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Effective Image Watermarking Method Based on DCT

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Abstract

Most includeding techniques of digital watermark even now working through the direct inclusion in the pixel without taking into account the level of compression (attack) that can go wrong, which makes digital watermark can be discarded easily. In this research, a method was proposed to overcome this problem, which is based on DCT (after image partitioned into non overlapped blocks with size 8×8 pixel), accompanied by a quantization method. The watermark (digital image) is embedded in DCT frequency domain seeking the blocks have highest standard deviation (the checking is only on the AC coefficients) within a predetermined threshold value, then the covered image will compressed (attacked) varying degrees of compression. The suggested methodology enables user to extract digital watermark even when the digital image compressed to low level bit ratios was showed in tables.

Keywords: Digital Watermarking,JPEG compression,DCT,Coefficients Quantization

طريقة فعالة لصورة العلامة المائية اعتمادا" على تحويل الجيب تمام

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الخلاصة

معظم تقنيات تضمين العلامة المائية الرقمية الان تعمل من خلال التضمين المباشر في عنصر الصورة بدون الاخذ بنظر الاعتبار مستوى الضغط (الهجوم) الذي يسبب اخطاء بحيث يجعل استخراج العلامة المائية الرقمية عملية صعبة. في هذا البحث تم اقتراح طريقة للتغلب على هذه المشكلة اعتمادا على تحويل الجيب تمام الخطي (بعد تقسيم الصورة الى مربعات/بلوكات غير متراكبة بحجم 8×8 عنصر صورة) مضافا اليه طريقة تكمية. يتم تضمين العلامة المائية(صورة رقمية) في الحيز الترددي لتحويل الجيب تمام من خلال البحث عن البلوكات التي تمتلك اعلى قيمة معيارية (الفحص يكون فقط على قيم المكافئات الترددية التناوبية) لاتتجاوز قيمة عتبة محددة مسبقا، ومن ثم يتم ارسال البيانات المضمنة الى منظومة ضغط بيانات لافقدية (مرمزات الازاحة و هوفمان) واعادة الاجرائات السابقة بالعكس وصولا الى استخراج العلامة المائية .لكي نختبر قوة الطريقة المقترحة ومدى صمود العلامة المائية ضد الضغط الذي قد تتعرض له الصورة المضيفة. تم تعريض الصورة المضيفة للعلامة المائية لدرجات مختلفة من نسب الضغط. النتائج التي حصلنا عليها بينت ان المنهجية المقترحة تمكن المستخدم من استخراج العلامة المائية حتى اذا تم ضغط الصورة الرقمية الى مستويات ضغط منخفضة. تم توضيح نسب الضغط وجودة العلامة المائية المستخرجة بعد الضغط في جداول خاصة اعدت لهذا الغرض.

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1. Introduction

With the high development of computer and network, the increment of digital information is becoming faster. But the digital information may be attacked unconsciously or consciously, and the integrality and authenticity of the digital information are suspected. How to protect and authenticate the authenticity of digital information has become a serious problem [1].

Therefore the digital watermarking must be a powerful way to protect author's copyrights and to prove that a digital content has not been modified. Watermarking is the process of altering the original data file, allowing for the subsequent recovery of embedded auxiliary data called watermark.

Digital images with hidden information (i.e., stego images) may be compressed using one of the lossy compression schemes. In such case the contents of these images may change and consequently this will cause degradation in the integrity of extracted hidden message [2].

In this paper, we present some recent applications in image processing. We think that some more applications will appear in the future, and specially, commercial devices able to insert a digital watermark in a multimedia content. This is the milestone to popularize these systems.

1.1 The Discreet Cosine Transform (DCT)

The steps involved in the proposed image compression after watermark embedding scheme are described in the following sections:

1. DCT module.
2. Quantization.
3. Huffman encoding module

In the current research work, the *DCT* was used as a tool for image compression. The image is divided into simple non-overlapping 8×8 blocks. Then all these blocks are converted into *DCT* transformed blocks in a frequency domain. Each block is in a 2-dimensional matrix. The 2-dimensional *DCT* of a block of the size $N\times N$ for $i, j=1,2,\ldots,N$ can be calculated as [3]:

$$F_{u,v} = \frac{1}{\sqrt{2N}} c_u . c_v \sum_{x=1}^{N} \sum_{y=1}^{N} f_{x,y} . \cos\left[\frac{(2x+1)u\pi}{2N}\right] . \cos\left[\frac{(2y+1)v\pi}{2N}\right], \qquad (1)$$

$$where: \; c_u = \begin{Bmatrix} \frac{1}{\sqrt{2}} & if \;\; u=0 \\ 1 & if \;\; u>0 \end{Bmatrix}$$

Where: $F_{u,v}$ is the transformed block, $f_{x,y}$ is the element of the block and N is the size of the block.

