Image Watermarking Method Base on DWT-DCT-SVD

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***Abstract*— Modernization leads the world to move in the extreme position, that's why modernization of internet techniques makes the transmission of information such as image, video file, data file convenient. But these modernizations have brought an astronomically immense threat in copyright protection. In this case watermarking can be way to protect the copyright. In watermarking design two vital points should be in aim. These are copyright protection & robustness. That's why in this paper we proposed a new watermarking scheme for digital image based on Discrete wavelet transform (DWT), Discrete cosine transform (DCT) & singular value decomposition (SVD). Here we apply 2 level of discrete wavelet transform (DWT), discrete cosine transform (DCT) & singular value decomposition (SVD) for embedding process. Experimental result shows that our propose scheme shows more robust against several assailment's like: image compression, image contrast, Gaussian noising. Moreover our scheme shows a good sensitive to maleficent manipulation such as filtering and desultory or random noising.**

***Keywords*— Copy right protection, Arnold transform, discrete wavelet transform, discrete cosine transform, singular value decomposition, watermarking, MATLAB.**

I. Introduction

The world is advancing in every aspect. That's why we have seen a rapid growth of network multimedia systems & other numerical technologies. This growth makes easier the transmission of digital data like image, audio, video etc. has to transmit through the world wide wave. But this availability of digital data makes threating to the copyright protection. It has withal become a refinement ground for a variety malefactions. Illegal reproduction, dissemination & tampering bring immensely colossal quandary in copyright protection.

Several types of method have been proposed for copyright protection. Those are cryptography [1], steganography & watermarking [2]. Among all these method, the watermarking method is one of the best solutions. Image watermarking is a process of hiding a message related to a digital signal (i.e. an image, song, and video) within the signal itself. Image watermarking scheme can be divided into two categories: time-domain methods and transform-domain methods. Time-domain methods embed the watermark directly in the spatial domain, such as Least Significant Bit (LSB) method [3], Patch work method [4]-[5]. Transform-domain methods use a mathematical transformation to transform the image into transform-domain, watermark information was embedded by changing some coefficients of the transform domain and then use inverse transform to generate the watermarked image, such as the DFT method [4]-[6], DCT method [7], and DWT method [8]. The important requirement of the blind image watermarking is given below:

A. Robustness

Even though an unauthorized person performs some modifications to the watermarked image through some common signal processing attacks and compression attacks etc. But the watermark can still be extracted. The scheme should resist the various attacks from hackers.

B. Non-invertibility

If we are unable to generate the same watermarked image with the help of different combinations of host and watermark images then it is called as Non-invertible watermarking scheme. This provides copyright protection.

C. Fidelity

This is about the perceptual similarity between the original image and the watermarked image. The watermark should be imperceptible and no visual effect should be perceived by the end user. The watermark may degrade the quality of the content, but in some applications a little.

In this article, we proposed a image watermarking algorithm is based on DWT, DCT & SVD. In first stage we use the Arnold transformation to scramble the watermark sequence, which enhance the security of the embedded watermark. Then we apply discrete wavelet transform for the host image. Then carry out a second discrete wavelet transform on middle-frequency. The embedding watermark in low frequency makes the watermark perceptible. On the other hand, to survive lessee data compression, watermark information should not be inserted. That's why traditional middle frequency region to embed watermark. After that we apply DCT & SVD respectively on the middle frequency region. In the last step we embed watermark into the original image. Section III describes this embedding process in details. A large number of simulation result show that the proposed algorithm has a good algorithm.

II. Theoretical Principle

A. Arnold transform

To increase the security of the watermark image, we use scrambling algorithm for the watermark image. It is a method to pre-process the watermark. That's why it's applied on the watermark image before embedding into host image. It can disorder the image matrix and make the image illegible. The Arnold transformation can be defines as below:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \mod N \in (x, y, x', y') \quad (1)$$

x & y denote the coordinate of pixels of the original watermark, x' and y' denote the coordinate of pixels of the transformed watermark; N denotes the size of original image. An example of Arnold transformation is shown below:

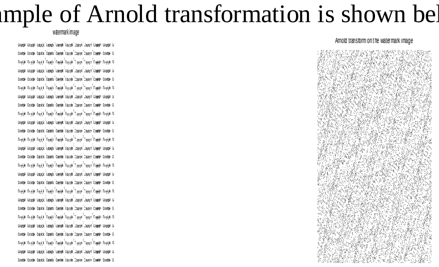

Fig. 1 Example of arnold transform

The right one is the watermark image after 6 times Arnold transform.

B. Discrete cosine transform

Discrete cosine transform (DCT) can linearly transform data into the frequency domain, where the data can be represented by a set of coefficients. The advantage of DCT is that the energy of the original data may be concentrated in only a few low frequency components of DCT depending on the correlation in the data. In the other word, a technique for converting signals into elementary frequency components. It can be referred to as the even part of the Fourier series but DCT involves using just cosine function & real coefficients. DCTs are simpler to calculate .designations. Here we two dimensional DCT & the equation of 2-D DCT are given below:

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

C. Discrete wavelet transform

The discrete wavelet transform is similar to the Fourier transform with a completely different merit function. The main difference is this: Fourier transform decomposes the signal into sins and cosines, i.e. the functions localized in Fourier space; in contrary the discrete wavelet transform uses functions that are localized in both the real and Fourier space. In two dimensional DWT, each level of decomposition produces four bands of data denoted by LL, LH, HL & HH. This process is continued until the desired number of level determined by the application is reached.

