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An Adaptive Visible Watermarking Algorithm for BTC Compressed Images

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Abstract: The development of modern communication technology, demand for digital image, audio, video and other digital contents transmission and storage are increasing rapidly. To protect digital product and ensure the secure transfer of the digital content become important issue in every fields. The researcher developed many visible watermarking algorithms; these are some specific fields. But can't applicable of the digital image perfectly. In this research, An Adaptive Visible Watermarking Algorithm for BTC compressed images presented. BTC one of the effective and real time application for the image compression compare with transform domain and other data hiding techniques. Existing BTC-based visible data hiding algorithms do not fully exploit visual perception of the host images. That is why cannot obtain high hiding capacity and high visual quality of watermarked-images and visible watermark images. To obtain high visual quality of watermarked images and good perceptual visible watermark image, an adaptive scaling factor and embedding factor calculated by exploiting luminance and texture masking characteristics of digital images. This study is useful for modern communication technology. An Adaptive Visible Watermarking Algorithm for BTC compressed images is presented in the paper. For the more, the experimental results proved that the algorithm adaptive visible hiding information capacity is very high. So, the visual quality of watermarked-images and visible watermark image is very good.

Key words: Visible watermarking, block truncation coding, human visual masking, transparency

INTRODUCTION

The expansion of network bandwidth, internet has become very popular to data transmission; such as digital text, image, video and audio (Swanson *et al*., 1998) but data transfer on internet has not secure at all. The watermark embedding system, embedding data represents the ownership of the owner according to the embedding information into the original digital content. The embedding information can be visible or invisible and its can be applied many digital terms, such as digital logo, digital signature, authentication digital seal, fingerprint, online transfer monitoring, secrete communication and so on (Cox *et al*., 2002). Recently the popular method for the protection of Intellectual Property Rights (IPR) used embedding of digital watermark into digital content (Hartung and Kutter, 1999). While copyright protection is the most prominent application of visible watermarking techniques. The IPR protection scheme for digital contents used visible watermark for some purposes; visibility is a meaningful protection, user intervention based watermark remover, active and direct viewing and so on. The watermark techniques in to the watermarked scheme can be either a single bit or several bits. Generally, the effective watermarking should maintain certain requirements (Keissarian, 2007), these are:

- Embedding data must be imperceptibility because of original image quality and commercial value
- Robust against hacker attacks
- Unambiguous to prove the ownership of the owner
- Secrete key against unsecure distribution
- High hiding capacity and low complexity

Presently many watermark techniques have been developed for digital images. But most of them are imperceptible (Luo *et al*., 2011) watermarking. The imperceptible watermarking scheme, hiding information is not visible so the digital content can't protect directly. And also the original image quality is not satisfied after the extraction of the embedded data. The visible watermarking (Yong *et al*., 2011) scheme, the embedded watermarking has clearly visible and the embedded watermarked image and original image both recover

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completely after the extraction of the embedded data. Generally, the existing scheme of visible watermark data hiding is two categories; Spatial domain visible watermarking data hiding (Min-Jen *et al*., 2011; Sarma and Ganguly, 2012). The spatial domain visible watermarking technique directly modified the image pixels and embeds the visible data into original image sub-blocks pixels. This technique is popular for its high hiding capacity and good host image quality. Most of research has chosen this method for reversible watermarking field. But it can apply only some specific fields and can't use real time application. In compressed domain visible watermarking (Luo *et al*., 2011) the reversibility has achieved by modifying the coefficients of the compressed code. Since most images transmitted over the internet used compressed format. Compress techniques, insert embedded data into the compress bitmap and it becomes a most advance method for copy right protection. The hiding capacity, image quality and recovery image quality are satisfied. Although visible watermark is more effective for copy right protection but very few works has done in this field. There are some works has done in visible watermarking data hiding but most of them are focused on spatial domain (Min-Jen *et al*., 2011; Sarma and Ganguly, 2012). And few researches has found in compress domain (Tu and Hsu, 2004). However, existing visible watermarking algorithms seldom embed visible logo into compressed bitmap. Although, several visible watermarking schemes claimed that they imposed directly visible watermark for compressed images. These schemes do not obtain good visual quality of watermarked images and high watermark visibility. So, these works doesn't exploited acceptable perception features in watermarked images. Hu and Kwong (2003) proposed a Fusion-Based Visible Watermarking Algorithm which the image quality is unacceptable and PSNR values is very low. Biao-Bing and Tang (2006) proposed Contrast-Sensitive Visible Watermarking with HVS model based on DWT. The scheme image quality is average but the algorithm is not real time and more complexity and high computational cost. Jiang (2012) proposed a visible watermarking algorithm for documents images but the watermarked image quality is not satisfied. Zeng and Wu (2010) proposed a visible watermarking in spatial domain using HVS model and they tested several images. The watermarked image quality and hiding capacity are average. To ensure security of removal attacks and better meet the requirements of image visual quality of both watermarked images and visible watermark image, improved the algorithm (Zeng and Wu, 2010) and compared the experimental results with recent work (Jiang, 2012). In order to achieve high visual quality and robust against removal attack, a new adaptive visible watermarking algorithm for BTC compressed images is proposed by exploiting the visual perception of the image of BTC compressed domain. The Adaptive Visible watermarking Algorithm for BTC compressed images which embeds visible watermark logo into BTC compressed modified bitmap is proposed. BTC is non information preserving coding method that achieves low bit rates with good results for monochromatic images. So it is widely choice for image compression. In this work, two quantization levels bitmap selected to embed visible watermark logo with HVS model. The results showed that the watermarked images visual quality (PSNR) is higher than previous work (Zeng and Wu, 2010; Jiang, 2012). And also the algorithm is robust against removal attack.

