Combine human's visual perception and wavelet method depending on the two absolute moment values

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تقديـــــم البحث : 2011/11/23
قبول نشر البحث : 3 /1 / 2012

Abstract:

In this paper, an image compression method have been developed by combining Human's visual perception and wavelet transform depending on the two absolute moment values. This algorithm, which has proposed it is very sensitive to information of blocks area type (such as uniform or edge block), where by depending on the constant threshold using Weber's law, and by combining Human's visual perception and Wavelet method, if the ratio between the change in the maximum and minimum luminance (change in the two Absolute moment values of the block in an image) to the minimum luminance (minimum absolute value) is smaller than that threshold constant, human being would recognize this block as a background (uniform region) and the coder compresses this block by sending the mean of block, otherwise it is edge block (edge region) and it is compressed using the wavelet transform. The proposed algorithm has four advantages which makes it very efficient in image compression, these are, low bit rate, low computational complexity, fast processing and edge preservation with good reconstructed image quality.

Keywords, Human's visual perception (HVS), wavelet transform, two absolute moment values.

الخلاصة:
في هذا البحث طورت طريقة ضغط الصورة بالجمع مابينWavelet trans.&HVP بالاعتماد على قيمتي الزخم المطلق. الخوارزمية المقترحه هي حساسه جدا لنوع معلومات البلوك (مثل منتظم او حافه)حيث تم استخدام قانون ويبر. وبالجمع مابين الطريقتين ان كانت النسبة بين التغير في القيمة الأكبر والأقل للمعانية إلى القيمة الأقل في البلوك اقل من الشرط المستخدم فان الشخص يمكن إن يميز البلوك كمنطقة منتظمة ويتم ضغط البلوك بإرسال معدل البلوك فقط وإلا فالبلوك يميز كبلوك غير منتظم ومن ثم يتم ضغطه باستخدام Wavele trans. للخوارزمية المقترحة أربع مميزات والتي تجعلها أكثر كفاءة، وهي قلة في نسب البتات وقلة في العمليات الحسابية وسرعة المعالجة والمحافظة على الحواف مع نوعية جيدة للصورة المسترجعة.

Introduction:

Digital image is generally used in a number of applications. It is seen that uncompressed digital images would need larger storage capacity and wider transmission bandwidth. Therefore one can use image compression to reduce the storage capacity and narrow transmission bandwidth [1], see fig.1.

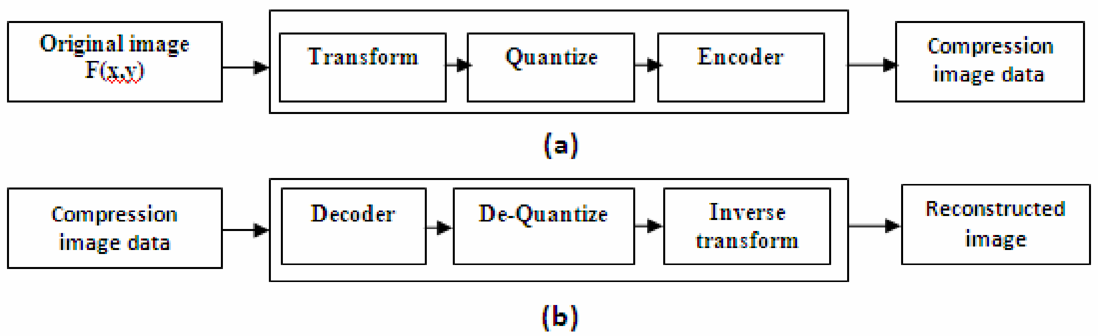


Fig. 1; Image compression system (a) encoder, (b) decoder.

In this paper, a simple idea which has psychophysics claims have been proposed, it based on Human's visual perception. Therefore one can derive the equation of the weber's law that helps the sensitivity of the human eye to luminance differences at different mean luminance levels, where the ability to detect any block (area) by the HVS is depend on the difference in luminance and the background's luminance of block [2]. If the change in the luminance δL to the background luminance L on human's sensitivity stays constant, where δL/L= the threshold (constant), this ratio is known as weber's law for sound and light perception [2]. This law is used in this paper to separating the uniform blocks (low detail) and the edge blocks (high details) in the image. When the ratio between the change in the luminance (in this work it is calculated by finding the difference between the two absolute moments (high and low mean) of the same block [3,4]) to the background luminance (here it is calculated by using the low mean of block) is smaller than that the threshold constant, human being would recognize this block as a background (smooth region) and the encoder is compressed it by sending only the mean of block, otherwise it is edge block (details region) and it is compressed using wavelet transform [5,6]. Here the researcher have combined Human's visual perception and wavelet transform depending on the two absolute moment values for each block in an image.

