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Improving the Performance and Finding Bitmap of the Compression Method Using Weber's law

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Abstract

Image compression is a suitable technique to reduce the storage space of an image, increase the area of storage in the device, and speed up the transmission process. In this paper, a new idea for image compression is proposed to improve the performance of the Absolute Moment Block Truncation Coding (AMBTC) method depending on Weber's law condition to distinguish uniform blocks (i.e., low and constant details blocks) from non-uniform blocks in original images. Then, all elements in the bitmap of each uniform block are represented by zero. After that, the lossless method, which is Run Length method, is used for compressing the bits more, which represent the bitmap of these uniform blocks. Via this simple idea, the result is improving the compression for the bitmap's size by reducing it, then reducing the bit rate further with a high ratio in compression and high speeding in the transition or storage while also retaining the reconstructed image quality.

Keywords: Bitmap, uniform, non-uniform blocks, Weber's law condition, RLE method.

تحسين أداء وإيجاد الصوره النقطيه لطريقة الضغط باستخدام قانون ويبر

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الخلاصه

يعد ضغط الصور تقنيه مناسبه لتقليل مساحة تخزين الصوره وزيادة مساحة التخزين في الجهاز وسرعة عملية النقل. في هذا البحث تم اقتراح تقنيه جديده لضغط الصور وهي تحسين أداء طريقة (AMBTC) بالاعتماد على شرط قانون ويبر لتمييز الكتل المنتظمه (أي الكتل ذات التفاصيل المنخفضه والثابته) عن الكتل الغير المنتظمه في الصوره الأصليه، ثم يتم تمثيل كافة العناصر الموجوده في الصوره النقطيه لكل كتله منتظمه بالصفر. بعد ذلك، يتم استخدام طريقة RLE للحصول على المزيد من الضغط على البتات التي تمثل الصوره النقطيه لهذه الكتل المنتظمه. من خلال هذه الفكرة البسيطة، تكون النتيجة تحسين ضغط حجم الصورة النقطيه عن طريق تقليله، ثم تقليل معدل البت بشكل أكبر مع نسبة عالية في الضغط وسرعة عالية في النقل أو التخزين مع الحفاظ أيضًا على جودة الصوره المعاد بناؤها.

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1. Introduction

Image processing is a two-dimensional signal which is processed by the human visual system. The signals which represent images are usually processed for many purposes [1], such as segmentation [2], change detection [3], analysis data [4, 5], study astrophysics data [6, 7], and compression for storage and transmission using image processing techniques [1].

Using image compression methods helps us reduce the space of storage or the transition's time for each input image data. There are different methods for compressing images, such as Vector Quantization method, Discrete Cosine Transform, Absolute Moment Block Truncation Coding (AMBTC) method, etc…. The simple AMBTC method was presented by Lema and Mitchell [8], in this method, the number of bits per pixel is equal to 2, for a 4x4 block size, which is very easy to implement with few computational complexities. Where it depends on the high and low means of the image's blocks [9, 10].

In this paper, a method is presented in order to achieve a bit rate fewer than 2 while keeping a good quality for the image despite compressing it [11], firstly, a simple idea (i.e., Weber's law) is introduced to reduce the bitmap's size, which is produced from the AMBTC method [12], without computational complications for storing or transmitting. Secondly, to achieve more compression, the lossless compression method, that is the Run Length Encoding method, is used to compress only bitmap blocks, which the condition of Weber's law succeeds on.

2. The Traditional AMBTC Method

The AMBTC is a simple image compression method which is usually used for two aims: Very good decoding image quality and easy in implementing.

In coding stage, an image is divided into n×n blocks. For each block, the mean value of pixels M, high mean value H_M (i.e., the mean of pixels which have values equal to or greater than the mean value of this block) and low mean value L_M (i.e., the mean of pixels which have values less than the mean value of same block) are calculated, then the bitmap for each block is generated, as follows; for the pixel's value which is equal to or larger than M, the corresponding pixel in the bitmap will take 1, otherwise it will take 0. In the decoding stage, for any block in bitmap, the pixel which has 1 value is replaced by H_M value, but other pixels which have 0 value are replaced by L_M value.

