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A Visible Watermarking Scheme for Digital Images in Frequency Domain

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---ABSTRACT---

A novel method is proposed for visible watermarking of digital image in frequency domain. The method is based on DCT modification of original image with respect to watermark image. The host image pixels are transformed into frequency coefficients as well as the watermark image pixels are also transformed into frequency coefficients using DCT. The compound mapping function is used to adjust the pixel values close to those of desired visible watermarks. Thus the watermarking is done in frequency domain using compound mapping function. One who has the watermark image and mapping function parameters only can remove the watermark. Thus it enhances the security. Experimental results demonstrate the effectiveness of the proposed approach.

Keywords: **Watermarking, Steganography, Compound mapping**

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I. INTRODUCTION

Digital steganography and watermarking are the two kinds of data hiding technology to provide hidden communication and authentication. The word steganography is derived from the Greek words "*stegos*" meaning "cover" and "*grafia*" meaning "writing" [1] defining it as "covered writing". The goal of steganography is to hide a secret message inside harmless cover medium in such a way that it is not possible even to detect that there is a secret message. Today, computer and network technologies provide easy-to-use communication channels for steganography.

Basic idea of watermarking is to embed covert information into a digital signal, like digital audio, image, or video, to trace ownership or protect privacy. Digital watermarking is defined as a process of embedding data into a multimedia object to help to protect the owner's right to that object. In digital watermarking, techniques have been widely proposed to protect the copyright of digital media. The growth of new imaging technologies has created a need for techniques that can be used for copyright protection of digital images. Copyright protection involves the authentication of image content and ownership and can be used to identify illegal copies of a (possibly forged) image.

Digital watermarking methods for images are usually categorized into two types: *invisible* and *visible*. The first type aims to embed copyright information imperceptibly into host media such that in cases of copyright infringements, the hidden information can be retrieved to identify the ownership of the protected host. It is important for the watermarked image to be resistant to common image operations to ensure that the hidden information is still retrievable after such alterations. Methods of the second type, on the other hand, yield visible watermarks which are generally clearly visible after common image operations are applied. In addition, visible watermarks convey ownership information directly on the media and can prevent attempts of copyright violations. Now digital visible watermarks such as electronic logos find their applications in digital library, video broadcasting, and other multimedia services. In this paper a novel method for generic visible watermarking within the frequency domain of the image is proposed.

II. LITERATURE SURVEY

A considerable amount of research on watermarking has been done over the past few years. Christine I. Podilchuk and Edward J. Delp [2] presented a general framework for watermark embedding and decoding for different media types. Niels Provos and Peter Honeyman [3] explained the basis of data hiding and the role of DCT in data hiding. Peter Adjei Fordjour and Wang shuo Zhong [4] proposed a visible watermarking technique in spatial domain. In this technique statistical properties of each pixel and its surrounding pixels are used for data embedding. Yongjian Hu *et al.* [5] proposed a method to an invisible watermark in visibly watermarked images to overcome watermark removal and unauthorized insertion problems. Jennifer L. Wong et al. [6] developed three classes of optimization Intensive Watermarking techniques. They demonstrated with an example of Boolean satisfiability (SAT) problem, and developed three SAT watermarking techniques: adding clauses, deleting literals, and push-out and pull-back. Coltuc D. and Tremeau A. [7] developed an approach for reversible watermarking that uses Integer Transformation to transform the pixels. Neminath Hubballi, Kanyakumari D P [8] presented a watermark generation scheme based on the histogram of the image and applied it to the original image in the transform(DCT) domain. Vaishali S. Jabade et al. [9] elaborated suitability of wavelet transform for image watermarking, wavelet transform based image watermarking process, classification and analysis of wavelet based watermarking techniques.

Most of the proposed techniques perform watermarking in spatial domain and invisible watermarking is mostly performed in frequency domain. In this paper, a visible watermarking technique is developed to embed watermark image within the frequency domain of the host image. The compound mapping function, the algorithm for watermark embedding and experimental results are presented in the following section.

