Journal Basrah Researches ((Sciences)) Vol. 35, No. 1, 15 February ((2009))

Enforcement of Color Image Copyright Using the Frequency Domain

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ISSN –1817–2695
((Received 5/7/2008 , Accepted 28/12/2008))

Abstract:

The advent of the Internet has resulted in many new opportunities for the creation and delivery of content in digital form. Applications include electronic advertising, real time video and audio delivery, digital repositories, libraries, and Web publishing.

An important issue that arises in these applications is the protection of the rights of digital data. One such effort that has been attracting increasing interest is based on *digital watermarking* techniques.

The watermark techniques are divided into two types, spatial domain and frequency domain techniques. The frequency domain techniques are more stronger than the spatial domain techniques. The proposed algorithm is used with Discrete Cosine transform (DCT). Several experiments were given to illustrates the performance of the proposed scheme. This research focuses on the frequency domain and deals with the images by choosing the best locations to embed the watermark to ensure the digital watermarking requirements.

Keywords: Image, watermark, spatial domain, frequency domain.

1. Introduction:

The development of the World Wide Web (WWW), the possibility of sharing this information by many users all over the world, and the development of software and hardware led to the ability of sending and receiving many data through the network, now it became possible to send and receive different types of animated, static images, and different types of digital media [1].

The digital media such as (images, audio, video) that can be got easily, copied, and distributed with other person's names all these led to the needs of the authentication or copyright. There are many methods to protect the copyright of these media. The important ones of these techniques are the watermark technique [2].

2. Aim of Research:

The research proposed a new technique to embed digital watermarking in the color images, to get an image that contains a digital watermarking. This technique has the ability to safe the watermark against attacks, and at the same time to keep the good quality of the reconstructed image. So, the resultant image can not be recognized by the Human Visual System (HVS).

3. Basic Concepts:

3.1 Digital Watermark:

It refers to embedding a message or digital watermark into another digital media. The purpose behind is the authenticity or copyright of this digital media. The digital watermark must be very difficult to remove, or destruct from the media by the attacks [3].

3.2 Structure of the Digital Watermark:

The structure of a digital watermark composes from two stages: the first stage is the watermark embedding, and the second is the watermark detection and extraction. Figure (1) shows the embedding and the extraction operations.

The digital media that contains the digital watermark is called the carrier. The watermarking is not attached to the carrier material as a separate file or link but it is a directly embedded information within the carrier material and deals with them as one material [4].

3.3 Digital Watermark Requirements:

The digital watermark should contain some features to be able to protect the digital media from the attacks, and the most important requirements are [5,6]:

1. **Transparency**: The watermark must not affect the quality of the digital media, and the HVS does not recognize it because the eye is sensitive to the low frequency and high brightness.
2. **Robustness**: The measure of the embedding algorithm ability to keep the watermark in the digital media in spite of the modification or attacks on the digital media such as (compression, scaling, filtering,…) before extraction or destruction of digital watermark.
3. **Capacity**: It refers to the quantity of information that can be saved in the used digital media depending on the application .
4. **Security**: It is possible to consider the embedding techniques as similar to cryptography techniques, by assuming disability of the attacker to discover the embedded algorithm and then to discover the embedding information that exist in the media.

3.4 Discrete Cosine Transform (DCT):

The image types are binary images, grayscale images, and color images.
The proposed algorithm deals with the color images, that can be considered as three grayscale images, that contain three basic colors red, green, and blue and each color represents (8 bits), that can represent each pixel which contains three colors by (24 bits) as shown in Figure (2) [7].
The proposed algorithm use DCT method to the watermark embedding, in which each image is divided into blocks with n*n pixels, that transform these blocks into the transform coefficients. The transformed coefficients are blocks with three levels of frequency signals. DCT is used in the image compression applications too, like Joint Photographic Experts Group JPEG [8].
Each block transforms from the spatial domain to the frequency domain using the 2D-DCT equation as shown in the equation (1) [9,10]:

$$B_{pq} = \alpha p \, \alpha q \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} A_{mn} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N} \qquad \text{…..(1)}$$

$$0 <= p <= M-1$$

$$0 <= q <= N-1$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p = 0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \qquad \alpha_q = \begin{cases} 1/\sqrt{N}, & q = 0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

where: M and N are the row and column size of A
p, q =0, 1, ……., n-1

This method produces block matrix that contains the transformed coefficients to each pixel, the image signal changes slowly from point to point. Therefore, the block energy is concentrated in a number of low frequency coefficients that exist in the upper left corner of the matrix. While the high frequency coefficients exist in the lower right corner. There are intermediary frequency coefficients that exist in the middle of the block as shown in Figure (3) , and these coefficients have real values.
On the other hand, the Inverse DCT (IDCT) retrieves the original information from the frequency domain to the spatial domain as shown in the equation (2) [9,10].