BTC AND VISUAL PERCEPTION MODEL IN BTC COMPRESSED DOMAIN

Block Truncation Coding (BTC) is a block based lossy image compression technique for gray-level images which first proposed in Delp and Mitchell (1979). In BTC, an image is segmented into (s×s) non overlapping blocks of pixels and a two-level (one-bit) quantizer is independently designed for each block. The average value"l" and the standard deviation "q" are calculated for each block. After that setting up first two expressions which indicate the moment before (a) and after (b) quantization. The original image block is encoded into a bitmap, shown in Fig. 1. The pixels which value are less than the mean value is set as "0" and the pixels which

(a)

Original image

(b)

100	79	126	99
98	131	92	68
104	120	80	143
110	112	120	130

4*4 image pixels

(c)

0	0	1	0
0	1	0	0
U	1	U	1
1	1	1	1

Bitmap matrix

(d)

90	90	124	90
90	124	90	90
90	124	90	124
124	124	124	124

Reconstructed pixels

Fig. 1(a-d): BTC process, (a) Original image, (b) 4*4 image pixels, (c) Bitmap matrix and (d) Reconstructed pixels value are greater than or equal to the mean value is set as "1". In BTC process; we calculate the average value as below equation:

$$\begin{cases} a = \frac{1}{q}\sum_{x_i \ge 1} x_k \\ b = \frac{1}{s*s-q}\sum_{x_i < 1} x_k \end{cases} \quad (1)$$

where, q is the total number of pixel and xk is the total sum of the Pixel k. (k = 1, 2, 3.….n). (s*s) is the size of each block. According to the Eq. 1, the value before and after quantization level has calculated.

Designing image adaptive visible watermarking scheme with human visual perception can obtain higher visual quality and lower distortion. In this approach, exploit the luminance masking and texture masking factor of the high order image generated by extracting high order bits of the original BTC image and create HVS masking model. After that the visual masking model used to develop an adaptive visible data hiding watermarking scheme. Human eyes usually have different sensitivity to different luminance. In fact, human eyes are more sensitive to changes in the areas with middle level luminance, while less sensitive to changes in those areas with high and low gray-scale values (Jiang, 2012; Zeng and Wu, 2010).

Define the contrast sensitivity as follows; For each block, given BTC triple (a_i, b_i, B_i).

So, the texture masking of each pixel can be estimated as:

$$\text{Calculate } \alpha_i = \frac{|a_i - b_i|}{\max(a, b)} \quad (2)$$

where, a_i and b_i are the lowest and highest BTC pixel value, respectively in the BTC compress domain.

For the luminance masking, define the following formula:

$$\beta_i = \frac{|t_i - 128|}{128} \quad (3)$$

Human eyes are more sensitive to the noise in to the image smooth areas than that of image texture areas. ti is the entropy of the (s×s), neighborhood of pixel I, greater or equal entropy value is corresponding to the image texture or edge areas and less entropy value corresponds to image smooth area. Here, use the entropy ti to indicate the texture characteristics of the (s×s) neighborhood of block (i).