The first uppermost DCT coefficient in the DCT block is F(0,0) in equation 1, it is also, called the DC coefficient and it represents the average intensity value of a block. The DC coefficient is also, described as the energy of the block. The other coefficients of the DCT blocks are called AC coefficients, which correspond to the different frequencies (co sinusoidal). Generally the coefficients of a DCT are linearly quantized by dividing by a predetermined quantization step.

1.2 The Quantization

Based on the quantization technique, quantizing the image's DCT coefficients minimizes the data required to represent an image. Quantization process minimizes the number of bits required to represent a quantity by minimizing the number of possible values of the quantity. A range of values are compressed to a single quantum value to achieve quantization. The quantization process can be described in the following equation [4]:

$$Q_{DCT} = round\left(\frac{D_{i,j}}{Q_{step}}\right), \qquad (2)$$

Here, $D_{i,j}$ are the *DCT* coefficients of the transformed image and Q_{step} is the quantization step.

1.3 Huffman Encoding Module

After obtaining the residual coefficients, Huffman coding is employed to convert the residual coefficients into bit stream, which is shown in Figure -1. In order to obtain the encoded bit stream, initially, we obtain the frequency of the residual coefficients that are arranged in ascending order. Then, two nodes that contain lowest frequency are selected to merge and the addition of two values is given into the new node. Subsequently, the same process is repeated for all nodes until we obtain a single node. Finally, the binary value is assigned to every node in accordance with the location (left or right) of the node. Then, each value obtains one code vector, which is used to create the bit stream of the input image stored instead of the image [5]. The implementation of Huffman encoding shown in an example illustrated in figure -1.

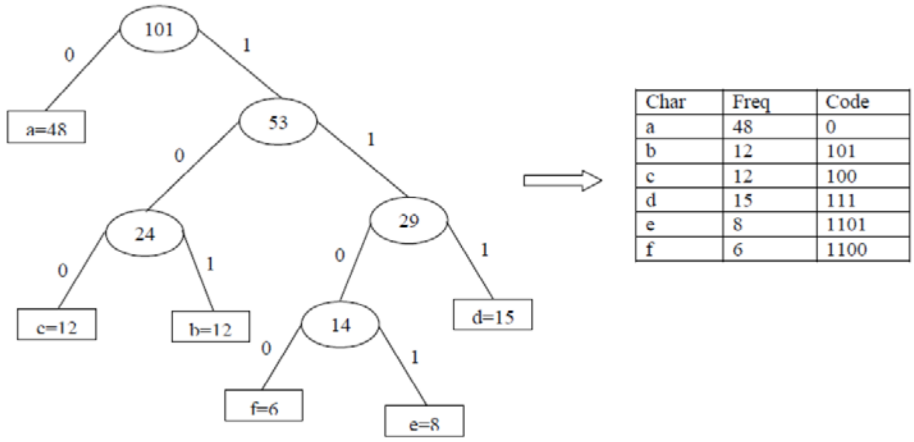

Figure 1- Huffman encoding procedure.

1.4 Shift Coding (S-code)

It is a variable encoding, it shows a good efficiency for coding the inputs set having monotically decreasing probabilities. The S-coding process is simply, based on partitioning the range of input set values into equal region, each of them has a width (2^n-1), see Figure -2 .Then n-bits codewords are used to index the first inputs group (having the high frequency of occurrence), and 2n-bits to encode the inputs located in the 2nd region and so on. The mean length b of the codewords for S-shift code could be given by the following relation:[6]

$$b_n = \sum_i n\ p(i)\,\{1 + i\ div(2^n - 1)\}, \qquad (3)$$

Where; p(i) is the frequency of occurrence of the input i, & div is the integer division operator.

