

DWT-DCT-SVD Based Semi Blind Image Watermarking Using Middle Frequency Band

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Abstract : In this paper a semi-blind algorithm is been developed using DWT-DCT and SVD technique which is robust against several attacks like cropping, noise, rotation, filtering, translation, etc. Trigonometric function is used to closely relate the singular values of the original image and the watermarked image. In this algorithm, firstly DWT is applied on the host image which results in four frequency bands LL, LH, HL and HH. As it is found that middle frequency band is less prone to attacks so the singular values of the DCT Transformed coefficients of the LH band of the image is been modified using the singular values of the DCT transformed coefficients of the watermark and the scaling factor with the help of inverse-trigonometric function. And then this modified singular values are used to reconstruct the watermarked Host Image. Now to validate the content authentication, the extraction technique is applied on the watermarked image. It consists of applying DWT on the watermarked image to get all the four frequency bands and then by using the singular values of the DCT coefficients of the middle frequency band and the scaling factor using trigonometric function, the singular values of the watermark are extracted to reconstruct the watermark using inverse SVD.

Keywords- DCT, DWT, Robust, Semi Blind Watermarking

I. Introduction

The evolution of internet, along with the advancement of digital multimedia tools have create a major impact in making the storage and distribution of multimedia content a straightforward tasks. Thus security of multimedia contents becomes a vital issue and there is a need in protecting the digital content against counterfeiting, piracy and malicious manipulations[2]. Digital watermarking is an evolving field that requires continuous effort to find for the best possible method in protecting multimedia content. In this paper, we describe overview of digital image watermarking technique and proposed an algorithm for copy write protection of digital images in DCT domain. Digital watermarking can be defined as the process of embedding a certain piece of information, technically known as watermark into multimedia content including text documents, images, audio or video streams, such that the watermark can detected or extracted later to make an assertion about the data. We have also implemented this algorithm using MATLAB 7.x. Watermark robustness is one of the major characteristics that influence the performance and applications of digital image watermarks[1]. The major advantage of transform domain methods is their superior robustness to common image distortions. In this paper, we are interested in invisible watermarks because they have a wider range of applications compared to visible watermarks.

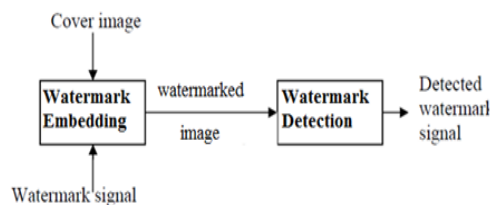


Fig1: Generic Watermarking Scheme

II. Aims

The aims of this paper are three fold:

- i. To investigate the strength and limitations of current watermarking schemes .
- ii. To design and develop new schemes to overcome the limitations.
- iii. To evaluate the new schemes using application scenarios of copyright protection, tamper detection and authentication.

Aimed at three goals mentioned above, we will find answers to these research questions:

- i. What are the major challenges in robust watermarking?
- ii. How can we reduce the computational cost of a robust watermarking method that is based on semi-blind scheme using trigonometric function?
- iii. What are the new capabilities of robust watermarking?

III. Prior Art

Three **essential factors** used to determine quality of watermarking scheme:

3.1 Discrete Cosine Transform (DCT)

The Discrete Cosine Transform (DCT) is a technique that converts a spatial domain waveform into its constituent frequency components as represented by a set of coefficients. DCT is one of the most popular linear transforms and a compression tool of digital signal processing[4]. It is a lossless procedure and has been widely used because of its good capacity of energy compression and de-correlation. These transforms are the members of real-valued discrete sinusoidal unitary transforms.

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

For u, v=0, 1, 2,.....N-1

WHERE

$$\alpha(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } u = 0, 1 \\ \frac{1}{2} & \text{for } u = 2, \dots, N - 1 \end{cases} \quad \alpha(v) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } v = 0, 1 \\ \frac{1}{2} & \text{for } v = 2, \dots, N - 1 \end{cases}$$

3.2 Discrete wavelet Transform (DWT)

This watermarking method is focusing on its embedding strength would provide useful insight in how to improve its performance. The performances measured include robustness, imperceptibility and computational cost. DWT decomposes an image into a low-pass sub band and three high-pass sub bands. In this study, this method embeds a watermark in high-pass (or higher frequency) band of the DWT domain[5]. This is due to the good imperceptibility provided by high-pass band. To reconstruct an image, an inverse DWT is used after modification has been made by using singular values of SVD of watermark.

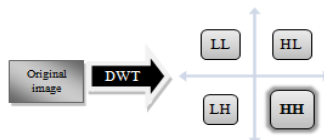


Fig 3: DWT decomposition

3.3 Singular Value Decomposition(SVD)

It is a linear algebra transform technique used in watermarking. It is composed of three vectors in which one vector consists of diagonal matrix and two vectors consist of orthogonal matrices. This diagonal matrix is responsible for an image luminance and orthogonal matrices are responsible for the geometry of an image. In this algorithm, the authors found the singular values of cover image and then modified them by adding a watermark[5]. SVD transform is again applied on the resultant matrix for finding the modified singular values. These singular values are combined with the known orthogonal components to get the watermarked image. For watermark extraction, inverse process is used.

