IMAGE WATERMARKING ALGORITHM USING DCT, SVD AND EDGE DETECTION TECHNIQUE

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ABSTRACT – Proposed watermarking algorithm is best suitable for the protection of multimedia content by using the concept of Digital Watermark. Proposed watermarking algorithm is developed by using a combination of Discrete Cosine Transform (DCT), Singular Value Decomposition (SVD) frequency domains and Canny Edge detection technique. The proposed algorithm is a Non-blind watermarking algorithm. By using SVD the robustness of the algorithm can be increased. By incorporating edge detection technique invisibility of the watermark can be increased. The proposed algorithm is more secure and robust to various attacks like JPEG Compression, rotation, histogram equalization, scaling, cropping, salt & pepper noise, and filtering etc. Experimental results are evaluated using PSNR (Peak Signal-to-Noise Ratio) and Correlation (CORR) values. Experimental results show that the new watermarking scheme is more robust than the existing DCT and SVD method. Analysis and experimental results show that the new watermarking algorithm performs well in both security and robustness

Keywords: Digital Image Watermarking, Copyright Protection; Discrete Cosine Transform (DCT); Singular Value Decomposition (SVD); Canny Edge Detection Technique

1. INTRODUCTION

With the advent of the Internet the online purchasing and distribution of the digital images can now be performed relatively easily. However, there exists one major problem associated with the distribution of any digital images is the important issue of copyright protection and the proof of rightful ownership. Over the fast few years, the technology of digital watermarking has gained prominence and emerged as a leading candidate that could solve the fundamental problems of legal ownership and content authentications for digital multimedia data(e.g. audio, image and video).

A digital watermark is a sequence of information containing the owner's copyright for the multimedia data [1 & 2]. Watermark is inserted invisibly in another image (host image) so that it can be embedded at later times for the evidence of rightful ownership.

Digital image watermarking techniques can be categorized into one of the two domains, viz., spatial and transform according to the embedding domain of the host image. The simplest technique in the spatial domain methods is to insert the watermark image pixels in the least significant bits (LSB) of the host image pixels [3 & 4]. However, spatial domain methods are hardly robust. Watermarking in transform domain is more secure and robust to various attacks.

In the classification of watermarking schemes an important criterion is the type of information needed by the detector. Based on the information required there are 3 types of watermarking techniques (i) Non-blind schemes require both the original image and the secret key(s) for watermark embedding. (ii) Semi-blind schemes require the secret key(s) and the watermark bit sequence. (iii) Blind schemes[6] require only the secret key(s).

In image watermarking two distinct approaches have been used to represent the watermark. In the first approach[5]&[7] the watermark is generally represented as a sequence of randomly generated real numbers having a normal distribution with zero mean and unity variance. This type of watermark allowing the detector to statistically check the presence or absence of the embedded watermark. In the second approach [8] & [10], a picture representing a company logo or other copyright information is embedded in the cover image. The detector actually reconstructs the watermark, and computes its visual quality using an appropriate measure.

In this work, a watermarking algorithm proposed is robust reasonably having good capacity (16x16 logo is embedded multiple times in the 512x512 Lena host image) and non-blind in nature. The proposed method uses DCT-SVD domains and for embedding watermark edge detection method.

The proposed work is organized as follows: In section '2' a brief overview of DCT and SVD is given. In section '3' the proposed watermarking algorithm is presented. In section '4' experimental results and in section '5' Conclusions are given.

2. OVERVIEW OF DCT AND SVD

2.1 Discrete Cosine Transform (DCT)

A transformation function which transforms image from spatial domain to frequency domain which makes the analysis of a signal simple. DCT Watermarking is done by using direct application of transform to entire image or block wise. One dimensional DCT is used in audio compression method. The only dimension of interest in audio is time. Two dimensional DCT is used in image compression, where vertical and horizontal dimensions are considered. Formulae for calculating DCT is given by equation 1 and inverse DCT is given by equation2.

