Study of Digital Watermarking Based on DCT Domain

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ABSTRACT

This thesis introduced a watermarking method based on DCT domain, which are designed to carefully analysis the information of the formulation ,the embedding and the extraction of the watermark. Wrote some programs by MATLAB and VC software, and did some experiment of embedding , extracting and attraction of the image. The experiment results show that this technology meets the demand of transparency and robustness to a great extent.

This paper is focused on digital watermarking technology based on the discrete cosine transform (or DCT), and its main idea is to superpose the watermark information into the low and median frequency coefficient on the choice of DCT domain images. Because the core compressing algorithms of as JPEG，MPEG，etc.. is to carry on data quantization in DCT transform domain, through cleverly integrating watermarking process and quantitative process, it can make watermarking to resist loss compressing.

1. A basic principle of digital watermarking based on DCT[2]

The basic ideas is to decompose the image into 8* 8 sub-blocks, and each sub-block for a separate DCT transforming, and then quantify and code the results of the transforming.

For the reason of unified description, one-dimensional finite discrete sequence uses x（i），0≤i≤N-1 用x={x_i，0≤i≤N-1}or vector x=(x_0，x_1，…，X_{N-1})^T to describe, two-dimensional finite discrete sequence uses x(i,k), 0≤i≤N_1-1，0≤k≤N_2-1, x={x_{ik}，0≤i≤N-1，0≤k≤N_2-1} or uses matrix x ={ x_{ik} }$_{N1\times N2}$to describe.

1.1 One-dimensional DCT

one-dimensional discrete cosine (Whether 1D-DCT)X={X_u,0≤u≤N-1} is defined as

$$X_u = a_u \sum_{i=0}^{N-1} x_i \cos\left[\frac{(2i+1)u\pi}{2N}\right] \tag{1}$$

The corresponding inverse transform （1D-IDCT） is defined as

$$X_i = \sum_{i=0}^{N-1} a_u x_u \cos\left[\frac{(2i+1)u\pi}{2N}\right] \tag{2}$$

in which the coefficient is defined as:

$$a_u = \begin{cases} \sqrt{1/N} & u = 0 \\ \sqrt{2/N} & u = 1,2,\cdots N-1 \end{cases} \tag{3}$$

1.2 Two-dimensional DCT

two-dimensional discrete cosine transform (Whether 2D-IDCT) X={X_{uv}，0≤u≤N-1,0≤v≤N-1} is defined as

$$X_{uv} = a_u a_v \sum_{i=0}^{N-1}\sum_{k=0}^{N-1} x_{ik} \cos\left[\frac{(2i+1)u\pi}{2N}\right]\cos\left[\frac{(2k+1)u\pi}{2N}\right] \tag{4}$$

The corresponding inverse transformation (Whether 2D-IDCT) is defined as

$$X_{ik} = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} a_u a_v x_{uv} \cos\left[\frac{(2i+1)u\pi}{2N}\right]\cos\left[\frac{(2k+1)u\pi}{2N}\right] \tag{5}$$

The 2D-DCT can not only concentrate the main information of natural image into the smallest low-frequency coefficient, but also, it can cause the image blocking effect being the smallest, which can realize the good compromise between the information centralizing and the computing complication. Therefore, it obtains the wide-spreading application in the compression coding. Specially, in the basic model of the JPEG loss compressing standard which is based on the 2D-DCT, the digital image is first divided into 8×8 sub- blocks, then through basic block DCT and coefficient quantification and entropy coding, finally it can be realized the loss compression.

Suppose the sub- picture is f (x, y), then the 2D-DCT may be realized by the formula.

$$u,v = 1,2,3\cdots N-1$$
$$F(u,v) = \frac{2}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[\frac{\pi}{2N}(2x+1)u\right]\cos\left[\frac{\pi}{2N}(2y+1)v\right] \tag{6}$$

$$u,v = 0$$
$$F(0,0) = \frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) \tag{7}$$

Of which F (u, v) expresses the high-frequency component of transformation domain, also it can be called the alternative current coefficient; F(0,0)expresses the low frequency component of the transformation domain, also it can be called direct current coefficient.

From the analysis to the transformation result, we can see that the energy mainly concentrate on the left angle. The properties of image is been keeping invariable after DCT. Generally, In the image compression coding, N takes 8.

When decoding, we first obtain each point of DCT coefficient, then through the basis IDCT we restore the original image. The 2-D IDCT formula is:

$$f(x,y)=\frac{1}{N}F(0,0)+\frac{2}{\sqrt{N}}\sum_{x=1}^{N-1}F(u,0)\cos\left[\frac{\pi}{2N}(2x+1)u\right]$$
$$+\frac{2}{\sqrt{N}}\sum_{y=1}^{N-1}F(0,v)\cos\left[\frac{\pi}{2N}(2y+1)v\right]$$
$$+\frac{2}{\sqrt{N}}\sum_{x=1}^{N-1}\sum_{y=1}^{N-1}F(u,v)\cos\left[\frac{\pi}{2N}(2x+1)u\right]\cos\left[\frac{\pi}{2N}(2y+1)v\right] \quad (8)$$

Also we can restore the original image with no loss by using this formula. Actually, it is easier to be understood by using the matrix description based on the DCT transformation. When decoding, we first obtain the DCT coefficient of each point, then restore the original image according to the primitive DCT.

