Robust Gray scale Watermarking Based on Two Levels of DCT and SVD

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ABSTRACT-- *In this paper, a novel robust grayscale Watermarking algorithm based on Two-Levels DCT and Two-Levels SVD is proposed. The watermark signal is (32×32 × 8) bit gray image. First, the original image is divided into blocks according to the size of the watermark; each block corresponds to each pixel value of watermark. Second, the DCT is applied in each block twice and form new blocks. Then, SVD on the each new block to get matrices U, S and V for each block and the first value of each matrix S is collected together to form a new matrix. Apply SVD on the new matrix again to get the S matrix .The pixel value of watermark is embedded into the new S matrix through some method. And the watermark can be detected with the original image. The experimental results show that the algorithm can satisfy the transparency and robustness of the watermarking system very well. Experimental evaluation demonstrates that the proposed scheme is able to withstand a variety of attacks very well.*

Keywords – Watermark; Two-Levels DCT; Two-Levels SVD.

I.INTRODUCTION

Networked multimedia systems have recently gained more and more popularity due to the ever increasing amount of information that is stored and transmitted digitally; the expansion will continue at an even more steep rate when advanced multimedia services such as electronic commerce, interactive TV, teleworking, etc., will be widely available. A limiting factor in the development of multimedia networked services is that authors, publishers and providers of multimedia data are reluctant to allow the distribution of their documents in a networked environment because the ease of reproducing digital data in their exact original form is likely to encourage copyright violation A digital watermark is a code carrying information about the copyright owner, the creator of the work, the authorized consumer and whatever is needed to handle the property rights associated to any given piece of information. The watermark is intended to be permanently embedded into the digital data so that authorized users can easily read it. At the same time, the watermark should not modify the content of the work but slightly (it should be unperceivable or almost unperceivable by human senses), and it should be virtually impossible for unauthorized users to remove it. By means of watermarking the work is still accessible, but permanently marked. To be really effective, a watermark should be [1, 2]: unobtrusive, readily extractable robust, unambiguous, innumerable Image watermarking techniques proposed so far can be divided into two main groups: those which embed the watermark directly in the spatial domain and those operating in a transformed domain ,e.g. the frequency domain [3]. Techniques can also be distinguished according to the way the watermark is extracted from the possibly distorted version of the marked image.

As one of the typical transforms, DCT is widely used in digital watermarking, but usually DCT is used only once when embedding watermarks, and DWT is used many times. How many times of

DCT can be used in watermarking is still unknown to us. In [4] , the 'Multiple-level' idea is introduced from Discrete Wavelet Transform to Discrete Cosine Transform, and the multiple-level Discrete Cosine Transform is called about it. The watermark algorithms based on multiple-level Discrete Cosine Transform are studied. Experimental studies show that the proposed algorithm has better robustness compared with common digital watermarking algorithms based on Discrete Cosine Transform, and its real-time property isn't affected by the multiple-level transform. Besides, the methods of choosing transform coefficients and transform levels are studied, and experimental results show that the best performance can be achieved by reasonably choosing transform coefficients for the two-level transform. Most of the domain transformation watermarking schemes works with DCT and DWT. However, singular value decomposition (SVD) is one of the most powerful numeric analysis techniques and is used in various applications. The SVD for square matrices was discovered independently by Beltrami in 1873 and Jordan in 1874, and extended to rectangular matrices by Eckart and Young in the 1930s. It was not used as a computational tool until the 1960s because of the need for sophisticated numerical techniques. In later years, Gene Golub demonstrated its usefulness and feasibility as a tool in a variety of applications [5]. SVD is one of the most useful tools of linear algebra with several applications in image compression, and other signal processing fields. A few proposed SVD-based watermarking of these S component coefficients obtained by SVD transformation, have been researched. In this paper we propose a novel Robust grayscale watermarking algorithm based on Two-Levels DCT and Two- Levels SVD .This paper is organized as follows two-level DCT method are introduced, in Section III blocked-SVD method are introduced, in Section IV digital watermark embedding and extraction scheme are mentioned, in Section V some experiment results are mentioned in Section VI conclusions are presented.