DCT is used in many standardized image, audio, and video compression methods. It has shown its superiority in reduction of the redundancy of a wide range of signals.

An image is subdivided into 8x8 block of samples. Each of these 8x8 blocks of samples of the original image is mapped to the frequency domain. It is represented as a composition of DCT basic functions with appropriately chosen 64 coefficients, representing different horizontal and vertical intensities.

Formulae of the 2-D DCT:

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

Formulae of the 2-D inverse DCT:

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

which

$$C(u),C(v)=\begin{cases}\sqrt{1/N}, & u,v=0\\ \sqrt{2/N}, & u,v=1,2,\cdots,N-1\end{cases}$$

2.2 Singular Value Decomposition (SVD)

The Singular Value Decomposition is one of the most useful tools of linear algebra with several applications to multimedia. Applications including Image compression, Watermarking and other Signal Processing. Given a real matrix, A (m,n); $1\leq m \leq M$, $1\leq n \leq N$, it can be decomposed into a product of three matrices given by equation 3.

$$A = USV^T \quad (3)$$

Where U and V are orthogonal matrices, $U^TU = I$, $V^TV = I$, and $S = diag(\lambda_1, \lambda_2, \ldots \lambda_r)$. The diagonal entries of S are called the singular values of A, the columns of U are called the left singular vectors of A, and the columns of V are called the right singular vectors of A. This decomposition is known as the Singular Value Decomposition (SVD) of A, and can be written as shown in equation 4,

$$A = \lambda_1 U_1 V_1^T + \lambda_2 U_2 V_2^T + \ldots + \lambda_r U_r V_r^T \quad (4)$$

Where r is the rank of matrix A. It is important to note that each singular value specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image layer.

An important property of SVD based watermarking is that the largest of the modified singular values change very little for most types of attacks like transpose, flip, rotation, scaling and translation.

3. PROPOSED WATERMARKING ALGORITHM

Proposed watermarking algorithm is an improvement over LIU Quan et al[1] method. By adding edge detection technique proposed algorithm is more robust than[1]. Instead of embedding watermark in the mid band of the DCT 8x8 blocks by using the SVD, here in the proposed algorithm the blocks are selected using edge detection technique based on the threshold number of edges and SVD is applied to the selected DCT coefficient blocks and singular values are modified using the watermark logo and gain factor. Gain factor differs from image to image. The block size is same as the watermark size. In the proposed method watermark logo is embedded multiple times and because of that robustness of the algorithm improves. Figure.1 shows the watermark embedding procedure in the block diagram format.

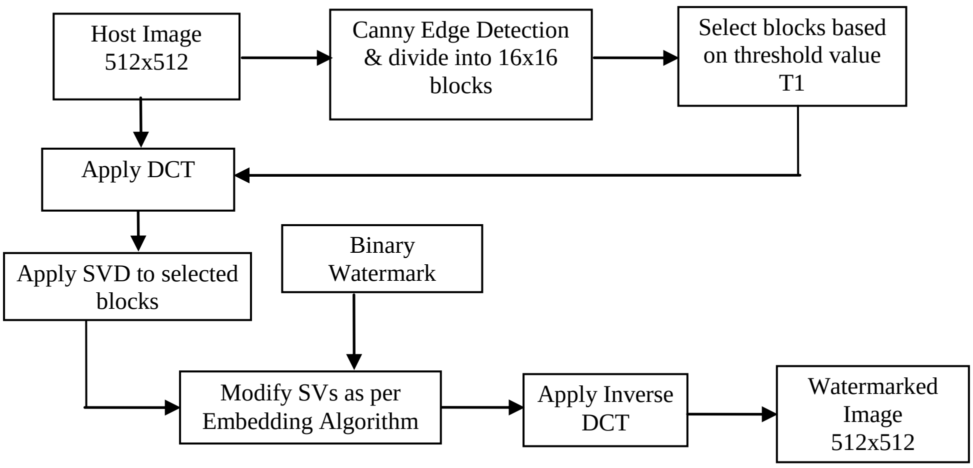

Figure1 Block Diagram for Watermark Embedding

If the watermark logo size is increased based on that block size is getting changed. Block size and watermark logo size are interdependent. Here the threshold value (T1) i.e. edge count of the block is chosen as the key parameter. Watermark is embedded into few of the blocks based on the key parameter. SVD is applied to each chosen individual blocks. Singular values are modified by embedding watermark with some gain factor of ‘α’. In the proposed algorithm gain factor ‘α’ chosen is 0.2.

