A Blind DCT Domain Digital Watermarking

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Abstract: A new blind gray-level watermarking scheme is described. In the proposed method, the host image is first divided into 4◊4 non-overlapping blocks. For each block, five first AC coefficients of its DCT are then estimated using DC coefficients of its neighbor blocks. A gray-level watermark is then added into estimated values. Since embedding watermark does not change the DC coefficients, watermark extracting could be done by estimating AC coefficients and comparing them with their actual values. Several experiments are made and results suggest the robustness of the proposed algorithm.

Key words: Blind Watermarking, Information Hiding, Image Watermarking.

1. Introduction

Under the rapid growth of the internet, digital data can now be distributed fast and easy. Because of the easy access to digital contents, copy control of digital data became an important issue. In the recent years, there was a great interest in digital watermarking. A digital watermark technique permits imperceptibly embedding a watermark, including a signature or a copyright message. It must be resilience against attempts to remove the hidden data.

Depending on the application, the original host image is or is not available to the watermark recovery system. While most watermarking techniques require the original picture, there is a great interest in techniques that do not require the original data for recovering, i. e. blind watermarking techniques. That is because of the larger applications of such techniques (Katzenbeisser et al., 2000). Watermark embedding could be done in spatial or transform domain. Frequency domain techniques are more robust and resistant to various attacks, and, most watermarking techniques use frequency domain to embed data.

In (Cox et al., 1997), authors Describe a method for embedding a binary watermark sequence in the highest magnitude DCT coefficients. Hsu and Wu (Hsu et al. 1998 and 1999) use the middle frequency coefficients of DCT/Wavelet transform to embed a binary watermark. These mentioned methods are robust against image processing. Their main drawback is requiring the original image to extract the watermark.

Wang et al. (Wang et al., 2004)describe a kind of blind watermarking based on relative modulation of the DCT coefficient value by referring to its estimated one. In their method, the DC values of a 3◊3 neighborhood of 8◊8 blocks are used to estimate the AC coefficients of central block. For each group of nine 8◊8 blocks, 5 watermark bits can be embedded by modulating the first five DCT AC coefficients in central block with the following rule:

Set $AC_i \leftarrow AC'_i + \Delta$ to embed bit ì1î
Set $AC_i \leftarrow AC'_i - \Delta$ to embed bit ì0î

Where, AC_i and AC'_i are the real and estimated value of the AC coefficients, respectively. The watermark recovery is done by comparing AC_i and its estimated value. If $AC_i > AC'_i$, then the extracted bit is ì1î, otherwise it is ì0î. The watermark capacity depends on the texture feature of the block, and, for a M◊N image, its maximal value is:

$$\frac{M \times N}{24 \times 24} \times 5 \quad (1)$$

Where, N is the number of pixels in host image. In this paper we propose a blind scheme for gray-level data embedding, which has a larger watermark capacity than Wang method.

2. The proposed Scheme

In the proposed algorithm, the host image is first divided into 4◊4 non-overlapping blocks. Our embedding procedure contains two parts. The first part is estimating the first five DCT AC coefficient of each block in a zigzag order, using its neighbor blocks. Gonzales et al. (Gonzales et al., 1990) proposed a technique for estimating low frequency AC DCT coefficients of a block using the DC values of its 3◊3 neighbor blocks using the following equations:

$$
\begin{aligned}
&AC'(0,1) = 1.13884 \times (DC_4 - DC_6)/8;\\
&AC'(1,0) = 1.13884 \times (DC_2 - DC_8)/8;\\
&AC'(0,2) = 0.27881 \times (DC_4 + DC_6 - 2DC_5)/8;\\
&AC'(2,0) = 0.27881 \times (DC_2 + DC_8 - 2DC_5)/8;\\
&AC'(1,1) = 0.16213 \times (DC_1 + DC_9 - DC_3 - DC_7)/8.
\end{aligned}
\qquad (2)
$$

Where, DC_i presents the DC coefficient of i-th block in Fig.1.

