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Watermarking Scheme based on Redundant Discrete Wavelet Transform and SVD

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Abstract- *The main objective of image watermarking is to provide protection of the digital data from illegal copying and distribution which can be obtained by hiding the specific information into the host image in such a way that the presence of watermark cannot be recognized by human visual. In this paper we proposes a image watermarking scheme based on (Redundant Discrete Wavelet Transform) RDWT and (Singular Value Decomposition) SVD where the host image is transformed into wavelet domain by applying 1-level RDWT and then the watermark is embedded by modifying the singular values of host image and watermark image.*

Key Words: Image Watermarking, Redundant Discrete Wavelet Transform (RDWT), Singular Value Decomposition (SVD).

1. INTRODUCTION

Now a days, Security of information data is become an important issue to concern. Due to the tremendous use of internet and computer networks have made the digital data distribution, duplication and copying from an unauthorized person very easy which causes affect on copyright owners. For solving this problem, digital watermarking has been emerged as a tool to protect the copyright infringement. It is a technique for inserting some information into the multimedia which can be retrieved back according to the requirement. That's why it has been become a hot topic for research and researchers throughout the world are trying to obtain the new method for the protection of digital data. The two main features of digital watermarking is to allow imperceptibility and robustness. Watermarking schemes are classified into three categories according to the extraction process: Non blind, Semi blind and Blind watermarking. In non blind scheme there is a requirement of both the original media and the secret key for the extraction process. Semi blind scheme require secret key and watermark bit sequence where in blind schemes requires secret key only. The next classification of watermarking process is based on the domain means where the secret message will be inserted which are spatial domain and transform domain. In spatial domain, without any modification the information is directly embedded into the LSB of the host image whereas in frequency domain, the secret data is hidden into the transform coefficient using frequency transformation techniques such as DCT (Discrete Cosine Transform), DWT (Discrete Wavelet transform), FFT (Fast Fourier Transform). The main criteria of watermarking system are robustness, imperceptibility and data payload. Robustness refers to the resistance against several attacks. Imperceptibility means the similarity between the original host image and the watermarked one where data payload stand for how many watermark bits can be embedded.

This paper is organized as follows:

In section 2, we briefly describe RDWT and SVD.

Section 3 discusses the proposed watermarking technique of embedding and extraction of watermark.

Section 4, we discuss the performance evaluation.

Experiment result and Conclusion are presented in section 5 and 6.

2. PRELIMINARIES

This section gives the basic technical background and theory of redundant discrete wavelet transform and Singular value decomposition on which the proposed technique is based.

2.1 Redundant Discrete Wavelet Transform (RDWT)

One of the popular methods of watermark embedding is DWT. But the major drawback of DWT is lack of shift invariance which is the result of subsampling or downsampling of its bands. This causes the large change in the wavelet coefficient of the image for minor shift in the input image results the improper reconstruction of the cover and watermark image. To overcome this problem the researchers have proposed watermarking technique using RDWT instead of DWT due to the elimination of Decimation step. RDWT analysis and synthesis is expressed mathematically as....

$C_j\,[k] = (C_{j+1}\,[k] * h_j\,[\,-k\,])$

$d_j\,[k] = (C_{j+1}\,[k] * g_j\,[\,-k\,])$

Synthesis can be,

$C_{j+1}[k]= \frac{1}{2}\,(c_j\,[k] * h_j\,\,[k] + d_j\,[k] * g_j\,[k]\,)$

RDWT decomposes image of size N X N into four subbands each of size N X N where in DWT it decompose the image in four subband but these subbands are of size $\frac{N}{2}$ X $\frac{N}{2}$.

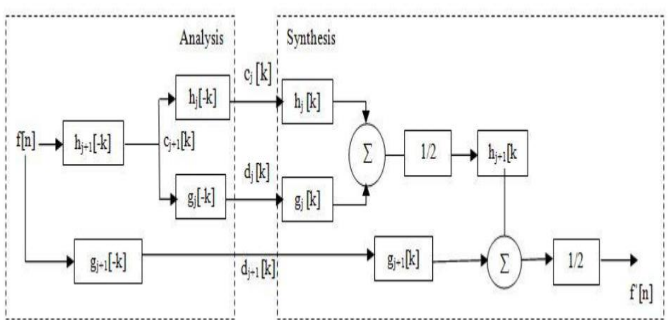


Fig -1: RDWT analysis and synthesis filter bank

2.2 Singular Value Decomposition(SVD)

The SVD is the tool to decompose a matrix into its eigenvectors and eigenvalues. The SVD of an image A is defined as:

$$A= U*S*V^T$$

Where U and V are the orthogonal matrices and S is the diagonal matrix. The column of U and V are known as left singular vector and right singular vector and T is the transpose of an image A .The concept of SVD in watermarking is used because of its two important characteristics i.e. (a) when a small perturbation is added to images its singular values are less affected (b) Singular values represents the algebraic image properties.