$$Amn = \sum_{p=0}^{M-1}\sum_{q=0}^{N-1} \alpha p\, \alpha q Bpq \cos\frac{\pi(2m+1)p}{2M}\cos\frac{\pi(2n+1)q}{2N} \qquad \ldots(2)$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p=0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \qquad \alpha_q = \begin{cases} 1/\sqrt{N}, & q=0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

4. The Proposed Technique:

4.1 The Embedding Algorithm:

1. Read the original image (Carrier). And, read the watermark images (Wimg1, Wimg2, Wimg3).
2. Divide the carrier into blocks of n*n pixels in this research 8*8.
3. Divide the watermark images (Wimg1, Wimg2, Wimg3) into blocks of n*n pixels, 2*2.
4. Transform the carrier blocks into frequency domain using DCT.
5. Choose the intermediary frequency coefficients and then adding it to the pixel values of the watermark images blocks.
6. Transform the carrier blocks from the frequency domain to the spatial domain using IDCT.
7. Assemble the carrier blocks to produce an image with watermark (Water-Image). As shown in Figure (4).

4.2 The Extraction Algorithm:

1. Read the Water-Image produced from the embedding algorithm. And Read the original image (Carrier).
2. Divide the Water-Image into blocks of n*n pixels 8*8.
3. Divide the carrier into blocks of n*n pixels 2*2.
4. Transform the Water-Image blocks into the frequency domain by using DCT.
5. Transform the carrier blocks into the frequency domain by using DCT.
6. Take the chosen intermediary frequency coefficients and then subtract the carrier intermediary coefficients from the Water-Image frequency coefficients to produce the original watermark blocks.
7. Assemble the watermark blocks to produce the watermark images (Wimg1, Wimg2, Wimg3). As shown in Figure (5).

5. Experimental Results:

Peak signal-to-noise ratio (PSNR) is the standard method for quantitatively comparing a reconstructed image with the original image. For an 8-bit grayscale image, the peak signal value is 255. Hence, the PSNR of an M×N 8-bit grayscale image x and its reconstruction $\hat{x}$ are calculated as [11]:

$$PSNR = 10\log_{10}\frac{255^2}{MSE} \qquad \ldots\ldots(3)$$

where the Mean Square Error (MSE) is defined as:

$$MSE = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left[x(m,n) - \hat{x}(m,n)\right]^2 \qquad \ldots\ldots(4)$$

Figure (6) shows the original image and the watermarking images using the proposed algorithm.