Where:

$$t_i = \frac{q_i \times a_i + (s \times s - q_i) \times b_i}{s \times s} \quad (4)$$

Finally compound HVS masking characteristics into the visual factor of each block as follows:

$$\rho_i = \alpha_i \times \beta_i \quad (5)$$

And Eq. 5 is normalized to a narrow range [r_1, r_2] .

For image block i, the final visible watermark embedding factor $\hat{\rho}_i$, where:

$$\hat{\rho}_i = \frac{r_2 - r_1}{\max(\rho) - \min(\rho)} \times (\rho_i - \min(\rho)) + r_1 \quad (6)$$

ADAPTIVE VISIBLE WATERMARKING EMBEDDING PROCESS BASED ON BTC

The detailed visible watermark embedding process is described as follows:

Input : Visible watermark image W, host image I
Output: Watermarked image I'
Step 1 : Read the original image I and the visible watermark image W
Step 2 : Obtain BTC compress code of the host image
Step 3 : Calculate the texture factor α_i and the luminance factor β_i for each image block of compressed BTC image
Step 4 : Generate the embedding factor $\hat{\rho}_i$
Step 5 : For each compressed block i, the corresponding watermark message bit w_i is embedded by modifying two quantization levels as follows:

$$I'_i = \left(1 - \hat{\rho}_i\right) \times I_i + \hat{\rho}_i \times w_i \quad (7)$$

where, $I_i \in \{a_i, b_i\}$.

Step 5 : Repeat the step 3-5 until all the watermark bits are embedded into the host image and finally the watermarked image I' is generated

EXPERIMENTS AND ANALYSIS

In the experiments, the performance of proposed visible watermarked scheme based on BTC is tested on

Fig. 2: Visible watermark image

different BTC compressed images. The visible watermark image is shown in Fig. 2. Figure 3 shows four test images which are Lena, Airplane, Zelda and Baboon. The test images are 8 bits per pixel and (512×512) pixels in size. In Fig. 4 shows the visible watermarking experimental results, watermarked BTC Images and difference images. In addition, we have compared the proposed scheme with Jiang (2012) and Zeng and Wu (2010). From the Fig. 4, we can see the embedding visible watermark visibility is clear and doesn't destroy the original image quality. And also embedded watermarked image quality (PSNR) is very good. The PSNR values of visible watermarked images produced by the proposed scheme are; Lena 28.7843 dB, Airplane 27.8523 dB, Zelda 26.7400 dB and Baboon 28.5312 dB and in average 27.9676 dB shown in Table 1. The previous work Jiang (2012) proposed scheme visible watermarked image quality (PSNR) average value is 22.3870 dB and Zeng and Wu (2010) proposed scheme visible watermarked image quality (PSNR) average value is 22.4013 dB. So, our approach achieved higher PSNR

Fig. 3(a-d): Test BTC compressed images, (a) Lena, (b) Airplane, (c) Zelda and (d) Baboon

