, j        {where i=(y+1)..y2,  j=(x+1)..x2}
   {Calculate the Mean and STD for all RGB bands and L component}
   m1 ⟵ m1+cimg(i,j)
   m2 ⟵ m2+cimg(i,j+1)
   sm ⟵ sm+(cimg(i,j)) ^ 2
End For i, j
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Continued

```
  m1 ⟵ m1/n
  m2 ⟵ m2/n
  std ⟵ ( (sm/n)-(m1)^2 ) ^ 0.5
Step 7: Calculate the correlation for each RGB and L between the two blocks according to the equation (1).
  cor1 ⟵ 0, cor2 ⟵ 0, cor3 ⟵ 0
  For i,j    {where i=(y1+1)..y2,   j=(x1+1)..x2}
{Calculate the correlation for each RGB bands and L component}
  If  std>=0 and std<=2 then    Cor ⟵ 1

  Else
     Cor1 ⟵ cor1+(cimg(i,j)-m1)*(cimg(i,j+1)-m2)
     Cor2 ⟵ cor2+(cimg(i,j)-m1)^2
     Cor3 ⟵ cor3+(cimg(i,j+1)-m2)^2
   End if
End For
If Cor=1 then Print Cor
        Else If cor1=0 and cor2=0 and cor3=0 then Cor ⟵ 1
        Else if cor2=0 or cor3=0 then  Cor ⟵ 0
      Else   Cor ⟵ Abs( Cor_1 / sqrt(Cor_2 * Cor_3) )

   End If
End Procedure
```

4. Results Evaluation and Conclusions

This study has considered different TV satellite images of (Abu Dhabi) channel that broadcasts through three commercial satellites (Arabsat, Hotbird, and Nilesat). Table (1) shows the characteristics of Abu Dhabi channel on the three mentioned satellites.

Table (1)
The characteristics of (Abu Dhabi) channel

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

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

Table (2)
TV-Satellite 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

The images used in this work are illustrated in Fig.(2) with their found regions of the three satellites (Arabsat, Hotbird and Nilesat). In this method the cross-correlation quality measure has been applied on an automatically selected homogeneous region of size 30×30. The selection was made according to a procedure based on searching the σ_{MinL} value of L in the image. Due to the number of blocks in the image have σ_{MinL} values equal to zero, the procedure had chose the last block found has σ_{MinL} value equal to zero of the image. After finding the block that has σ_{MinL} value, then calculate the correlation for all RGB-L component between the found block and the block next to it shifted to the right direction by one pixel.

After the implementation method, it has been found two different regions that have σ_{MinL} for the three images of the three satellites. The two regions are R1 which its starting top left point is (493,188) for images on Arabsat and Nilesat, and R2 which its starting point is (489,188) for the image on Hotbird. The two found σ_{MinL} regions gave an indication for the different appearance of the images on the three satellites. Table (3) reveals that region R1 of the image on Nilesat has the higher correlation, then Arabsat comes second, more than the region R2 of the images on Hotbird. In the second stage of this study, it has been selected the same location of region R1 from the image on Hotbird to compare the results with the results of the images on Arabsat and Nilesat for the same region. It has been found that the correlation values for the images on Nilesat are the highest then Arabsat comes second and the Hotbird comes last. Therefore, the Arabsat and Nilesat were the best for this region (R1) as shown in Table (4).

In the same way that has been discussed in the previous paragraph, the region R2 has been selected from both images on Arabsat and Nilesat. As shown in Table (5) the results indicate that the Nilesat and the Arabsat have the highest correlation values for all RGB-L components more than Hotbird.

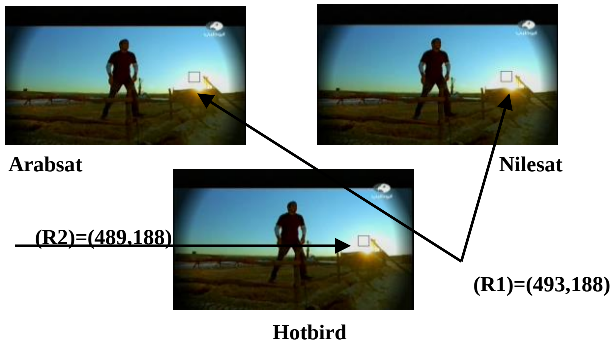

Fig.(2) The images for three satellites used in the Correlation method.

Table (3)
Image Searched correlation results of the (30x30) block Size for the regions R1 and R2.

Satellite	Operation	Color Bands			
		Red	Green	Blue	L
Arabsat	μ	227	234	232	232
	σ	6.76	3.11	2.88	1.16
	Cor(R1)	0.98	0.96	1	1
Hotbird	μ	228	233	231	232
	σ	4.99	2.81	2.9	1.11
	Cor(R2)	0.98	0.97	1	1
Nilesat	μ	226	233	231	232
	σ	7.28	3.25	3.31	1.12
	Cor(R1)	0.99	0.96	1	1

Table (4)
Image Searched correlation results of the (30x30) block Size for R1 = (493,188) of the three satellites.

Satellite	Operation	Color Bands			
		Red	Green	Blue	L
Arabsat	μ	227	234	232	232
	σ	6.76	3.11	2.88	1.16
	Cor(R1)	0.98	0.96	1	1
Hotbird	μ	229	233	231	232
	σ	3.87	2.54	2.88	1.22
	Cor(R1)	0.94	0.95	1	1
Nilesat	μ	226	233	231	232
	σ	7.28	3.25	3.31	1.12
	Cor(R1)	0.99	0.96	1	1

Table (5)
Image Searched correlation results of the (30x30) block Size for R2 = (489,188) of the three satellites.

Satellite	Operation	Color Bands			
		Red	Green	Blue	L
Arabsat	μ	226	234	232	231
	σ	8.04	3.26	2.77	1.24
	Cor(R2)	0.99	0.97	1	1
Hotbird	μ	228	233	231	232
	σ	4.99	2.81	2.9	1.11
	Cor(R2)	0.98	0.97	1	1
Nilesat	μ	225	234	232	231
	σ	8.62	3.33	2.98	1.29
	Cor(R2)	0.99	0.97	1	1

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الخلاصة

ان طريقة الترابط المتعامد تم استخدامها وبشكل واسع في عملية المطابقة بين الصور. في هذا البحث تم دراسة عمل طريقة الترابط المتعامد على الصور التلفزيونية الفضائية. هذه الصور تم الحصول عليها من قناة ابو ظبي التي تبث على ثلاث اقمار (العرب سات والهوت بيرد والنايل سات). ان الهدف من هذا البحث هو تحديد افضل جودة صورة من بين الصور على ثلاث اقمار. لقد تم اعتماد مناطق متجانسة مستقطعة بطريقة اوتوماتيكية من الصورة بالاعتماد على البحث على المنطقة ذات نحراف معياري ادنى لمركبة الاضاءة (L) فقط. ان طريقة الترابط المتعامد قد تم حسابها للمنطقة المستقطعة ذات الانحراف المعياري الادنى للمنطقة المتجانسة والمنطقة المجاورة لها ببكسل واحدة فقط. هذه الطريقة قد تم حسابها لكل الحزم اللونية (RGB) بالاضافة الى مركبة الاضاءة (L). لقد اشارت النتائج الى ان الصورة على النايل سات قد اعطت افضل ترابط من بين الصور.