In this proposed scheme the host image chosen is Lena image of size 512x512. DCT is applied to the entire host image. Canny edge detection is applied to host image & it is divided into 16x16 blocks. In each block the number of edges are found and based on the threshold number of edges the blocks are chosen for watermark embedding. Watermark logo chosen is 16x16 size which is same as the block size.

The watermark embedding procedure is briefly described in the following steps:

Step1: DCT is applied to entire host image ‘I’ of size 512x512.

Step2: Canny edge detection is applied to entire host image, later on it is subdivided into 16x16 blocks (B_i).

Step3: The blocks (N) are selected based on the threshold value which depends upon the high frequency components of the respective blocks.

Step4: SVD is applied to each 16x16 blocks to obtain the SVs (Singular Values) of each block called as ‘S_i’ matrix.

Step5: Binary watermark logo is added to the S_i matrix of each block.

$$D_i = S_i + \alpha W \qquad (5)$$

Where ‘α’ is a gain factor

Step6: SVD is applied on each D_i matrix to obtain the SVs of each (S_{wi} matrix) block.

$$D_i = U_{wi} S_{wi} V_{wi}^T \qquad (6)$$

Step7: Use the S_{wi} matrix of each block to build the watermarked blocks

$$B_{wi} = U_i S_{wi} V_i^T \qquad (7)$$

Where B_{wi} is the watermarked block. Repeat from step4 to step7 for all the selected N blocks.

Step8: Combined the watermarked and unwatermarked blocks into a single matrix.

Step9: Applied Inverse DCT (idct2) and the watermarked image (I_w) is obtained.

The watermark extraction procedure is briefly described in the following steps:

Step1: Apply DCT to watermarked image and divide the watermarked image into 16x16 blocks.

Step2: Apply canny edge detection to the original host image & divide it into 16x16 blocks. Find the blocks which are watermarked using the key.

Step3: SVD is applied on any one of the selected watermarked block

$$B_{wi}' = U_i' S_{wi}' V_i^{T'} \qquad (8)$$

Step4: Obtain the matrices that contain the watermark using U_{wi}, V_{wi}^T and S_{wi}' matrices

$$D_i' = U_{wi} S_{wi}' V_{wi}^T \qquad (9)$$

Step5: Extract the watermark (W' matrix) from the D_i' matrix

$$W_i' = (D_i' - S_i) / \alpha \qquad (10)$$

Step 6: The process is repeated to all the 16x16 blocks until the extracted watermark nearly matches with the original one.

4. EXPERIMENTAL RESULTS

In this proposed watermarking algorithm host image Lena of size 512x512 is used as shown in Figure.2. Watermark logo taken which is ‘SV’ of size 16x16 shown in Figure 3.

Figure2 Host Lena Image (512x512)

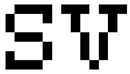

Figure3 Watermark Image (16x16)

DCT is applied to entire host image. Using canny edge detection the blocks are found which are having more number of high frequency components. SVD is applied to the selected DCT blocks. Singular values of the selected blocks are modified using binary watermark logo and α gain factor. Figure4 and Figure5 show the watermarked image and the extracted watermark logo respectively.

The proposed watermarking algorithm is simulated using MATLAB 7.01. The proposed watermarking algorithm is tested for the various host and watermark images. Here the results are given for Lena image only.