2 Experimental results

We Runs the procedures prepared by Matlab 6.5 to test the various attacks on the watermark embedding, hiding, extracting, and so on, and to identify the defects in the experimental results, Using C language in the Visual C + + environment to revise and get to meet the requirements of running experimental results [6]. The experimental data is as shown in table 1.

Attack recover time means that the time of attacks and extraction processing.

PSNR is an abbreviation of "Peak Signal to Noise Ratio", expressing the PSNR of the carrier images and the containing hidden information and images, which is used to evaluate the quality of the image. Generally speaking, the higher the value is， the greater the quality is.

NC means the cross-correlation coefficient of original hiding image and the hiding image after abstracting, Which is used to reflect the robustness of the digital watermarking, of which the maximum value is 1, the value is more close to 1, the robustness is the better.

Table 1: experimental data

		Attack recover time	PSNR	NC
Original images	10	7.2210	668.7400	0.9893
	20	7.9210	238.2500	0.9978
	40	7.9420	171.2323	1.0000
	50	8.0410	145.9637	1.0000
	80	8.1220	94.5527	1.0000
After the white noise increases	10	9.0030	143.4423	0.6464
	20	8.5020	126.2237	0.9790
	40	8.7520	110.1294	0.9815
	50	8.7820	87.3891	0.9994
	80	8.2920	48.8020	1.0000
Cutting Image	10	9.8640	2.9263	0.8378
	20	8.9330	2.9262	0.8372
	40	8.7220	2.9256	0.8393
	50	9.0030	2.9263	0.8393
	80	9.5840	2.9308	0.8393
Rotating 10 degrees	10	10.4750	2.9328	0.4672
	20	9.8640	2.9323	0.4553
	40	9.9860	2.9314	0.4776
	50	10.1240	2.9309	0.4857
	80	10.1850	2.9308	0.4132

According to the data in Table 1 drawing the curve in the following figure1 to figure 6.

we use different symbolic representation different condition,as in following:

--- represent attacking recover
_ __ represent PSNR
-- -- represent NC

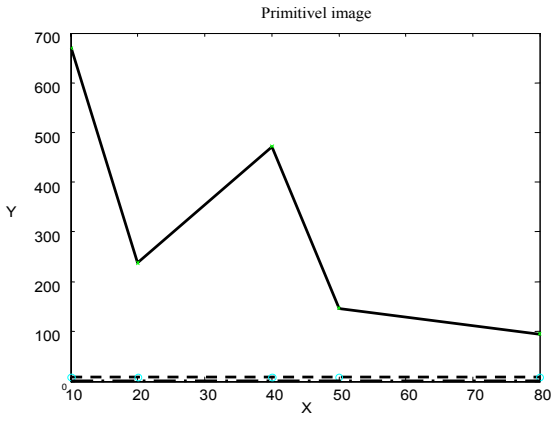

Figure 1,*the analysis to the attacking of primitive image data*

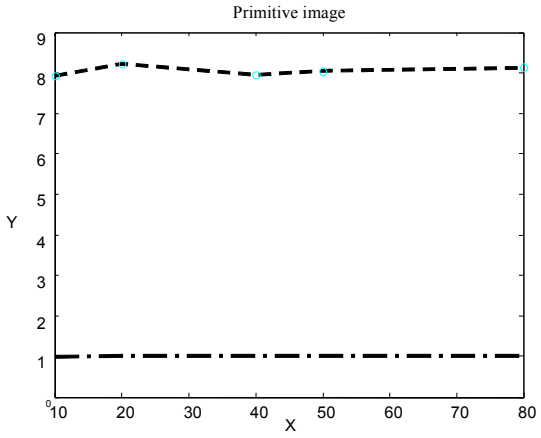

***Figure 2**,supplementary charts for figure 1*

From Figure 1 and Figure 2 we can see that the lack of any attack the PSNR of carrier images and hidden information images declines with alpha PSNR (quality factor) declining, that is to say the depth declines as the watermark embedding declining, the more deeply the watermark embedding, the more difficulty the extraction is. If the correlation coefficient between the original images and the hidden image after extracting is nearly a straight line, it shows the stability of the embedded images before inserting and after extracting becomes more stronger, and its value closer to 1 or even equal to 1.

That shows its robustness is very good. In addition, the extraction time for watermarking is relative short but the quality is very stable, which reflects the performance of the embedding and extracting for DCT-based digital watermark is good.