3. Proposed watermarking Scheme

In this paper we proposes a robust image watermarking using RDWT and SVD where a host image (I) is of size 512 X 512 and watermark image (W) is 64 X 64 size.

3.1. Watermark Embedding process

a. First we decompose an image into 1-level RDWT using HAAR filter on I, to obtain LL sub-band coefficient.
b. Perform SVD on LL subband to obtain singular values S.
   [Ui Si Vi]=SVD(LL)
   .
c. In the same way we apply SVD on watermark image (W) to obtain singular value matrices (Sw).
   $[U_w, S_w, V_w\,] = SVD(w)$
d. The singular value matrix (Sw) of the watermark (W) multiplied by the scaling factor (α=0.05) is added to the singular values matrix(Si) of the host image i.e.

$$S' = Si + \alpha * Sw$$

e. Apply inverse SVD on S' to obtain watermarked LL' sub-band coefficient.
f. Watermarked image is obtained by applying 1-level inverse RDWT.

3.2. Watermark Extraction Process

By reversing the steps of embedding scheme, the watermark can be extracted.

a. First of all we apply 1-level RDWT using Haar filter to obtain LL* sub-band coefficient.
b. Apply SVD on LL*to obtain singular values S*
   [U*,S*,V*] = SVD(LL*)
c. Singular value of watermark being extracted is formulated by
   $$Sw^* = (S^* - Si)/\alpha$$
d. Compute the extracted watermark image W by taking inverse SVD.

4. Performance evaluation

In order to evaluate the performance, various experiments are carried out to check the robustness and imperceptibility.

PSNR (peak signal to noise ratio) is used to analyze the visual quality of the watermarked image correspond to the original image and is define by

$$PSNR(dB) = 10 \log_{10}.(255^2 / MSE) \quad (7)$$

$$MSE = \frac{1}{m.n} \sum \sum \| I(i,j) - K(i,j) \|^2$$

Mean square error between the original image and the watermarked image

To verify the similarity between the original watermark and extracted watermark, the normalized correlation coefficient is used and is given as

$$NC = \frac{\sum_i \sum_j W(i,j).W'(i,j)}{\sum_i \sum_j [W(i,j)]^2}$$

Where W (i,j) = Watermark image

W' (i,j) = Extracted watermark image

5. Results

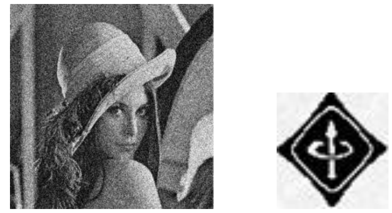
In this section, some of the results obtained by the proposed watermarking technique are shown. For testing the performance of proposed method we choose a binary watermark image of size 64 X 64 and host image of size 512 X 512 shown in Fig. 2.

(a) (b)

Fig -2: (a) original image (b) watermark image

(c) (d)

Fig-2: (c) Watermarked image (d) Extracted Watermark (PSNR=43.06)

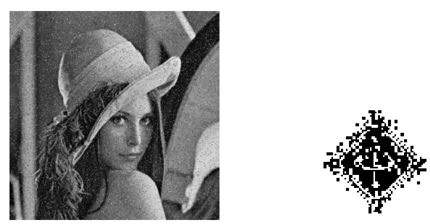


(a) (b)

Fig-3: Result against Gaussian noise (variance =0.05) (a) Watermarked Image (b) extracted watermark

(a) (b)

Fig-4: Result against median filter (window size=3x3), (a) Watermarked image (b) Extracted watermark



(a) (b)

Fig- 5: Result against Salt & pepper noise(density= 0.05) , (a) Watermarked image (b) Extracted watermark

(a) (b)

Fig- 6: Result against JPEG compression(Quality factor = 50), (a) Watermarked image,(b) Extracted watermark

Table-1: NC values of extracted watermark for different attacks over four images.

Images	Attacks			
	Gaussian (Variance=0.05)	Median (3X3)	Salt & pepper (Density=0.01)	Compression (Quality=80)
Lena	0.8768	1	0.8931	0.8671
Pepper	0.9788	0.9453	0.6530	0.8312
Barbara	0.8132	0.9710	0.7468	0.7398
Mandrill	0.8652	0.7646	0.8361	0.8646

6. CONCLUSION

In this paper, a robust image watermarking technique using RDWT and SVD has been introduced, where the original image is decomposed by 1-level RDWT using haar filter. Then in both image (host image and watermark image) SVD is applied and watermark embed in approximation subband which contain maximum information about the image. Experimental results shows the algorithm is robust after different kinds of attacks like JPEG compression, salt and pepper noise, Gaussian noise and median filtering and watermark is successfully recovered.

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