D. Singular value decomposition

The techniques that dealing with sets of equations or matrices that are either singular or numerically very close to singular is the so-called singular value decomposition (SVD). SVD allows one to diagnose the problems in a given matrix and provides numerical answer as well. The SVD of an image of A of size M×N is defining as:

$$A = U\, S\, V^T \quad (3)$$

Where U & V are the orthogonal matrices. $U^T U = I, V^T V = I$ & $S = \mathrm{diag}(\lambda_1, \lambda_2 \ldots \ldots \lambda_r)$. The diagonal values of S are called the singular values of A & each value represents the luminance of an A where r is the rank of A. The columns of U & V are called the left & right singular vectors of A.

III. Proposed Watermarking Scheme

The proposed Watermarking scheme is characterized as follows:

A. Watermark Embedding

Step 1 Select the watermark image that is similar or co-related with the host image.

Step 2 Scramble the watermark image with Arnold transform to increase the robustness of a model against cropping. In my program, I have done this transformation 6 times.

Step 3 Then Apply Discrete cosine transform (DCT) in the watermark image.

Step 4 Then apply SVD on the watermark image.

$$W = U_w S_w V_w^T$$

Step 5 Then read the Host image. Apply discrete wavelet transform (DWT) on the host image to decompose it into four non overlapping multi resolution coefficients i.e. LL, LH, HL & HH.

Step 6 Chose the coefficient LH in order to apply second DWT operation & divide this coefficient into another four coefficients i.e. LL*, LH*, HL* & HH*.

Step 7 Chose coefficient LH* & perform 2D discrete cosine transform.

Step 8 Then apply singular value decomposition after DCT. We obtain:

$$B_h = U_h\ S_h V_h^T$$

Step 9 A Then we perform:

$$S_{wh} = S_h + \Phi . S_w$$

Where Φ is the scaling factor.

Step 10 Then Perform :

$$N = U_h S_{wh}\ V_h^T$$

In order to construct the host image with watermark image.

Step 11 Apply inverse Apply Discrete cosine transform.

Step 12 Performs the inverse DWT by using modified & non modified coefficient to get the watermarked image.

B. Watermark Extraction

Step 1 Perform the pre-filter operation on the performance on the watermarked image.

Step 2 Apply DWT on the pre-filter watermarked image to decompose it into four non-overlapping multi-resolution coefficient sets i.e. LL, LH, HL, and HH.

Step 3 Chose LH coefficient & apply again DWT in order to divide this coefficient into another four coefficients i.e. LL*, LH*, HL* & HH*.

Step 4 Chose coefficient LH* & apply DCT on it.

Step 5 After applying DCT on the coefficient make subtraction between DCT coefficient of watermarked image & host image.

Step 6 Perform SVD on the subtracted result.

Step 7 Compute the distorted part by

$$E_x = (U_w * S * V_w^T)\ /\ \Phi$$

Step 8 Then apply inverse DCT & inverse Arnold transformation to obtain the extracted watermark image.

IV. Performance Evaluation

The images of “Cameraman” of size 512×512 & “Copyright” of size 128×128 are considered as the host & watermark image respectively. These images are shown in figure 2.

(a) (b)

Fig. 2 (a) Cover or host image (b) Watermark image

After applying the proposed algorithm we have obtain the watermarked image that shows in figure 3(a). The PSNR of the watermarked image “Cameraman” is 72.70. Figure 3(b) shows the recovered watermark image.

(a) (b)

Fig. 3 (a) Watermarked image (b) Recover watermark image

The quality of the watermarked image can be estimated using peak signal to noise ratio (PSNR) & is calculated as follow:

$$PSNR = 10\ \log_e \frac{255^2}{MSE} \tag{4}$$

The similarities between original & extracted watermarks can be determined by using the normalized correlation coefficient (NC) & it’s define as follow:

$$NC = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (w(i,j)) - w')(\varepsilon_w(i,j) - \varepsilon'_w)}{\sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} (w(i,j) - w')^2 * \sum_{i=1}^{m} \sum_{j=1}^{n} (E_w(i,j) - \varepsilon'_w)^2}} \tag{5}$$

The following figures represents the extracted watermark images with several attacks of the proposed scheme.

TABLE I
EXTRACTED IMAGE AFTER DIFFERENT ATTACK

Extracted watermark	Attacks
	Gaussian Noise and Filtering Attack
	Salt & pepper Noise and Filtering Attack
	Image Contrast Attack
	Image Sharpening
	Intensity transformation

Image compression

Poisson Noise and Filtering Attack

Fig. 4 Extracted watermark with several attacks

The different values of PSNR for different attack in watermarked image is given below:

TABLE III
VALUES OF PSNR FOR DIFFERENT ATTACK

Attacks	PSNR
Gaussian Noise and Filtering Attack	56.28
Poisson Noise and Filtering Attacks	56.46
Salt & pepper Noise and Filtering Attack	56.28
Image Contrast Attack	56.65
Image Sharpening	78.66
Intensity transformation	56.66
Image compression	56.25

TABLE IIII
VALUES OF PSNR FOR DIFFERENT ATTACK

Attacks	Correlation coefficient (NC)
Gaussian Noise and Filtering Attack	0.766

Poisson Noise and Filtering Attacks	0.674
Salt & pepper Noise and Filtering Attack	0.696
Image Contrast Attack	0.698
Image Sharpening	0.987
Intensity transformation	0.987
Image compression	0.994

V. CONCLUSIONS

This paper introduces a new technique of image watermark base on a combine DWT, DCT & SVD algorithm. We use Matlab to process simulation experiments and attack test. Here we make the cover image on the conduct of the two DWT & take DCT & SVD on the middle frequency region. From the test, the algorithm we proposed has shown good performance & good robust. And our algorithm shows good result in both peak signal to noise ratio (PSNR) & normalized correlation coefficient (NC).

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