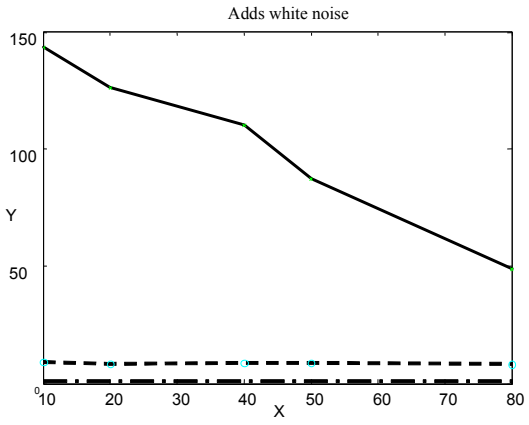

***Figure3** the analysis to the attacking of adding white noise image data*

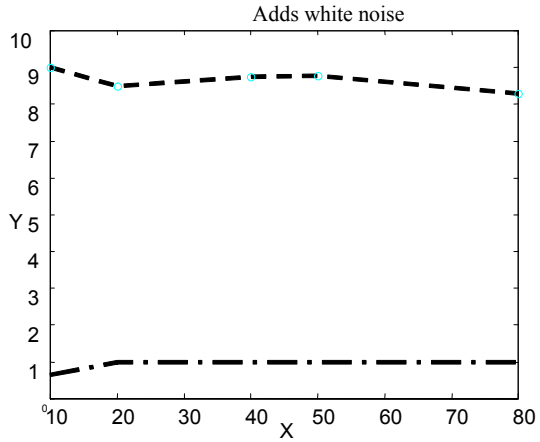

***Figure 4** supplementary charts for figure 3*

The shows for the Figure 3 and figure 4 has the similar results with the shows for Figure 1, that is, it has a stability quality for embedding and extracting, and the value of the PSNR would becomes smaller with the deeper of the embedding, and the value of NC would increases with the increasing factors and eventually to attain numerical 1.

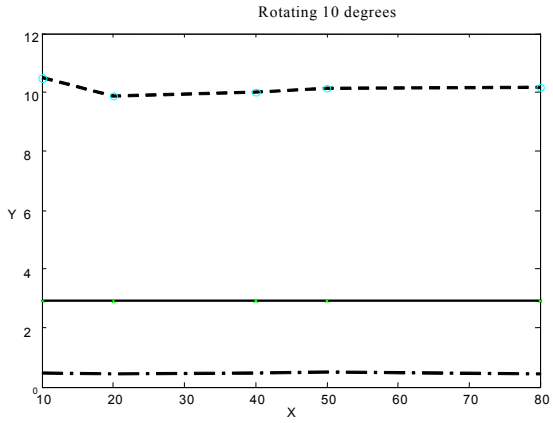

***Figure 5** the analysis to the attacking of cutting image data*

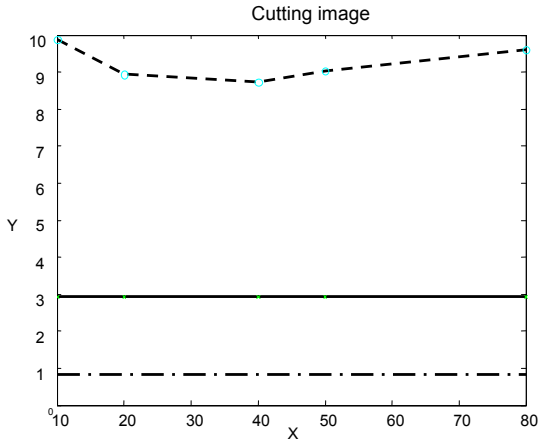

***Figure 6** Rotating 10 degrees attack data analysis*

The figure 5 is an image after shearing, PSNR value suddenly dropped to the single digits and into a straight line, which shows the numerical is critical. Now, the value of NC become a balanced statue, but its value drops compared to
the previous two experiment results, of which the maximum value of dropping less than 1.

The figure 6 is an image after rotating, its experimental results is similar to that images after shearing. And the NC value of response robustness is very small, less than 0.5.

3 Conclusions:

In this paper, we get a detailed record of DCT-based digital watermarking procedures for data analysis, and a visual observation for experimental images. As we compared with the original image and the embedded watermark images, we can not get an obvious difference from the visual feeling, also we can not get any watermark information when using our eyes to observe the images directly. First of all, Attack recover time in every experiment is relatively shorter, which explains that program are applicable, Secondly, as to PSNR of carrier image and hiding information images, the value is relatively higher than before rotating and shearing, but after rotating and shearing, the value decreases rapidly and keep constant, this shows that it's the critical value of the PSNR and the poor adaptive ability of the DCT-based watermark. At last, in the whole experiment, value of NC has all been very steady all the time, and is up to 1 many times. So, the information of hiding algorithms based on two-dimensional DCT has many good characters to process image, such as securities, not intangible and robustness.

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Gensheng Hu received his master's degree in computer imagery processing from xi'an university of technology in 1994.Since then he has worked in the department of Packing and Printing of ZhuZhou institute of technology.His work has focused on thedevelopment of digital watermarking technology, especially in the aspect of two value image base on DCT.publish many papers in core periodical,and now,he works in the college of Printing Engineering,Hang Zhou Dianzi University.

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