III. PROPOSED WATERMARKING SCHEME

In this section, we describe the proposed approach to visible watermarking, based on which appropriate one-to-one compound mappings can be designed for embedding different types of visible watermarks into images. The watermark can be removed from the watermarked image by using the corresponding reverse mapping and the function parameter like DC coefficient of the block and mean of the block.

3.1. Compound Mapping function

We use a generic *compound mapping function* for converting a set of numerical values to another set. The compound mapping is governed by a one-to-one function defined in the following way:

$$Q = f(P) = F_b^{-1}(F_a(P)) \qquad (1)$$

Where F_x^{-1} is inverse of F_x. In our proposed scheme 'a' is the mean of DCT block of original Image block and 'b' is the DCT value of watermark image on the corresponding location. The functions F_x and F_x^{-1} can be defined as

$$F_x(P) = (P - x)$$
$$F_x^{-1}(P) = (P + x) \qquad (2)$$

3.2. Visible Watermarking Scheme

The proposed generic visible watermarking scheme uses one-to-one compound mapping to embed a variety of *visible watermarks* into images. The watermarking is performed in frequency domain because many image compression algorithms perform compression in frequency domain. So it is easy to compress the watermarked image if the watermarking is performed in frequency domain.

Let I is the original image and W is the watermark image. In the proposed scheme first the area where the watermark image is to be embedded is identified. Let the area be S. Then the pixels of S are divided into number of blocks of size 8 x 8 and each block is converted into frequency domain. In our implementation Discrete Cosine Transform (DCT) is used to convert pixels into frequency coefficients. The watermark image is also converted to frequency coefficients.

The watermark embedding is performed using one to one compound mapping defined in (1) where P is the frequency coefficient of the original image block, b is the frequency coefficient of the watermark image block. P is divided into two halves: High frequency half and Low frequency half. The mean value of each half is computed. Let a_1 is the mean of the high frequency half and a_2 is the mean of low frequency half.

Watermark Embedding Algorithm

Input: Host image I, Watermark image W

Output: Watermarked Image L

Algorithm:

1) Select the watermark area S from I based on the size of W.
2) Divide the set of pixels of S into set of 8 x 8 blocks.
3) Each block is converted into frequency domain using DCT.
4) Perform step (2) and (3) for watermark image W.
5) for each block B of S
   a) Divide the block B into two halves: High frequency half and Low frequency half.
   b) Compute 'a1' as the mean of absolute value of High frequency half and 'a2' as the mean of absolute value of Low frequency half .
   c) for each frequency coefficient P of B compute the new value using the one-to-one function in equation (1). Where 'b' is the corresponding frequency coefficient in W.
6) Perform Inverse DCT.
7) The watermark will appear on the area S of the original image I. This is the watermarked Image L.

The proposed generic visible watermarking scheme with a given image I and a watermark image W as input and the resultant watermarked image L is described in an algorithm as above. The mean 'a' of each block is combined as secret key K. Therefore K is in the form of

$$K = a_{11}, a_{12}, a_{21}, a_{22}, a_{31}, a_{32} \ldots\ldots\ldots\ldots\ldots\ldots\ldots a_{n1}, a_{n2}$$

Volume:04 Issue:03 Pages: 1635-1639 *(2012) ISSN : 0975-0290.*

Where 'n' is the number of blocks in the watermarking area S. In each block there are two mean values.

975.2500	-110.9998	-229.9044	-196.0908	-75.2500	69.5119	45.9807	74.0282
89.4691	35.5835	-3.4489	-57.2390	-16.6745	13.5673	28.8052	26.7710
44.4114	79.5083	102.6697	5.4700	-95.7998	4.1084	-21.4218	0.5460
-77.6836	-16.5859	-53.4910	23.1758	12.0521	56.7932	31.0033	7.5947
28.5000	15.2589	-29.5625	73.1154	-24.5000	48.1794	39.0344	-81.5286
-37.0045	-32.1434	40.1867	9.9768	11.4049	-44.7967	39.1840	28.9077
-58.7149	13.6181	-32.6718	-4.9488	-13.0851	49.0652	34.0803	-12.3490
12.0454	-54.0454	-28.8262	-11.5608	-18.1386	42.3097	-16.3804	31.5374