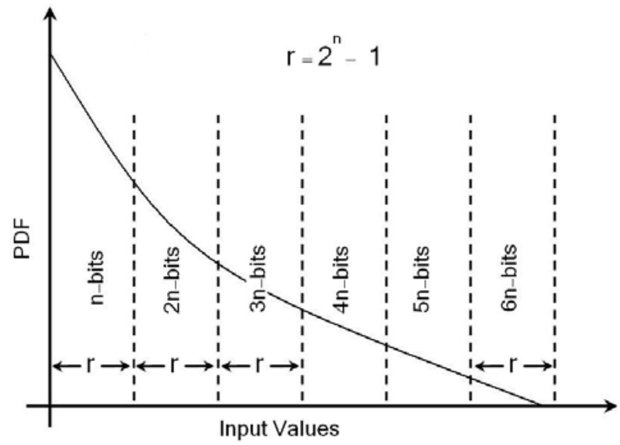

Figure 2 - Shift coding.

2. Proposed watermark embedding scheme

In the next sections, the description of proposed scheme is introduced. The proposed scheme is a digital image watermarking procedures based on combining DCT and quantization. Watermarking is done by altering the DCT coefficients of carefully selected from DCT sub-bands, followed by the application of the quantization, S-Shift and Huffman coding. The purpose of doing these steps during watermark embedding is to fortify the watermark against attack like compression. In other words the basic purpose of these steps is to select the best DCT coefficients that do not change when the image is compressed. The proposed watermark embedding is shown in Figure -3. In the recent work proposed system stages showed in the next sub sections.

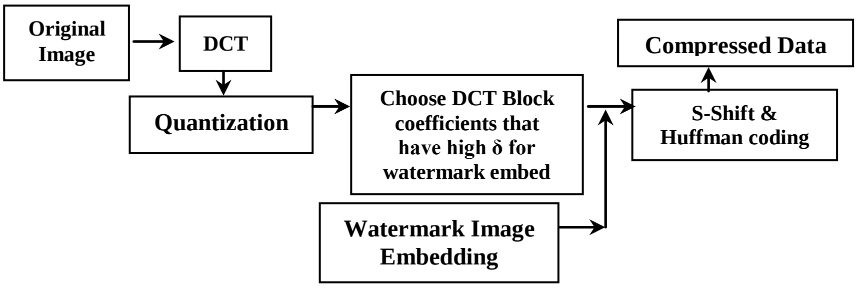

Figure 3- Proposed Watermark Embedding Sketch Map.

2.1 Watermark Embedding Steps

The embedding processes are involved on the following steps:-

Step1: image partitioned into a non-overlapped 8×8 blocks.

Step2: apply DCT transformation and then all the coefficients of a DCT are linearly quantized by dividing by a predetermined quantization step according to the previous equation (2).

Step3: Choose the candidate blocks to embed watermark within it: all the standard deviation for all AC coefficients within each DCT block are calculated according to the equations (8+9). Then the DCT blocks are rearranged in ascending order depending on its **δ** values. Now the candidate DCT blocks will be obtained by neglecting block have less than a thresholded **δ** value.

Step4: Embedding the watermark: Append the DCT coefficient values $\boldsymbol{C_k}$ of the selective DCT blocks from step3 ($\boldsymbol{B_k}$) to complete the watermark embedding. And the embedding formula is as follow [7]:

$$Bit_k = \begin{cases} 0, & S_{ij} = C'_{ij} + \dfrac{Qstep}{3} \\ 1, & S_{ij} = C'_{ij} - \dfrac{Qstep}{3} \end{cases}, \qquad for\ Embeding \qquad (4)$$

$$Bit_k = \begin{cases} 0, & C_{ij} < C'_{ij} \\ 1, & C_{ij} \geq C'_{ij} \end{cases}, \qquad for\ Extracting \quad (5)$$

Where, S denoted to selected Stego-block, $\acute{C}$ is an array from Quantization step.

Step5: Data Stream Compression: the final output data sending to the S-Shift and Huffman codices to check the possible compression ratio could be reached with reliable retrieved watermark data.

2.2 Evaluation Measures

Generally speaking, the evaluation of a watermark algorithm contains two parts: robustness and concealing. The comparability of the distilled watermark with the original watermark is quantitatively analysized by using Normalized Cross-Correlation (NC)[8]. The Normalized Cross-Correlation (NC) is defined as:

$$NC = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} W(i,j)\,.\,W'(i,j)}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M}\left[W(i,j)\right]^2}\ \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M}\left[W'(i,j)\right]^2}}, \qquad (6)$$

The value of NC is between 0 and 1. And the bigger the value is, the better the watermark robustness is.