The second part is embedding a gray-level value of watermark by replacing each low frequency AC value in the central block with its estimated modified value according to the following formulae:

$$AC_i \leftarrow AC'_i + \alpha \times Iw(k,l) \qquad (3)$$

Here $Iw(k,l)$ is the current pixel value in watermark image and α is a constant. If α is chosen small, the watermark will be very weak to attack. In the other hand, a large value of α, will degrade the quality of watermarked image. From our experiment, α can be chosen 0.1.

Block1 DC_1	Block2 DC_2	Block3 DC_3
Block4 DC_4	Block5 DC_5	Block6 DC_6
Block7 DC_7	Block8 DC_8	Block9 DC_9

Figure1: *The central block and its neighbor blocks*

To recovery the watermark, one can simply calculate the difference between AC_i and its estimated value, so, the original image is not required.

Remark: embedding a watermark value will not change the DC component of the block, so, all blocks could be chosen for watermark embedding (excepted blocks in the margins of image).

If an AC coefficient has too small value, embedding watermark will degrade the watermarked image quality. So, to embed a watermark, we choose only AC coefficients larger than a threshold value.

The watermark capacity depends on the texture feature of the block, and, for a M◊N image, its maximal value is:

$$\frac{(M-8)\times(N-8)}{16} \times 5 \times 8 \, bits \qquad (4)$$

3. Experimental results

In our experiment, we used two test images ì Lenaî and ì Vilageî with a size of 512◊512, and, two gray-level 64◊64 watermarks, as shown in Fig.2. The watermarked images are presented in Fig.3.

To detect the existence of a watermark, one can calculate the normalized cross-correlation score, S, (Wong 2002) between original watermark and extracted watermark.

Our algorithm survives all attacks. The results for ì Vilageî image are shown in Fig.4. As these results show, there is a meaningful correlation between the extracted, and original watermark.

a1 **b1**

a2 **b2**

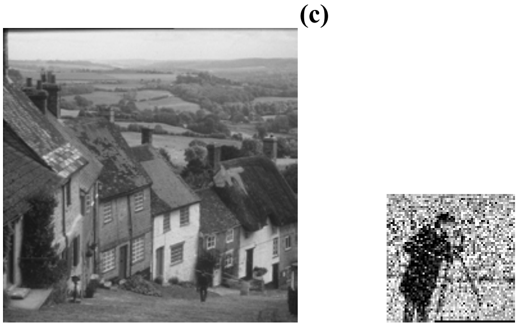
Figure 2: *a1, b1)Host images, a2, b2) their respective watermark image*s

Figure 3: *Watermarked image*s

(a)

(b)

(c)



(d)

(e)

Figure 4: *Some image processing attacks with their obtained extracted watermark, a) "salt and pepper" noise added (S =0.872), b) JPEG compression with a compress factor of 40%, (S=0.8955), c) histogram equalization, (S =0.9401), d) sharpen, (S= 0.8442), e) median filter, (S =0.8415).*

To demonstrate robustness of our algorithm, we performed different attacks by applying some typical image processing techniques:

- Adding ìsalt and pepperî noise
- JPEG compression with a compress factor of 40%
- Histogram equalization
- Sharpen

3◊3 Median filter

4. Conclusion

For most watermark application, it is desired to recover the embedded data without using host image. In this paper, such a watermarking scheme for embedding gray-level watermarks is presented. In the proposed method, the five first DCT AC coefficients are estimated by their neighbor blocks. Then, a number proportional to the gray-level watermark value is added to each estimated AC coefficient. The recovery procedure consists of comparing the estimated values with actual ones. Though our technique, can be considered as an extension of blind watermarking technique proposed by Wang et al., it has some advantages:

- it has a very larger watermark capacity (a maximum capacity of 635040 bits for a 512◊512 image, against 2205 bits for Wang technique)
- it is able embedding gray-level watermarks

Several attacks are performed, and, results confirm robustness of the proposed algorithm.

5. References

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