Fig.1. DCT of the original image block

High frequency half

0	-110.9998	-229.9044	-196.0908	-75.2500	69.5119	45.9807	74.0282
89.4691	35.5835	-3.4489	-57.2390	-16.6745	13.5673	28.8052	26.7710
44.4114	79.5083	102.6697	5.4700	-95.7998	4.1084	-21.4218	0.5460
-77.6836	-16.5859	-53.4910	23.1758	12.0521	56.7932	31.0033	7.5947
28.5000	15.2589	-29.5625	73.1154	-24.5000	48.1794	39.0344	-81.5286
-37.0045	-32.1434	40.1867	9.9768	11.4049	-44.7967	39.1840	28.9077
-58.7149	13.6181	-32.6718	-4.9488	-13.0851	49.0652	34.0803	-12.3490
12.0454	-54.0454	-28.8262	-11.5608	-18.1386	42.3097	-16.3804	31.5374

Low frequency half

Fig.2. Divison of Fig.1. into two halves

Mean of High frequency half $a_1 = 52.8239$

Mean of Low frequency half $a_2 = 29.3086$

(The DC coefficient is excluded in mean computation and mean is computed on absolute values).

728.0000	10.6897	69.4432	-56.8274	-25.5000	38.2119	18.0492	-43.5959
123.3304	-19.0470	81.5956	43.3185	-33.9599	26.9569	-28.1713	-73.2989
-80.9583	55.4127	117.9717	64.5501	-50.6288	-59.6842	27.2442	-12.5442
29.0894	-27.1060	-7.4544	121.4391	-10.7794	-44.3923	-1.3370	-23.3628
37.2500	-13.7508	2.4851	-27.0058	-27.2500	-20.9467	43.8899	48.1556
13.2230	-104.3886	46.7835	4.1740	45.5654	18.6009	-76.5216	-9.8846
35.1576	-7.2946	-8.5058	-113.0529	24.7595	67.1295	-10.7217	20.5820
68.2894	5.7675	-81.0949	-78.6784	37.9795	70.0699	-11.2274	-22.9930

Fig.3. DCT of watermark image block

728.0000	68.8657	246.5237	86.4395	-3.0739	54.9000	11.2060	-22.3915
159.9756	-36.2874	32.2206	47.7336	-70.1093	-12.2996	-52.1900	-75.8365
-89.3708	82.0971	167.8175	17.1962	-7.6529	-108.3996	19.3574	-41.3067
53.9491	-63.3440	-6.7873	91.7910	-51.5511	-16.9078	0.3577	-45.0767
12.9261	-51.3157	-20.7762	-6.7142	-32.0586	-2.0759	53.6157	100.3756
-2.5963	-125.0691	34.1464	-15.1578	27.6617	34.0890	-66.6462	-10.2855
41.0487	-46.5003	-5.1426	-137.4127	8.5360	86.8862	-5.9500	3.6224
27.5109	30.5042	-81.5773	-96.4262	26.8095	83.0709	-24.1556	-20.7641

Fig.4. DCT of watermarked image block

The proposed algorithm is explained with an example. Fig.1 shows a 8 x 8 DCT transformed block of a host image. The frequency coefficients are divided into two halves: High frequency coefficients half and low frequency coefficients half as shown in Fig. 2. Fig. 3 shows a 8 x 8 DCT block of a watermark image. The frequency coefficient value is modified using compound mapping function defined in equation (1). For example take the DCT value 89.4691 of original image block on position (2,1). First subtract by a_1. That is 89.4691 – 52.8239 = 36.6452. Then add the corresponding DCT value of the watermark image 123.3304 from Fig.3. That is 36.6452 + 123.3304 = 159.9756. This is the modified coefficient value of the watermarked image on position (2,1). The DCT block of the watermarked image is shown in Fig.4.