3. Weber's Law

Weber's law was first defined in 1834 via E.H. Weber [13]. This law finds the change that you can sense between two values, for example, weight or brightness, and this depends on how these values are different. This law states that the sensitivity of humans to changes in the light intensity ΔL is approximately proportional to the intensity of the background L_B. This law can be represented as follows:

$$\mathrm{C} = \frac{L-L_B}{L_B} = \frac{\Delta L}{L_B} \quad \text{….. (1)}$$

Where "C" is called Weber's law condition. In other words, it is the ratio of the increment in intensity to the background intensity, which may be constant [14]. The change that allows an observer to detect the center stimulus is called the Just Noticeable Difference "JND". Therefore, this amount is used to measure the differences in luminance, which are less dependent on the luminance of the background L_B. If L_{JND} is a just noticeable difference between L and L_B, therefore, equation (1) can be written as follows:

$$\mathrm{C_{JND}} = \frac{L-L_B}{L_B} = \frac{\Delta L}{L_B} = \frac{L_{JND}}{L_B} \quad \text{….. (2)}$$

Where C_{JND} is known as a Weber's condition, C = 1, 2, 3…., L_B is the background luminance to which the eyes are adapted, and L_{JND} is the change in the luminance (i.e., L and L_B).

In this paper, depending on this law (eq. 2) and for each block, L_{JND} can be founded by calculating the change between the two mean values (high and low) produced from the AMBTC method (i.e., $\Delta M = H_M - L_M$), and L_B can be founded using the low mean of this block (i.e., L_M), where the blocks are distinguished using Weber's condition as follows:

$$if\ (\frac{\Delta M}{L_M}) \begin{cases} <= C & \text{uniform block} \\ > C & \text{non} - \text{uniform block} \end{cases} \quad ….. (3)$$

4. Run Length Encoding

RLE is a simple form of lossless compressing data by identifying the number of times a character or pixel value repeats by sequence; in other words, it computes the same value that was sequenced, then stores these values as a single data value with the count of repeating this value [15]. For Example:

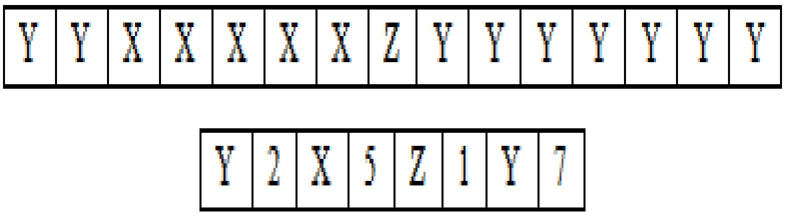


Figure 1: Illustrates the uncompressed and compressed pixels using the RLE method

This example shows a section of fifteen pixels from an image; these are uncompressed representations. When these are compressed using the RLE method, the first two pixels are "Y" and it is repeated two times. The compression will be the value "Y" itself and the number of repeated times for the "Y" value (i.e., Y,2) [16], as shown in Figure 1.
Using the RLE method is a very suitable idea when it comes to processing images such as simple graphics and map images, because most of the large maps have large areas that have identical or near pixel values or colors among each other. Therefore, when half of the picture is river, by using the RLE method in this case, long runs can be skipped.

5. Material and Methodology

In this paper, a new method based on Weber's law and the Run Length Encoding technique was implemented on the bitmap's blocks of an original image. Here, the coding steps distinguished uniform blocks into bitmap images by using Weber's law, where each element in the uniform block was replaced by zero instead of using the bitmap's block values. Then, the RLE method was used to encode large runs of repeating blocks (i.e., uniform blocks) by sending or saving only two values; the first value represented zero value (instead of uniform bitmap blocks), and the second was a number that represented how many times a uniform bitmap is repeated. Figure 2 illustrates the flowchart of the proposed method; it can also be displayed in these steps:
Encoding steps;
Step 1: Initialization, divide an original image into blocks of size 2×2, 4×4, or 8×8 pixels, then process each block separately. Input the threshold value "*TH*".
Step 2: Take the number of groups "G"=1, the block's number "Nb"=1, and Counter=0, Counter is the length or the number of repeated sequent blocks.
Step 3: Input a new block from the original image.