Figure4 Watermarked Lena

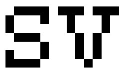

Figure5 Extracted watermark

To evaluate the performance of the proposed method, evaluation metrics used are PSNR (Peak Signal to Noise Ratio) and CORR (Correlation coefficient). PSNR is widely used to measure visual fidelity between the original image and watermarked image. PSNR is defined by the equation 11. The similarity between the original watermark and extracted watermark from the attacked image is evaluated by using correlation coefficient given by the equation 12.

$$PSNR = 10\log_{10}\left(\frac{255\times 255}{MSE}\right) \tag{11}$$

Where

$$MSE = \frac{1}{M\times N}\sum_{m=1}^{M}\sum_{n=1}^{N}\left[I(m,n)-I_w(m,n)\right]^2$$

$$NC = \frac{\sum_i \sum_j w(i,j)w'(i,j)}{\sum_i \sum_j |w(i,j)|^2} \tag{12}$$

Table.1 shows PSNR values of the host image and watermarked images with attack and also the correlation (CORR) values between the actual watermark and extracted watermark from attacked watermarked image for the proposed method and Dct-Svd method.

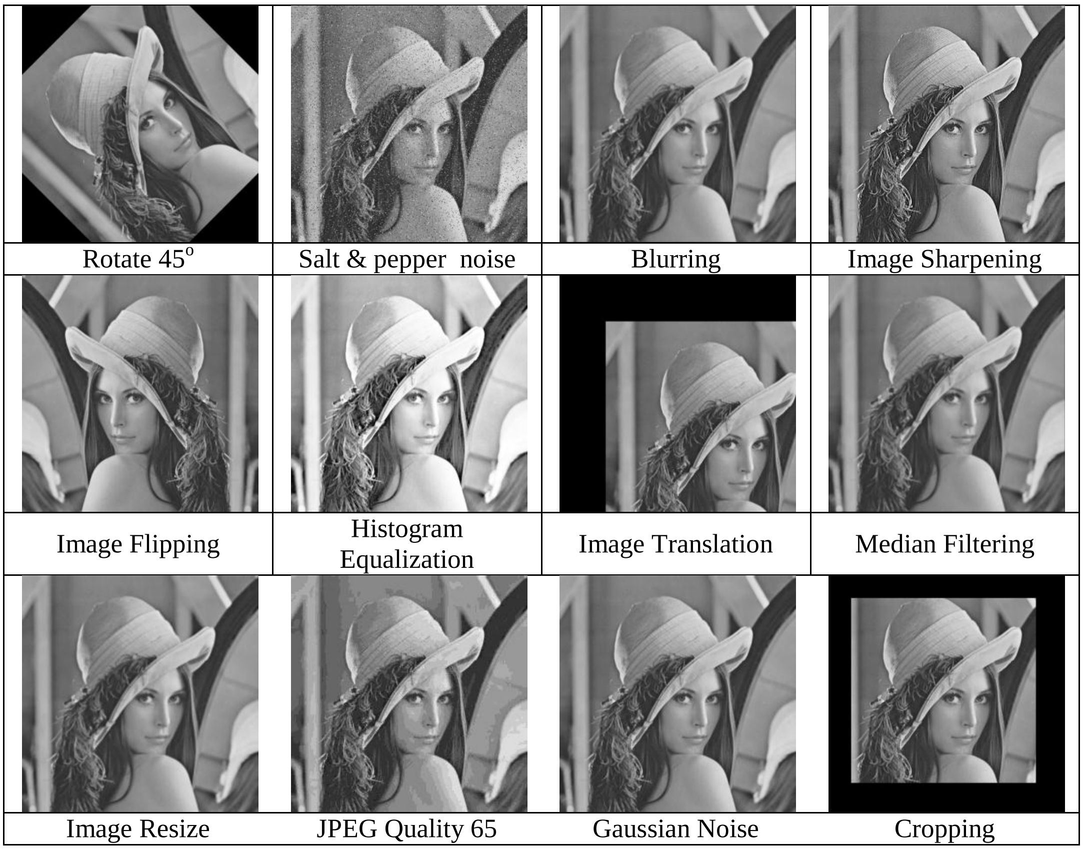

Figure 6 Watermarked Images with Attack

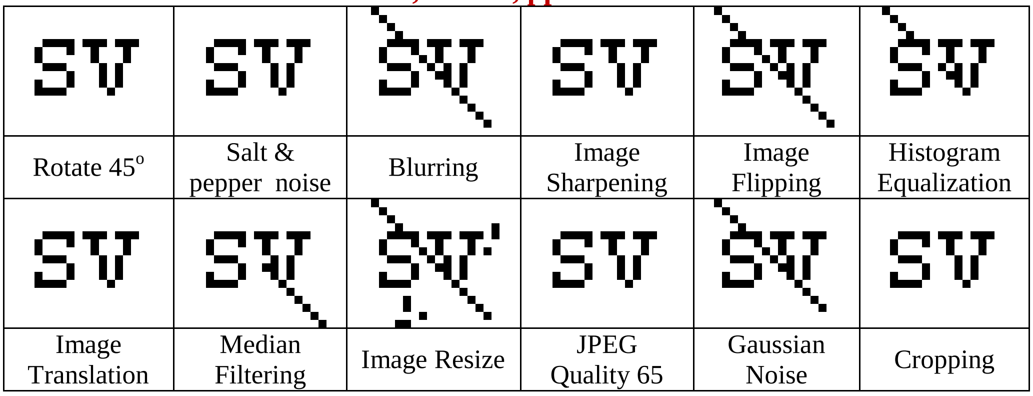

Figure 7 Extracted Watermarks for Various Attacks

Table.1 Performance results in terms of PSNR and CORR values

Attacks	Proposed Dct-Svd-Edge Method		Dct-Svd Method	
	PNSR	CORR	PSNR	CORR
without Attack	73.2935	1	58.053	1
Salt & Pepper Noise	40.1485	1	38.971	0.7477
Image Flipping	27.6713	0.9094	33.577	0.6767
Sharpening	31.9638	1	34.749	0.8925
JPEG (QF: 65%)	40.6674	1	38.576	0.9748
JPEG (QF: 50%)	39.6527	1	38.254	0.9551
Gaussian Blurring	37.79	0.8474	39.754	0.6236
Histogram Equalization	40.3556	1	65.213	0.8196
Gaussian Noise	45.992	0.859	39.68	0.9988
Rotate (45^0)	27.2838	1	33.129	0.3172
Median Filter	37.1949	0.6917	39.908	0.5336