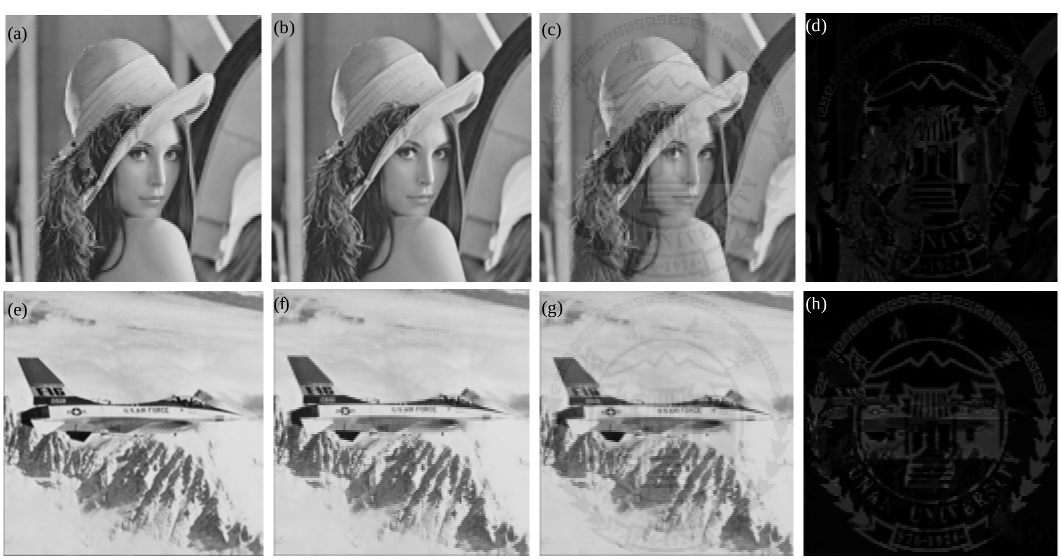

Fig. 4(a-p): Continue

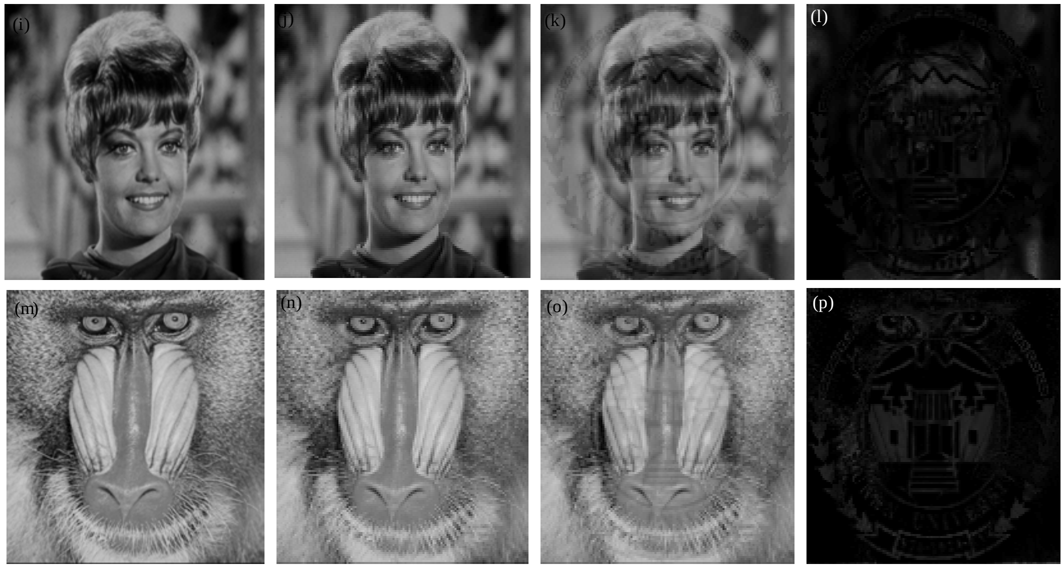

Fig. 4(a-p): Original image, BTC compressed image, watermarked BTC compressed images and image difference, (a) Lena original image, (b) Lena BTC compressed image, (c) Lena watermarked BTC compressed image, (d) Lena image difference, (e) Airplane original image, (f) Airplane BTC compressed image, (g) Airplane watermarked BTC compressed image, (h) Airplane image difference, (i) Zelda original image, (j) Zelda BTC compressed image, (k) Zelda watermarked BTC compressed image, (l) Zelda image difference, (m) Baboon original image, (n) Baboon BTC compressed image, (o) Baboon watermarked BTC compressed image and (p) Baboon image difference

Table 1: Compared proposed method with Zeng and Wu (2010) method

Image	Proposed method (PSNR) (dB)	Zeng and Wu (PSNR) (dB)	Difference (PSNR) (dB)
Lena	28.7843	00.0000	00.000
Airplane	27.8523	22.2536	5.5987
Zelda	26.7400	21.9730	4.7670
Baboon	28.5312	22.9773	5.5539

average value of watermarked images than both of two previous works. In Table 1, lists the performance comparison between the proposed scheme and Zeng and Wu (2010) approach. The simulation results show that our scheme can achieve about 5 dB higher PSNR values than Zeng and Wu (2010) method. In addition, the visual quality of both watermarked and visible watermark image is acceptable because of combining luminance and edge masking characteristics with HVS model.

CONCLUSION

An adaptive visible watermarking technique based on BTC proposed which can be applied multimedia real-time communication via internet. A visual perception model is applied for exploiting the masking characteristics of the HVS. The algorithm has very low computational complexity because the visible watermark embedded in to BTC compressed domain. From the experimental results in section 4, found that when apply present scheme to ‘a gray level image for embed into another gray level image’, the average PSNR value of embed images is 27.9776 dB. It is better than previous work and the embedded visible watermark is clear. In summary, the scheme increases PSNR value and perception of the image. In addition, the adaptive embedded visible image can be safely protected in this scheme because the HVS model is employed. Therefore, the algorithm not only increases the safe data transmission performance but also is very suitable for protecting valuable content in the current on-line trading environment.

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