Step 4: Calculate the mean M, then two mean values (i.e., H_M and L_M).
Step 5: ΔM is calculated from the difference between the two mean values.
Step 6: According to Weber's law condition, a bitmap's block is categorized as a uniform block if $\Delta M/L_M \leq TH$, using eq. 3. Otherwise, it is a non-uniformed block, then Go to 10.
Step 7: If Nb=1 (i.e., the first block), then the length "Counter" =1, then Go to 9.
Step 8: If Nb-Nb1=1, then the length of this group should be incremented by one, Counter = Counter +1. Otherwise, a new group should be created G=G+1 and take Counter =1.
Step 9: Nb1=Nb: Nb=Nb+1. Go to step 3.
Step 10: The block is compressed using the AMBTC method. Go to step 3.

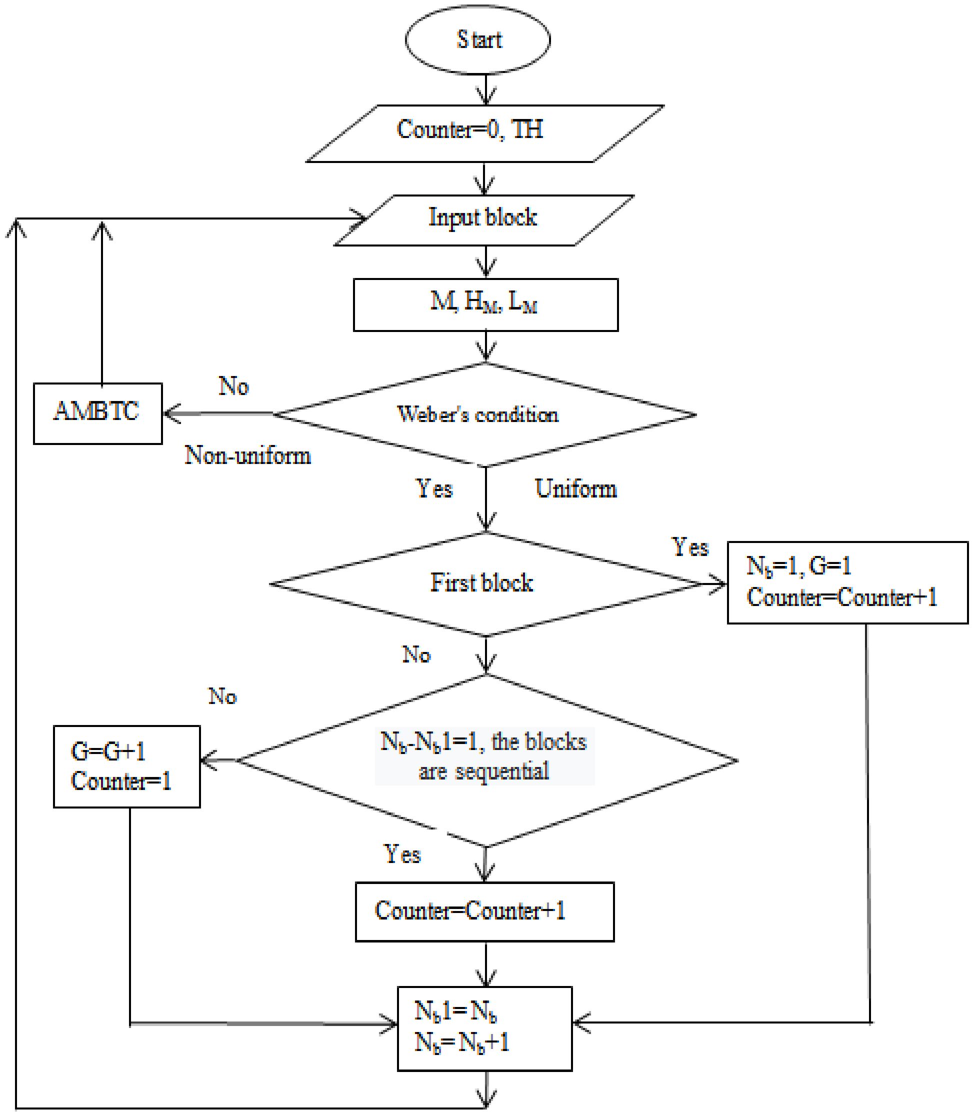


Figure 2: Flowchart of the proposed method

Decoding steps;

If the decoder receives the length's value (i.e., counter) and blocks' means, the bitmap of these blocks will be reconstructed by building L from blocks; each of them has a size of n × n, and all elements in these will have zero values in the reconstruction bitmap image, then the decoding image will be reconstructed by replacing the zero values of each block with its mean's value M, but if it receives a bitmap block and two mean values, this block will be reconstructed by the AMBTC method.