The concealing of the watermark is quantitatively analysis by using Peak Signal to Noise (PSNR). This Peak Signal to Noise (PSNR) is defined as [8]:

$$PSNR = 10\log_{10}\frac{A^2}{\dfrac{1}{N\times M}\sum_{i=1}^{N}\sum_{j=1}^{M}\left[f(i,j) - f'(i,j)\right]^2}, \qquad (7)$$

Its unit is db. And the bigger the ***PSNR*** value is, the better the watermark conceals.

In a rectangular moving window $\boldsymbol{N_{k,l}}$ containing $\boldsymbol{M \cdot M}$ pixels, centered on each pixel $\boldsymbol{f_{i,j}}$ of the host image the local mean is computed with [9]:

$$\hat{\mu}_{k,l} = \frac{1}{M.M} \sum_{f_{i,j} \in N_{k,l}} f_{i,j}, \qquad (8)$$

and the standard deviation is given by[9]:

$$\partial_{k,l} = \sqrt{\frac{1}{M.M} \sum_{f_{i,j} \in N_{k,l}} (f_{i,j} - \hat{\mu}_{k,l})^2} \quad , \qquad (9)$$

3. Experimental results

For testing the performance of the proposed scheme, the experiments are simulated with the Visual Basic ver. 0.6. In the following experiments, the gray-level images with size of 128×128 and 256×256 “Lena” and "Baboon" were used as host images to embed watermark, see Figure -3 (a) and (b) respectively. Another gray level image with size of 16×16 and 32×32 “Logo” is used as the watermark showed in Figure -3 (c).

(a) (b) (c)

Figure 3- (a) and (b) represents original cover images, while (c) represent watermarked image.

Generally, the image watermark system must embed the content of a hidden message in the image such that the visual quality of the image is not perceptibly changed. Thus to study the embedding perceptual effect, this distilled watermark is a distorted image. The exact NC values and PSNR values of the processing's are shown in Table -1.

Table 1- "Lena" cover and watermarking images results after extracting, and quantization step =2.

Cover Image Properties				**Watermark Image Properties**	
DCT Block Size	Compression Ratio	PSNR	Cover image size: pixel	Watermark image size: pixel	Normalized Cross Correlation
8×8	5	56.68	128×128	16×16	0.906
	7	56.33	256×256		0.971
16×16	4	47.32	128×128		0.838
	6	55.72	256×256		0.867
8×8	4	39.44	128×128	32×32	0.969
	6	47.50	256×256		0.887
16×16	4	41.46	128×128		0.850
	6	44.51	256×256		0.873
32×32	4	43.34	128×128		0.870
	6	46.00	256×256		

Table 2- "Baboon" cover and watermarking images results after extracting, and quantization step =2.

Cover Image Properties				**Watermark Image Properties**	
DCT Block Size	Compression Ratio	PSNR	Cover image size: pixel	Watermark image size: pixel	Normalized Cross Correlation
8×8	4	44.54	128×128	16×16	0.900
	4	49.82	256×256		0.921
16×16	4	42.00	128×128		0.854
	4	49.17	256×256		0.859
8×8	4	38.48	128×128	32×32	0.882
	4	45.59	256×256		0.878
16×16	4	39.86	128×128		0.886
	4	40.68	256×256		0.858
32×32	4	47.57	128×128		0.881

The popular block-based DCT transform segments image non-overlapping blocks and applies DCT to each block. These results in giving three frequency sub-bands: low frequency sub-band, mid-frequency sub-ban and high frequency sub-band. DCT-based watermarking is based on two facts. The first fact is that much of the signal energy lies at low-frequencies sub-band which contains the most important visual parts of the image. The second fact is that high frequency components of the image are usually removed through compression and noise attacks. The watermark is therefore embedded by modifying the coefficients of the middle frequency sub-band so that the visibility of the image will not be affected and the watermark will not be removed by compression.

4. Conclusions

In the current research work effective watermarking type of pixel-wise masking, based on the local standard deviation of the original image was proposed. DCT transformation was used in order to obtain a texture subimage of the same size with the subimages where the watermark is inserted. The proposed method was tested against compression, and found out that it still works better with the low level of bit representations. Future work will involve testing the new mask on a large image database and possibly look into using lower resolution levels for embedding, in order to increase robustness.

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