Image Resize	37.7262	0.859	40.04	0.5674
Translation	26.615	1	32.519	0.249
Adjustment	24.0654	1	30.133	0.653
Cropping	28.633	1	33.659	0.4036

From Table 1 it is observed that the proposed watermarking algorithm is more robust than the Dct - Svd method. It is observed that watermarked image visual quality can be increased by using proposed method. Finally it is observed that Dct-Svd-Edge watermarking algorithm is more resilient to number of attacks.

Figure 6 shows watermarked images with attack and Figure 7 shows extracted watermark images for various attacks applied to watermarked image. From the resultant images it is observed that the extracted watermark visual quality is good. The proposed algorithm is resilient to number of attacks, so the algorithm is best suitable for copyright protection application.

5. CONCLUSIONS

The proposed watermarking algorithm is a non-blind robust watermarking algorithm. The proposed watermarking algorithm using DCT, SVD and Edge detection is more robust in comparison with many watermarking algorithms developed using DCT and SVD methods.

The watermark is inserted in few of selected blocks of original image, so that perceptual quality of the watermarked image is good. Watermark is inserted into the blocks number of times so retrieval of watermark is good.

From the experimental results it is observed that the proposed watermarking algorithm is robust against to many signal processing and geometrical attacks compared to existing DCT and SVD method. The visual quality of extracted watermark image is good.

Proposed algorithm can be further improved using various edge detection techniques and further can be extended to color images and video processing.

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