6. Results and Discussion

The proposed idea increases the compression ratio (i.e., CR) of the bitmap image by improving the performance of the compression's method using Weber's law. Here, the tested image in this paper is SAWA Lake image, where the image size is 256×256 then each block in the original image is recognized in two types; uniform or non-uniform depending on the condition of Weber's law; when the ratio between the change in the two mean values to the lower mean value is smaller than the threshold value "TH", which is selected, in this case, the block will be recognized as a uniform block. It will be compressed using the RLE method by sending the length (i.e., the number of sequence blocks) and the mean value for each bitmap's block from these uniform blocks, otherwise it is non-uniform block and it is compressed using the traditional AMBTC method by sending the bitmap and two mean values of the mentioned block. See Table1 and Figures 4 and 5.

Table 1: Shows the b/ p, C.R and PSNR values achieved by implementing our proposed method using different values of Threshold

Block 2x2 , No. of all blocks = 16384					
TH	**No. of uniform blocks**	**b/p**	**C.R**	**MSE**	**PSNR**
0	0	5	1.6	.0087	78.76
1	10727	3.2549	2.4577	.0156	68.2138
5	15161	2.1647	3.8745	.0379	63.5375
10	16376	2.0010	3.9999	.0383	63.4115
Block 4x4 , No. of all blocks = 4096					
TH	**No. of uniform blocks**	**b/p**	**C.R**	**MSE**	**PSNR**
0	0	2	4	.0045	71.6690
1	1824	1.3936	5.7402	.0331	63.0255
5	3811	0.5390	14.8405	.0647	60.1168
10	4096	0.5000	16.0000	.0717	59.0008
Block 8x8 , No. of all blocks = 1024					
TH	**No. of uniform blocks**	**b/p**	**C.R**	**MSE**	**PSNR**
0	0	1.250	6.400	.0183	68.2160
1	270	0.9670	8.2726	.1274	59.7946
5	978	0.1798	44.4915	.1278	58.4282
10	1024	0.1250	63.9975	.2746	54.7381

In this paper, from table 1, only AMBTC method was used when TH=0, but the RLE method was used to compress gray scale bitmap images using different TH values, where this proposed idea was successful to decrease the size of the bitmap image and increase the compression ratio.

In other words, the idea behind using the Run Length Encoding method was to decrease the bit rate for the bitmap as follows: If the uniform block "P" in the bitmap repeated "t" sequentially, the encoder would replace all these blocks by the single pair only "P, t". For example, if a bitmap contained black background blocks, here most of these blocks would be sequences of black blocks in the image. In this case, the encoder compressed these blocks as a pair of numbers (number of times repeated, zero).