The characteristics of the Human visual systems (HVS):

The person eye is sensitive to information distortion of an image, edge and uniform area and the degree of the sensitive of eye to these areas in an image is different. Therefore by deriving the equation of the weber's law that helps the sensitivity of the human eye to luminance differences at different mean luminance levels, where the ability to detect any block (area) by the HVS is depend on the difference in luminance and the background's luminance of block. While weber's law states that the ratio between the change in the luminance (i.e. just noticeable difference JND) δL and the background luminance L is remained constant [7]. In this work, L is assumed the low mean value of block, but the change between the two absolute moment values (high and low mean values of block) is used as change in luminance δL, (i.e. $\delta L/L=$ constant), when this ratio is smaller than this constant, human being recognize this block as uniform area otherwise it is an edge area.

Determine the two absolute moment values:

To determine the two absolute moments, firstly, divide the image into blocks of size 4× 4 or 8× 8 pixels. The coder first takes the average gray levels (i.e. mean pixels value) of each block as threshold then each pixel value in that block is compared to this mean and the two mean pixel values are calculated, the first mean of the upper range (i.e. the mean of gray levels which are greater than the block average or mean value (high mean)), but the remaining brought into the lower range and the mean of the lower range (low mean) is calculated [3,4]. These two values define how methods the input block will compress.

Wavelet coding:

Wavelet coding also called sub-bands coding [5] .The basis idea is split up the two dimensional frequency band image into sub-sampling channels which are encoded using techniques accurately matched to individual signal statistics and possibly to the properties of the human visual system in the individual sub-bands. One-dimensional filter is used in order to separate the frequency bands both horizontally and vertically, the reason is that separable filter implementation of non-separable two-dimensional filters. On other hand, the gain in coding efficiency obtain by applications of non-separable filter is usually small or negligible [6]. The main purpose behind using the sub-band coding technique for video and digital image applications is the acquisition of a set of sub sampled frequency bands where each band contains various structural features of the original image. The base-band of the image presents a smaller replica of the original consisting of all the low frequency components that are of major perceptual importance. The neighboring picture elements of the base are highly correlated and this spatial redundancy needs to be exploited by an appropriate coding scheme [5]. Sub-band filtering provides asset of disjoint upper bands that are structurally different from the base band and do not display strong pixel to pixel intra-band correlation. The original image can be transformed into four sub-images, as shown in Fig. 2.

Low/Low	**Low/High**
High/Low	**High/High**

Fig. 2; The four sub-images result from the transformation.

In the Low/Low sub-image, both horizontal and vertical directions have low frequencies, but in the Low/High sub-image, the horizontal direction has low frequencies and the vertical direction has high frequencies. In the High/Low sub-image, the horizontal direction has high frequencies and the vertical has low frequencies. Finally, in the High/High sub-image, both horizontal and vertical directions have high frequencies.

The Haar basis vector is more popular example for wavelet transform. This is separable, so they can used to implement a wavelet transform by first convolving them with the rows and then the columns [5].

The Haar-basis transforms:

The Haar wavelet transform was first described in the early years of this century and described in almost every text on the wavelet transform. The Haar transform uses square pulses to approximate the original function. The basis function for Haar wavelets at some level look like a unit pulse, shifted along the x-axis [5]. Scales are the name of the basis function in the wavelet terminology, and are usually denoted as function Φ(t), where t denotes time.

$$\begin{cases} \mathbf{1} & \mathbf{-t \leq 0 \text{ and } t-1<0} \end{cases}$$

Φ(t)=

0 otherwise

The Haar scales are all of the unit pulses. The function Φ(t-1) is the shifted pulses, shifted by "s" units to the right. The Haar basis vectors are simple:

Low Pass= $\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\end{bmatrix}$, High Pass= $\frac{1}{\sqrt{2}}\begin{bmatrix}1 & -1\end{bmatrix}$

To use the basis vectors to implement the wavelet transform, they must be zero-padded to be the same size as the image (or sub-image). Also note that the origin of the basis vectors is in the center, corresponding to the value to the right of the middle of the vector. The inverse is [5].

$$\begin{pmatrix} \mathbf{1} & \mathbf{-1} \\ \mathbf{1} & \mathbf{1} \end{pmatrix}$$

Proposed method:

The proposed algorithm for the Human's visual perception and wavelet transform depending on the two absolute moment values by using Weber's law is involved in the following steps:

Encoding steps;

• Step 1: Determine the threshold value.

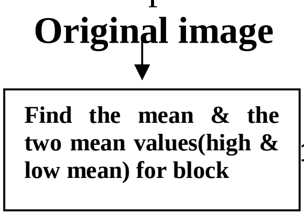
• Step 2: An image is divided into non-overlapping blocks. Such as (4x 4) or (8x 8).