IV. Proposed Method

For the implementation of the proposed algorithm it is assumed that the dimension of the cover image I is N x N. First we will embed the watermark in a cover image or host image by using watermark embedding algorithm and then the watermark will be extracted using extraction algorithm . The robustness of the algorithm will be measured by applying attacks on watermarked image and then with the help of PSNR values the robustness of the extracted logo will be evaluated .

4.1 Watermark Embedding Algorithm

Step1. Using DWT, decompose the original image I into 4 sub-bands: LL, HL, LH, and HH.

Step 2. Apply DCT on LH sub-band to obtain the coefficient matrix 'A'.

Step 3. Apply SVD on coefficient matrix 'A':

$$A = U^h S^h V^h$$

Step 4. Apply DCT on the watermark to obtain the coefficient matrix 'W'.

Step 5. Apply SVD to coefficient matrix 'W':

$$W=U^w S^w V^w$$

Step 6. Modify S^h : $S^{h*} = \tan^{-1}(\alpha * S^w)$ where α is scaling factor.

Step 7. Obtain the modified high frequency matrix component I^{*h}

$$I^{*h} = [U^h . S^{h*} . V^{h*}]$$

Step 8. Apply IDCT on matrix I^{*h} to obtain the modified middle frequency band LH^* .

$$LH^* = IDCT(I^{*h})$$

Step 9. Using LL, HL, LH, and HH^* , apply IDWT to obtain the watermarked image I^* .

The result of embedding algorithm is shown in figure below:

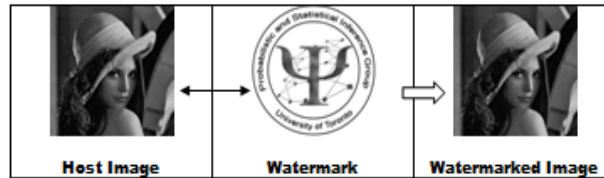


Fig 4: Embedding Process

4.2 Watermark Extraction Algorithm

Step1. Using DWT, decompose the watermarked image I^* into 4 sub-bands: LL, HL, LH and HH.

Step 2. Apply DCT on LH band to obtain the coefficient matrix 'C'.

Step 3. Apply SVD to matrix 'C':

$$C = [U^k S^k V^k]$$

Step 4. Apply DCT on watermark W to obtain a coefficient matrix A2.

Step 5. Apply SVD to matrix A2:

$$W^* = [U^w S^w V^w]$$

Step 6. Extract the singular values of watermarking:

$$S^{w*} = [\tan(S^k)] / \alpha$$

Where S^k are the singulars of watermarked image after applying DCT. [$\alpha=0.00015$]


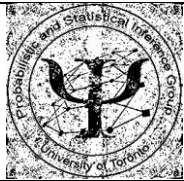

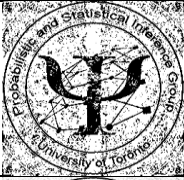


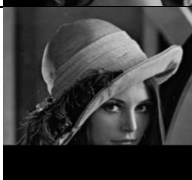
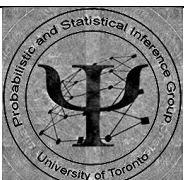
Step 7. Recover the watermark: $w^* = (U^w) * (S^{w*}) * (V^w)$

Step 8. Apply IDCT on w^* to obtain an extracted watermark WM.

Results of various attacks applied on the watermarked image and watermark extracted with its PSNR values is given in the following table:

Table 4: Results of Watermark Extraction after applying various attacks

ATTACKS (Parameters)	Attacked Image	Watermarked	Watermark	PROPOSED METHOD	
				PSNR	Correlation
<i>Rotate(75°)</i>				+53.56dB	0.5308
<i>Medfilt2</i>				+53.74dB	0.6019
<i>Histeq</i>				+65.52dB	0.9123

Gaussian noise (0.01)			+56.36dB	0.6320
Salt & Pepper Noise (0.03)			+56.54dB	0.6500
Left Cropping (1,1,100,512)			+68.59dB	0.9665
Bottom Cropping (1,375,512,512)			+56.07dB	0.8730

V. Conclusion

In this paper, we proposed a semi-blind reference image watermarking by using the technique DWT-DCT-SVD. The proposed method has a good performance in the case of robustness and imperceptibility. It is more robust to some common image processing including Gaussian noise, Left cropping, Bottom cropping, Salt & Pepper noise, Histogram equalization, Medium filter, Rotation, etc. PSNR values are computed to find out the imperceptibility performance between watermarked image and its cover image. The maximum PSNR values is of Left Cropping i.e. +68.59 dB and the minimum PSNR values is of Rotation i.e. +53.56 dB. Correlation values are also computed here for finding the relation between them. The maximum correlation exists for left cropping attack whose value is 0.9665 and the minimum correlation exists for rotation attack whose value is 0.5308. We compared the results of our proposed method with the existing method of Nidhi H. Divecha and N.N.Jani [3]. The PSNR values and correlation factor of the proposed method are much more robust than the existing one. In the existing method, an original image is of 256 * 256 pixel values while in the proposed method, we took an original image of 512 * 512 pixel values.

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