Performance Analysis of IWT-SVD based Image Watermarking with DWT-SVD under Various Attacks

Amit Kumar
Department of Electronics Engineering
Rajasthan Technical University, Kota
Rajasthan, India

Rajesh Bhatt
Department of Electronics Engineering
Rajasthan Technical University, Kota
Rajasthan, India

Girish Parmar
Department of Electronics Engineering
Rajasthan Technical University, Kota
Rajasthan, India

Abstract—There are numerous applications of watermarking, i.e., in security, protection of rights and authentication, etc. This paper deals with watermarking technique based on Integer Wavelet Transform (IWT) and Singular Value Decomposition (SVD). The technique has been implemented and compared with other combined image watermarking technique based on DWT-SVD. In both watermarking techniques, the cover image is decomposed into four sub bands (LL, LH, HL and HH) using DWT or IWT and thereafter SVD is applied to LL sub band. Both the watermarking techniques; DWT-SVD and IWT-SVD have also been compared without and with several attacks. Experimental results demonstrated that IWT-SVD watermarking technique is imperceptible and robust against most of the applied attacks such as; noise addition, resizing and filtering.

Keywords— Digital Image Watermarking, DWT, IWT, SVD, Attacks.

I. INTRODUCTION

Watermarking is the process of embedding the watermark into cover image with the help of embedding algorithm for security and other purposes. Later on, this embedded image can be extracted with the help of extraction algorithm.

The work deals with Watermarking based on DWT-SVD and IWT-SVD. A performance analysis of IWT-SVD with DWT-SVD based algorithms has also been carried out. The performance analysis is based on imperceptibility and robustness test for cover and watermark images against various attacks. Imperceptibility and robustness tests have been performed in terms of Peak Signal to Noise Ratio (PSNR) and Normalized Correlation Coefficient (NCC), respectively. The values of PSNR and NCC have been shown in tabular forms. DWT-SVD and IWT–SVD watermarking techniques have also been tested against a number of geometrical (i.e. resize) and non-geometrical (i.e. noise addition) attacks.

As IWT algorithm stores the coefficients in the integer form and SVD provides stability to the image, so the combination of IWT with SVD gives comparable results with DWT-SVD based algorithm.

II. METHODOLOGY

A. *Discrete Wavelet Transform (DWT)*

DWT decomposes an image hierarchically in single level decomposition. It also provides both spatial and frequency description of the image. It splits an image into four different sub bands, i.e., LL, LH, HL and HH. Here, first letter refers to applying either low pass or high pass frequency operations to the rows and the second letter refers to the filter applied to the columns of the cover image. LL level is the lowest resolution level while rest of the three levels, i.e., LH, HL, HH give the detailed information of the image. Figure 1 shows the single level DWT decomposition structure.

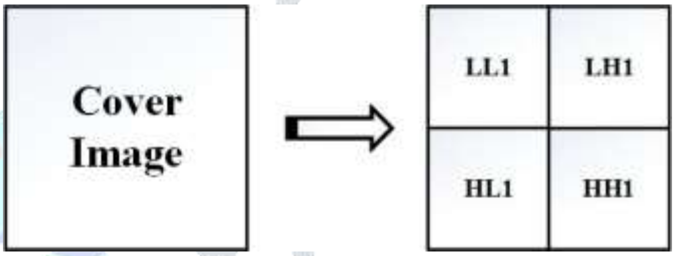


Fig. 1. Decomposition Structure "Single level DWT

B. *Integer Wavelet Transform (IWT)*

Integer Wavelet Transform is a flexible watermarking technique given by Sweldens [5]. Integer or Lifting wavelets are second generation wavelets that have distinctive advantages over first generation wavelets. The lifting wavelets reduces the calculation time and memory requirements. Unlike traditional wavelets, all computations for lifting wavelets are performed in integer domain.

Applying IWT will help in increasing the robustness of watermark.

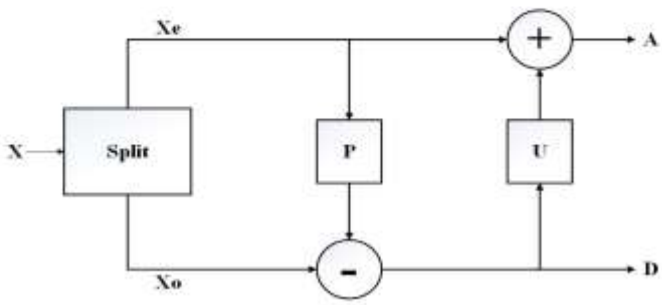


Fig. 2. One lifting Step Illustration

Figure 2 illustrates the single lifting step described by three basic operations: *Split, Predict (P) and Update (U).*

C. Singular Value Decomposition (SVD)

In SVD transformation, a matrix can be decomposed into a multiplication of three matrices that are left singular vectors, set of singular values and right singular vectors.