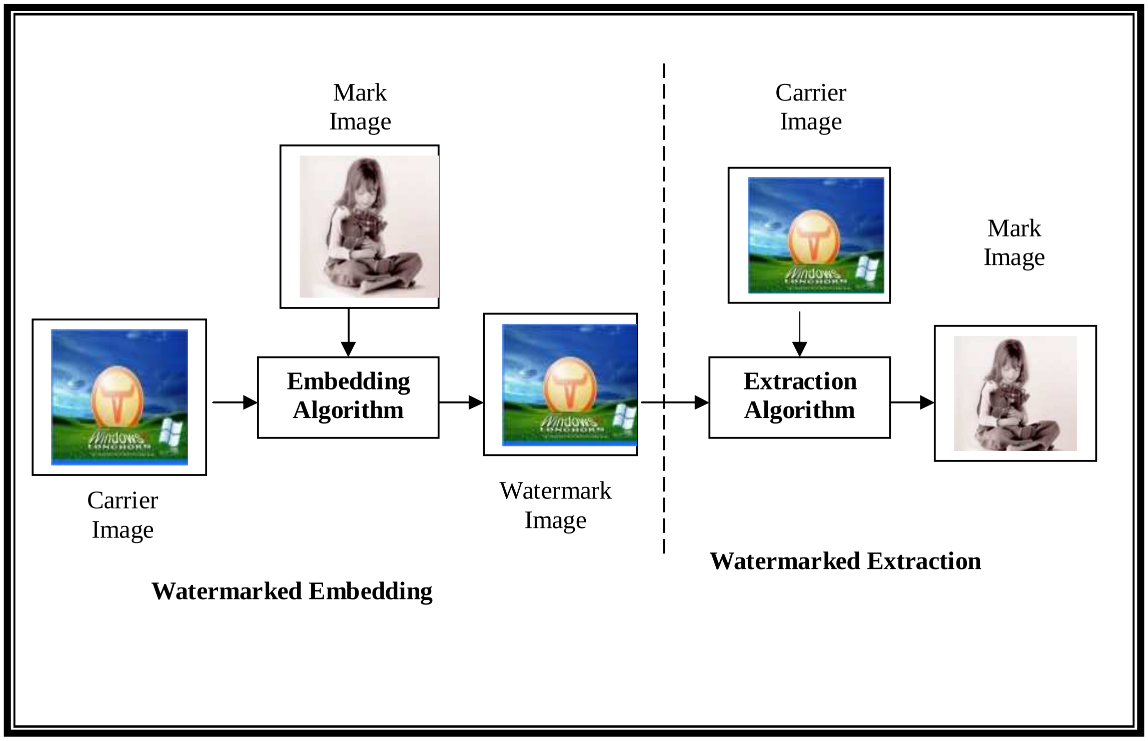


Figure (1) The embedding and the extraction

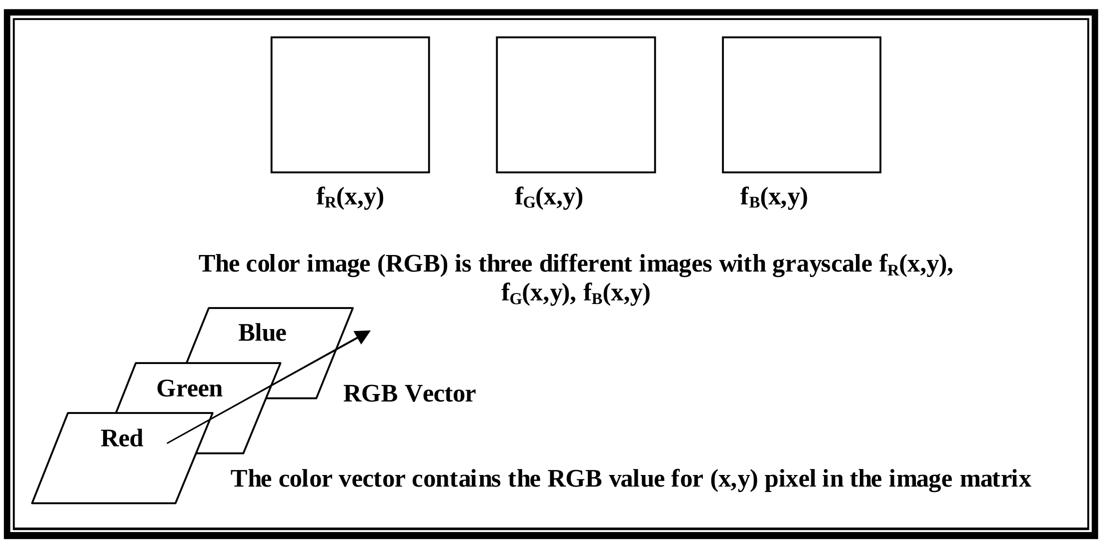


Figure (2) Representation of color image

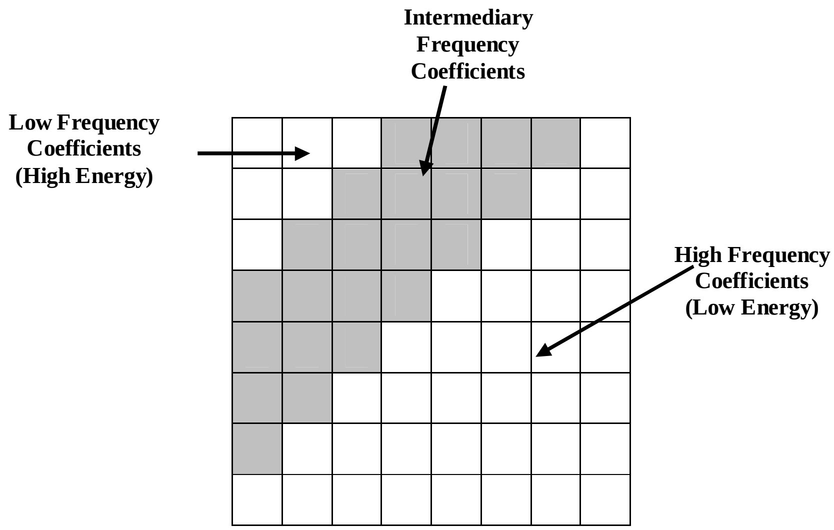
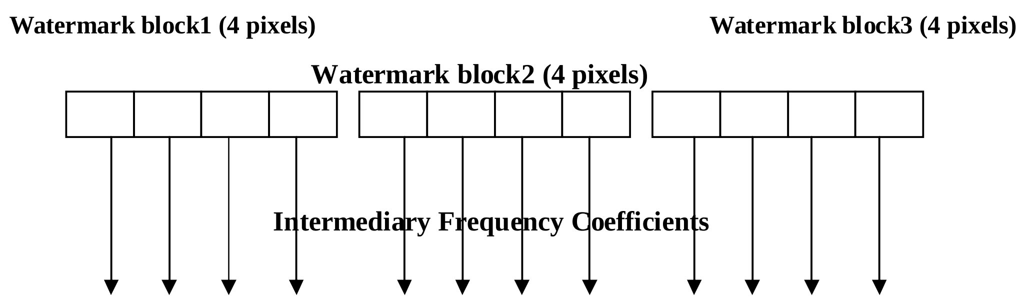