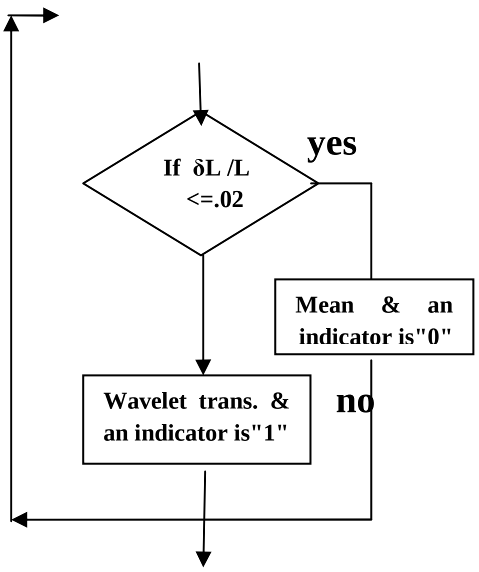
• Step 3: Calculate the mean of the block then the two absolute moments (i.e. the two mean pixel values of block) are also calculated.

• Step 4: The blocks in the image are recognized and classified into two areas depending on Human's visual perception by using weber's law. Where if the ratio between the change in the luminance (in our work it is calculated by finding the difference between the two absolute moment values) to the background luminance L (low mean value) is smaller than that taken threshold constant, human being recognize this block as a background (uniform region), otherwise it is edge block (high details region), see fig.3.

•Step 5: Then encode a background block (uniform region) with sending the mean of block, put "0" as an indicator bit as prefix code for decoding proposed, and go to 3, otherwise continuo.

• Step 6: Encode an edge block (high details) with wavelet transform method, put "1" as an indicator bit as prefix code for decoding proposed, go to 3.





Output image.

Fig.3;The diagram of the mentioned algorithm.

Decoding steps;

For each block, the decoder receives an indicators, if an indicator is "1" then the block is reconstructed by performing an inverse wavelet transform method to reconstruction the edge block, but if an indicator is "0", then the decoder build block of size n x n and all pixels in it will have the mean value of the original block.

Experimental work:

In this paper, the main advantage that could be expected is to improve the compression ratios (decreasing in bit rate) by recognizing the uniform blocks like backgrounds, using Weber-Fechner's condition, then encoding it by transmitting only the mean value of low detail block on the channel instate of transmit the block, while the high detail block like edge is encoded by wavelet transform this idea leads to decreasing in the bit rate, decreasing in the number of computation, fast processing and edge preservation with good reconstructed image quality better than that produced from wavelet transform method.

For 8 bits per pixel image and a 4 x 4 block size. If the wavelet method is implemented, the bit rate is; B.r = 2 bits/pixel. But when we combine Human's visual perception and wavelet transform depending on the two absolute moment values which is used to decrease the computational complexity and compress a background block (uniform region), where the encoder is compressed the block of uniform region by sending only the mean of this block. In our work, the computing bit rate for the same size of the block is; B.r = ((No. of blocks which compressed them by sending only the mean of each block x (8 bits for mean + 1 bit for coding indicate))+ (No. of blocks which compressed them by wavelet transform x (32 bits + 1 bit for coding indicate)))/(image size ^2).

Table 1. Performance comparison of wavelet transform method and the proposed work, by take the threshold .02 for "HOUSE" 64x64 image size.

Block size	Wavelet trans. Method		The proposed method	
	B.r	PSNR	B.r	PSNR
4x4	2	29.999	.891	31.242
8x8	.5	26.711	.347	28.769

Table 2. Performance comparison of wavelet transform method and the proposed work, by take the threshold .02 for "MUSTFA" 64x64 image size.

Block size	Wavelet trans. Method		The proposed method	
	B.r	PSNR	B.r	PSNR
4x4	2	26.469	1.148	28.021
8x8	.5	23.112	.434	26.259

a. Original image. b. wavelet trans.4x4. c. the proposed work 4x4.

Fig.4; Reconstructed images of wavelet transform and the proposed work method.

a. Original image. b. wavelet trans.4x4.c. the proposed work 4x4.

Fig.5; Reconstructed images of wavelet transform and the proposed work method.

Conclusions:

In this paper, on can see that, the proposed algorithm has four advantages which make it very efficientin image compression, these are, low bit rate, low computational complexity, fast processing and edge preservation.

From the experimental results, we found that the proposed system gives a good image quality with low computational complexity and low bit rate. Table.1, 2 and fig. 4,5 show the results of our algorithm on "HOUSE" and "MUSTFA" images, by take the threshold .02.

Finally, in most image compression methods the blackness is one of reconstruction image distortion, this blackness appears in smooth blocks of the original image because the luminance values are constant or changing slowly, while in our work this blackness is disappear, see fig. 4&5.

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