The block diagram of the proposed watermark embedding scheme is shown in fig. 5. In the proposed scheme first the area where the watermark image is to be embedded in the host image is identified. Then the pixels are divided into number of blocks of size 8 x 8 and each block is converted into frequency domain using Discrete Cosine Transform. At the same time watermark image is also divided into blocks of size 8 x 8 and each block is converted into frequency domain using DCT. The watermark embedding is performed using one to one compound mapping. Finally perform Inverse DCT to get the watermarked image.

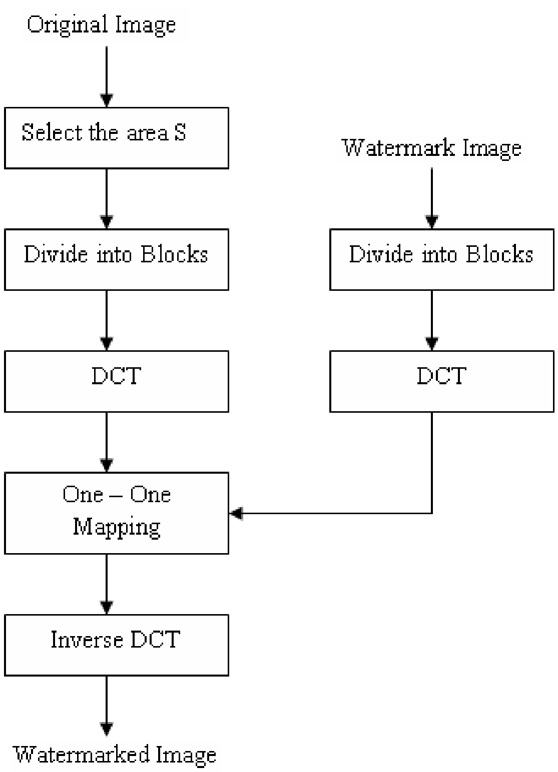
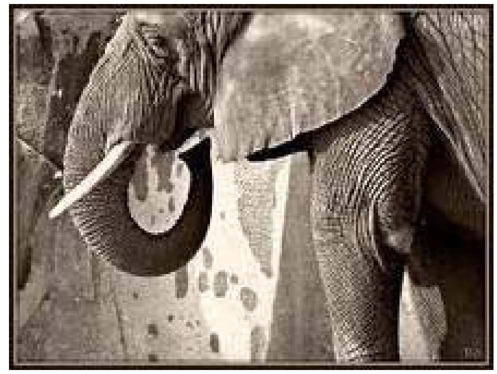


Fig.5. Proposed watermarking Scheme



(a)

(b)

(c)

Fig. 6. (a) Original Image (b) Watermark Image (c) Watermarked Image

IV. EXPERIMENTAL RESULTS

The proposed scheme was tested on several gray-level and color images. Results obtained for the classical 512 x 512 image is shown in Fig. 6. The watermark can be embedded on any place in the original image. All the pixels in the selected area can be used for watermarking. PSNR value is used as quality measure. For a 512 x 512 original image, the PSNR value for different watermark size is shown in Table 1. For small size watermarks, the algorithm provides good PSNR value. When the watermark size increases PSNR value decreases. One who has the watermark image and mapping function parameters only can remove the watermark. Thus it enhances the security.

Table 1. PSNR Value

Watermark Dimension	PSNR Value (dB)
100 x 50	33
90 x 70	29
70 x 70	32
190 x 120	22

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V. CONCLUSION

A frequency domain based visible watermarking scheme for digital image is proposed. Watermarking is an important security technique for network applications. The watermarking in frequency domain is important because many image compression algorithms perform compression in frequency domain. This method is based on DCT modification of original image with respect to watermark image. The watermarking is done in frequency domain using compound mapping function. Experimental results show that the proposed scheme is simple and provide good PSNR value. It also robust against possible watermark attacks. This method can be extended to compressed images and video.

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