Figure (3). The different frequency regions



0	1	…	8	…	16	…	24	…	32	…	63	R
0	1	…	8	…	16	…	24	…	32	…	63	G
0	1	…	8	…	16	…	24	…	32	…	63	B

Figure (4). The Embedding Stage

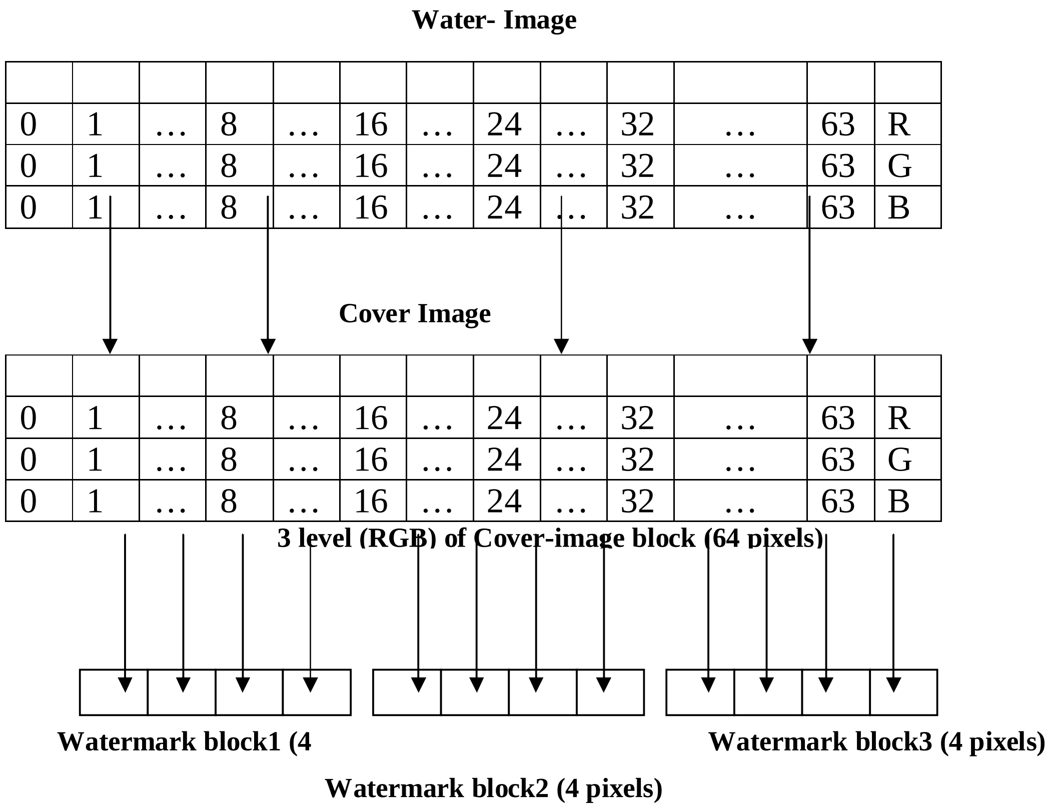
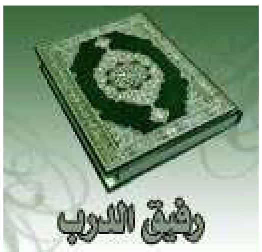