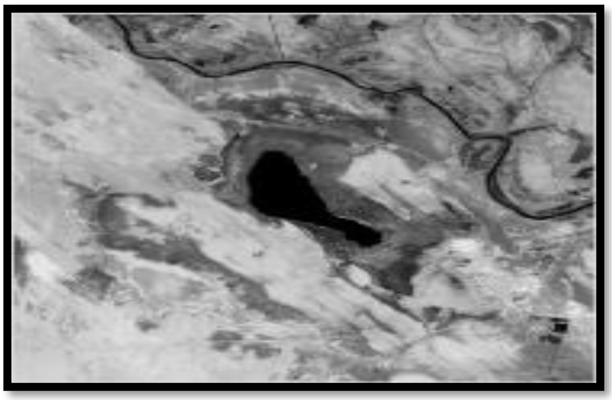
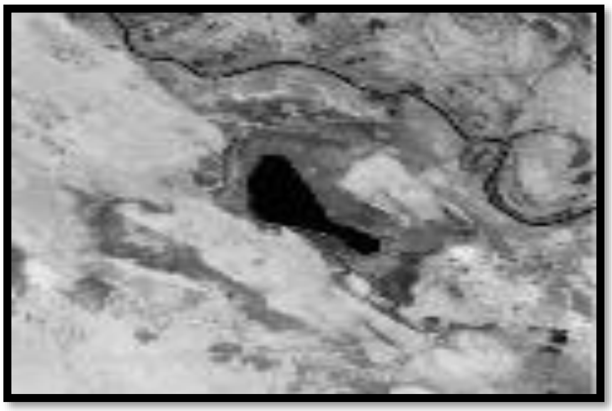
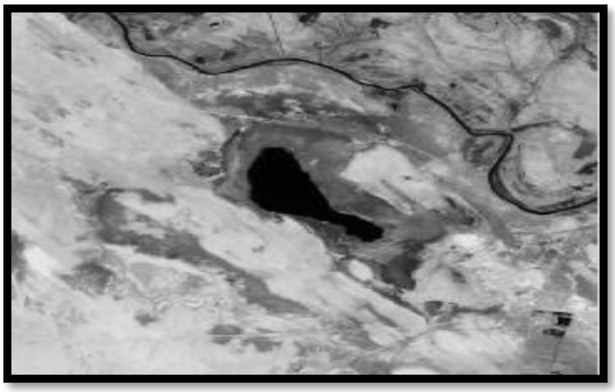


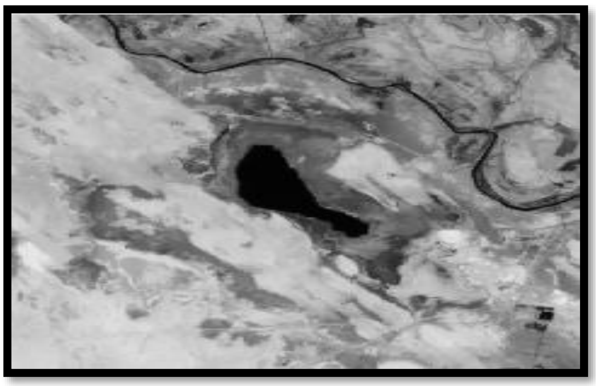
Figure 3: Original "SAWA Lake" image



(a) Block size 2x2.

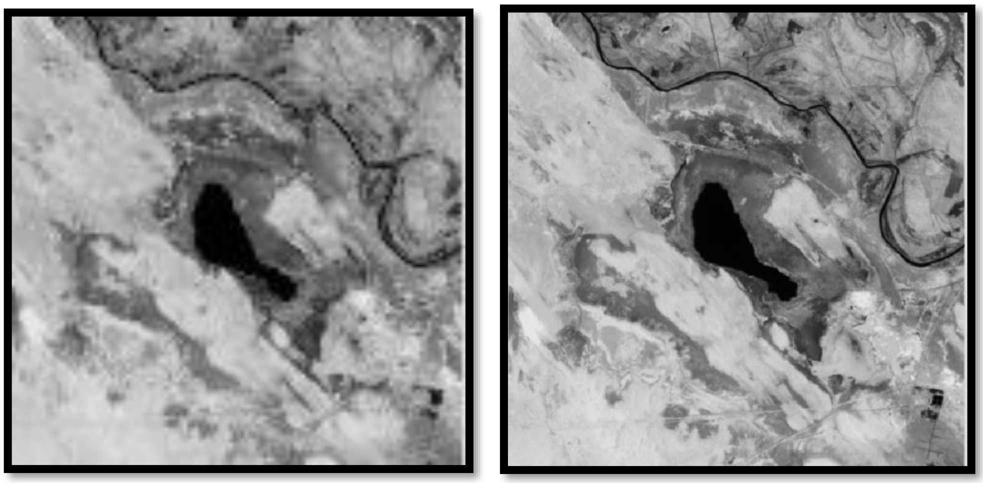


(b) Block size 4x4.