II. THEORETICAL BACKGROUND—2-LEVEL DCT

We choose to work in the block DCT domain for the following reasons: DCT has good energy compaction capability; it is feasible to incorporate the HVS characteristics; the sensitivity of HVS to the DCT basis images has been extensively studied resulting in a default JPEG quantization table .Generally speaking, the watermark has to be added to frequencies of high energy in order to be resistant to noise. So, we embed the watermark to the largest value of the block which the two-levels DCT is applied in. The two-Level DCT [4] is that the DCT is used two times when embedding watermark. The 'Two-level' idea is introduced from Discrete Wavelet Transform to Discrete Cosine Transform, and it is called two-level Discrete Cosine Transform. The conventional DCT domain watermarking algorithms only use DCT on the original image once , and then choose the appropriate transform coefficients to modify the watermark information embedded. In this paper , to take full advantage of DCT's " energy concentration" characteristics, we use two level DCT on the original image which is divided into square blocks of size 8_8 pixels.
The process of two-levels DCT can be described in Fig.1

  

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Fig.1 (a) the original image (b) the one-level DCT (c) the two-level DCT

III. SVD METHOD

SVD is a numerical technique used to diagonalize matrices in numerical analysis. It is an algorithm developed for a variety of applications. The main properties of SVD from the view-point of image processing applications are:

1) the singular values (SVs) of an image have very good stability, that is, when a small perturbation is added to an image, its SVs do not change significantly
2) SVs represent intrinsic algebraic image properties. In this section, we describe a watermark casting and detection scheme based on the SVD.

From the viewpoint of linear algebra, we can observe that a discrete image is an array of nonnegative scalar entries, which may be regarded as a matrix. Let such an image be denoted by. Without loss of generality, we assume in the subsequent discussions that is a square image, denoted by, where represents either the real number domain or the complex number domain. The SVD of is defined as

$$A=USVT \quad (1)$$

where U and V are orthogonal matrices(UUT = I,VVT = I) by size mxm and nxn respectively. S, with size mxn , is the diagonal matrix with r (rank of A matrix) nonzero elements called singular values of A matrix. Columns of U and V matrices are called left and right singular vectors respectively. If A is an image as in our case, S have the luminance values of the image layers produced by left and right singular vectors. Left singular vectors represent horizontal details while right singular vectors represent the vertical details of an image. SVs come in decreasing order meaning that the importance is decreasing from the first SV to the last one, this feature is used in SVD based compression methods. Changing SVs slightly does not affect the image quality and SVs do not change much after attacks, watermarking schemes make use of these two properties. In embedding stage of the method introduced in [5], SVD is applied to the cover image, watermark is added with a gain parameter to the SV matrix S, SVD is applied once, resultant U and V matrices are stored and resultant SV matrix is used with U and V matrices of the cover image to compose the watermarked image. In extraction stage, the steps in embedding are reversed: SVD is applied to watermarked image. An intermediate matrix is composed by using stored U and V matrices and singular matrix of watermarked image. The watermark is extracted by subtracting singular matrix of cover image from the intermediate matrix.

IV. DIGITAL WATERMARK EMBEDDING

Our digital watermark embedding process is divided into 6 steps and is briefly described below:

Step 1: The original image I (512x512) is first divided into square blocks of size 8 8 pixels, then the DCT is applied in each block twice. Then each new block is expressed as the matrix Fm,n ($1\le m \le 64, 1\le n \le 64$)

Step 2: Perform SVD on the matrix Fm,n ($1\le m \le 64, 1 \le n \le 64$) to get matrices $U_{fm,n}$, $S_{fm,n}$ and $V_{fm,n}$ for each matrix Fm,n and the $S_{fm,n}$ (1,1)of every matrix $S_{fm,n}$ is collected together to get a new matrix A (64x64).

Step 3: Perform SVD on the new matrix A (64x64) and obtain U, V and S.

Step 4: Using W (32 x 32) to represent the grey watermark. Then according to $S+\alpha W \Rightarrow U_1 S_1 V_1^T$, obtain$V_1$,U_1 and then obtain Aˆ (64x64) according to $A\hat{} \Leftarrow U\ S_1\ V^T$ (α=0.1).

Step 5: Using Aˆ(m, n) ($1\le m \le 64, 1\le n \le 64$)to replace the $S_{fm,n}$ (1,1) of every matrix $S_{fm,n}$ to get $S^*_{fm,n}$, then the $F_{m,n}$ which obtained in step 1 become F*m,n according to $F^*_{m,n} \Leftarrow U_{fm,n}\ S^*_{fm,n}\ V^T{}_{fm,n.}$

Step 6: Apply inverse 8x8 block DCT to $F^*_{m,n}$ twice to produce watermarked image I *(512x512).

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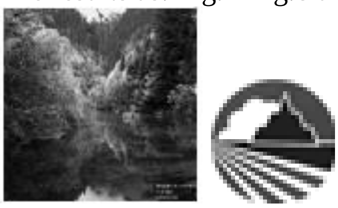
V. DIGITAL WATERMARK EXTRACTING

Our digital watermark embedding process is divided into 3 steps and is briefly described below:
Step 1: Apply 8x8 block DCT to watermarked images I*(512x512) twice and Then apply SVD in each block .The first value of the S matrix of each new block is collected together to get a new matrix A*(64x64).
Step 2: Apply SVD to the A* , A*=> U*S1 *V*T ,and obtain U*, S1 * and V*.
Step 3: Associating with U_1, V_1, and S_1 * □obtain D* according D*<=USV, in the end we can obtain the watermark which is embedded according to W *<= (D- S) / α.