Figure (5). The Extraction Stage

Cover1 Image 1024*768 pixel

Cover2 Image 1024*768 pixel

Cover3 Image 1024*768 pixel



Wimg (1)

Wimg (2)

Wimg (3)

Wimg (4)

Wimg (5)

Wimg (6)

Wimg (7)

Wimg

Wimg (9)

Figure (6) The Original and Watermark Images

5.1 The Experiments:

The result of the experiments is shown in Table (1):

Table (1) The results of The Experiments.

Original Image No.	Watermark No.	Watermark Dimensions	PSNR (dB)
Cover1	1	60*60	55.0152
	2		
	3		
Cover1	4	128*128	42.7072
	5		
	6		
Cover1	7	256*256	43.1063
	8		
	9		
Cover2	1	60*60	58.1724
	2		
	3		
Cover2	4	128*128	42.6596
	5		
	6		
Cover2	7	256.256	42.6596
	8		
	9		
Cover3	1	60*60	67.0151
	2		
	3		
Cover3	4	128*128	40.0744
	5		
	6		
Cover3	7	256*256	40.0744
	8		
	9		

The watermark can be embedded in the (4, 8, 16) locations at least in each block (8*8=64 locations). Where the watermark blocks that are using in this research are 2*2, to get a small piece of watermark that can be embedding in cover without resulting any noise. To get a higher PSNR ratio the watermark image must be small resolution as shows in the result if the water-images small, then getting up a higher PSNR and vice versa .

6. Conclusions:

The experiments show the ability of the proposed algorithm to embed the watermark image in an efficient manner by achieving the watermarking requirements that showed the following:

1. **Transparency**: The proposed algorithm provide a high degree of transparency that the HVS does not recognize the watermark that embedded in the original image. And this can be achieved by choosing the embedded locations which are far from the low frequency locations (blocks energy).
2. **Capacity**: The proposed algorithm has a high capacity that can reach half of the original image size.
3. **Security**: The important requirement that must be provided in the system by embedding the watermark in the appropriate frequency domain coefficients and produce an embed image with good PSNR.

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دعم حقوق الملكية في الصورة الملونة
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المستخلص:

النمو السريع لشبكات الاتصال عبر الإنترنت وتطور التجارة الالكترونية وانتشار الأوساط الرقمية المختلفة مثل (الصور، الصوت، الفيديو) والتي أصبح من السهل الحصول عليها ونسخها وتوزيعها بأسماء أشخاص آخرين كل هذا أدى إلى خلق حاجة ملحة لحماية حقوق النشر واثبات الملكية وغيرها. وأحدى أهم التقنيات المستعملة في هذا المجال هي تقنيات العلامة المائية الرقمية.

تنقسم تقنيات التضمين إلى قسمين رئيسيين هما تقنيات التضمين في المجال المكاني وتقنيات التضمين في المجال الترددي وعادة ما تكون تقنيات التضمين في المجال الترددي أكثر قوة من تقنيات التضمين في المجال المكاني وهذا ما تم التركيز عليه في هذا البحث وذلك باختيار أفضل مواقع للتضمين في الصور الملونة لتحقق متطلبات تضمين العلامة المائية الرقمية.

الكلمات المفتاحية: صورة، العلامة المائية، المجال المكاني، المجال الترددي