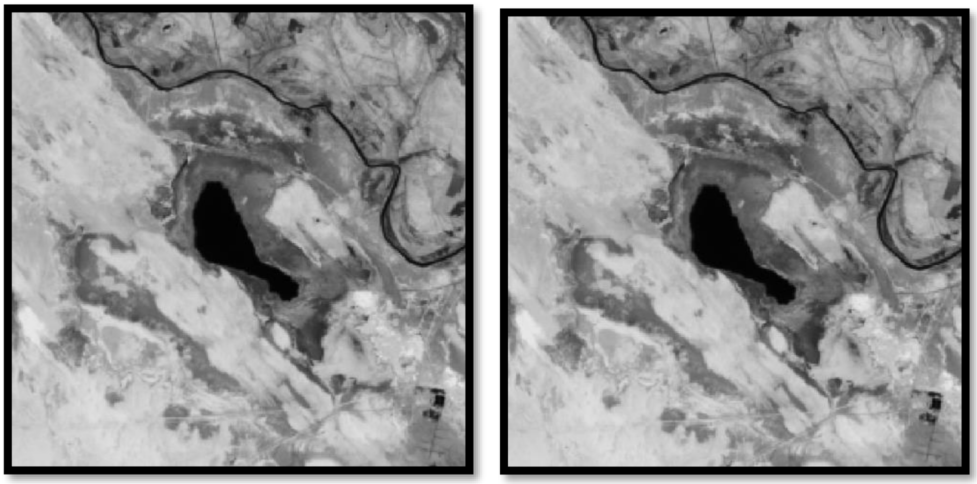


(c) Block size 8x8.

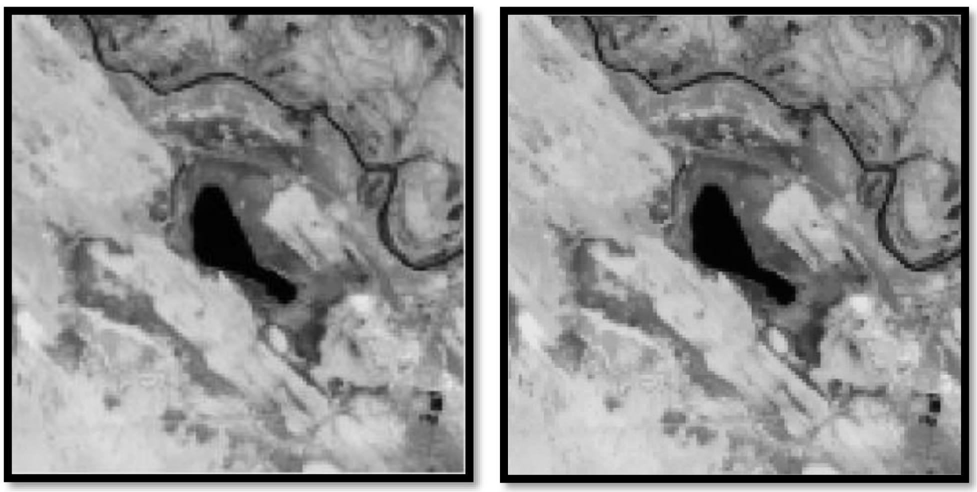
Figure 4: Illustrates implementing the traditional method on "SAWA Lake" image, (TH=0), for a different block size



(a) Block size 2x2.



(b) Block size 4x4.



(c) Block size 8x8

Figure 5: Illustrates implementing the proposed method on "SAWA Lake" image, using different block size and Threshold values (TH=5 and TH=10)

7. Conclusions

1. By comparing the results for different block sizes with different threshold values depending on C.R and PSNR, for the same image, "SAWA Lake", these values were listed in

Table1. One can see that when the threshold value "TH" was increased, the number of uniform blocks would be increased and compressed by the RLE method. After that, the bit rate would fall down, therefore the Compression Ratios would be high.
2. For the 4×4 block size, using only AMBTC method (i.e., when TH=0), the b/p was "2", but it would be less than "2" when using the proposed method with a very good quality of compressed image.
3. The RLE method works on the bitmap image using the same technique as text compression which was explained above (Figure1).
4. The size of the bitmap image and the time of encoding and decoding using Weber's law with the RLE method have fewer bits and a short time in transition or storage.

Finally, the results change from image to another; depending on the number of blocks which achieve the Weber's law condition (i.e., the threshold value).

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