VI. EXPERIMENTAL RESULT

In this study, the cover image size is 512x512 and DCT block size is 8x8, SVD block size is 64x64 . MATLAB and Image Processing Toolbox are used for the experiments and attacks. We put the performance investigation of our algorithm by computing the PSNR (Peak Signal-to-Noise ratio) between the original image and the watermarked image and the normalized correlation coefficient C (W,W*) between the original watermark and the extracted watermark.
The algorithm is tested on a variety of images, but for the sake of space, here we only give the results obtained using the 512 x512 grayscale image “Street.bmp” and 32x32 grayscale watermark “Logo.bmp” and test robustness under practical conditions: JEPG compressing, rotating, adding noise, geometric cropping, median filter.

The results as: Fig.2-Fig.8 and Table1, Table2



(a) (b)

Fig2. (a) The original image; (b) The original watermark

(a) (b)

C(W ,W*) =0.995

Fig3. (a) The watermarked image; (b) The extracted watermark

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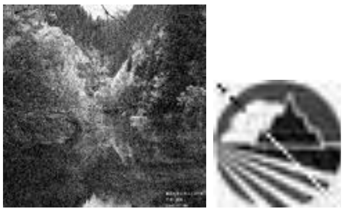
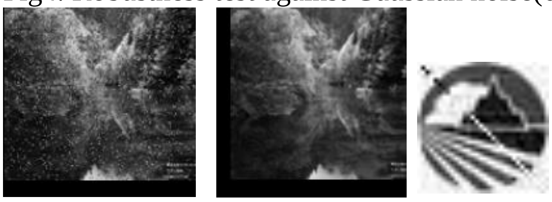


(a) (b)

C(W ,W*) =0.958

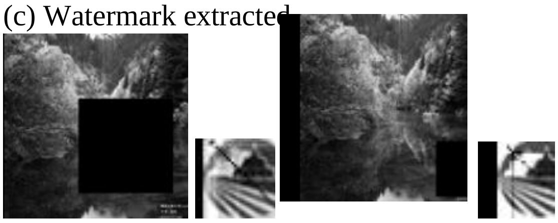
Fig4. Robustness test against Gaussian noise(0.01)



(a) (b) (c)

C(W ,W*) =0.941

Fig 5. Robustness test against Salt & Pepper(0.02) and Median Filter (3×3);
(a)The Watermarked image attacked by Salt&Pepper (0.02) (b) The Filtered image attacked byMedian Filter (3×3)
(c) Watermark extracted



(a) (b) (c) (d)

C(W ,W*) =0.913 C(W ,W*) =0.942

Fig 6.Robustness test against Gometric cropping
(a)(c)TheWatermarked image attacked by Geometric cropping
(b)(d) Watermark extracted

(a) 10% (b) 20% (c)30% (d) 40% (e)60% (e)80%

Fig 7. JPEG attacks: quality factor from 10 to 80

Table 1 C(W ,W*) under JPEG attacks

Quality	10%	20%	30%	40%	60%	80%
C(W ,W*)	0.947	0.963	0.985	0.987	0.991	0.995

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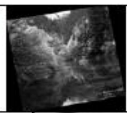
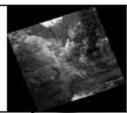
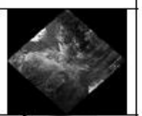
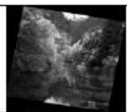
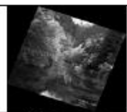
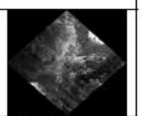
(a) (b)

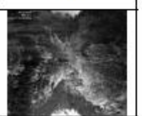
C(W ,W*) =0.904

Fig 8. Robustness test against Median Filter (3×3)
(a) The Watermarked image attacked (b) Watermark extracted.

Table 2 Under Rotating attacks

Rotate Angle	+10°	+20°	+45°
The watermarked image rotated			
The watermark extracted			
C(W ,W*)	0.912	0.889	0.887

Rotate Angle	-10°	-20°	-45°
The watermarked image rotated			
The watermark extracted			
C(W ,W*)	0.908	0.883	0.865

Rotate Angle	-90°	+90°	180°
The watermarked image rotated			
The watermark extracted			
C(W ,W*)	0.999	0.999	0.999

CONCLUSIONS

In this paper, a novel robust grayscale watermarking algorithm based on Two-Levels DCT and Two-Levels SVD for copyright protection and authenticity is proposed, which is very robust to the common signal processing techniques including JEPG compressing, rotating, many kinds of noise, median filter,

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geometric cropping. The watermark signal is (32× 32 x8) bit gray image. Experimental results show the algorithm can satisfy the transparence and robustness of the watermarking system very well.

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