SVD of an image M with dimensions m x m is given by:

$$M = USV^T$$

where, U and V are the orthogonal matrices:

$$U = [u_1, u_2, \ldots u_r, u_{r+1}, \ldots u_m]$$

$$V = [v_1, v_2, \ldots v_r, v_{r+1}, \ldots v_m]$$

$$UU^T = VV^T = I$$

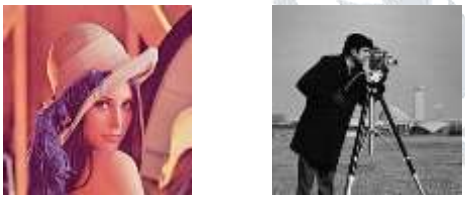
The columns of U are known as left singular vector and columns of V are known as right singular vectors of M. U and V basically describe the geometry details of the original image. Horizontal and vertical details of the original image are represented by U and V, respectively.

S is known as a diagonal matrix having positive singular values of matrix M.

III. Simulation Results

In this Section, performance analysis of DWT-SVD and IWT-SVD has been carried out for Lena (512x512) as cover and Cameraman (256x256) as Watermark images as shown in Fig. 3. The values of PSNR (Peak Signal to Noise Ratio) and NCC (Normalized Cross Correlation) have been calculated to know the imperceptibility and robustness of the watermarking techniques.

For analysis the IWT-SVD watermarking technique has been compared with DWT-SVD with and without attacks. Analysis has been dived into two sections; Imperceptibility and robustness tests.



(a) Lena (512x512) as Cover (b) Cameraman (256x256) as Watermark

Fig. 3. Input Images for Simulation

A. *Performance Analysis (without Attacks)*

TABLE I. VALUES OF PSNR AND NCC WITHOUT ANY ATTACK AT DIFFERENT SCALING FACTOR; ALPHA (LENA (512 X 512) AS COVER AND CAMERAMAN (256 X 256) AS WATERMARK)

Scaling Factor	DWT-SVD		IWT-SVD	
α	PSNR (Watermarked Image)	NCC (Recovered Watermark)	PSNR (Watermarked Image)	NCC (Recovered Watermark)
0.01	45.5259 dB	0.9945	47.6244 dB	0.9834
0.02	39.5889 dB	0.9989	40.7072 dB	0.9957
0.025	**37.7271 dB**	**0.9994**	**38.5990 dB**	**0.9977**
0.03	36.1196 dB	0.9996	36.8684 dB	0.9983
0.04	33.6567 dB	0.9998	34.1787 dB	0.9990
0.05	31.6899 dB	0.9998	32.1506 dB	0.9994

Fig. 4. Watermarked and Recovered Images for DWT-SVD at α=0.025

Fig. 5. Watermarked and Recovered Images for IWT-SVD at α=0.025

Table I shows the values of PSNR and NCC without applying any attack. The values of scaling factor; α has been varied from 0.01 to 0.05. Figures 4-5 show the watermarked and recovered watermark images at α=0.025 for DWT-SVD and IWT-SVD, respectively.

B. *Performance Analysis (under Attacks)*

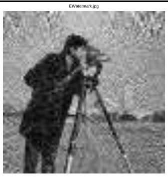
From Table-I, the value of Scaling factor α=0.025, has been chosen according to invisibility of watermark and kept constant for comparison.

TABLE II. IMPERCEPTIBILITY TEST AGAINST SEVERAL ATTACKS (LENA (512 X 512) AS COVER AND CAMERAMAN (256 X 256) AS WATERMARK)

Attacks	DWT-SVD	IWT-SVD
Noiseless Image	 37.7271 dB	 38.5990 dB
Poisson Noise	 27.1572 dB	 27.1854 dB

Salt & Pepper Noise (density = 0.001)	 35.1400 dB	 35.9663 dB
Gaussian Noise (Variance = 0.001)	 30.0267 dB	 30.0371 dB
Resize (512→256 →512)	 40.2942 dB	 40.2763 dB
Filter (3,3)	 34.4741 dB	 34.4897 dB
Filter (5,5)	 30.0638 dB	 30.0625 dB

TABLE III. ROBUSTNESS TEST AGAINST SEVERAL ATTACKS (LENA (512 X 512) AS COVER AND CAMERAMAN (256 X 256) AS WATERMARK)

Attacks	**DWT-SVD**	**IWT-SVD**
Noiseless Image	 0.9978	 0.9977
Poisson Noise	 0.5957	 0.5650
Salt & Pepper Noise (density = 0.001)	 0.9263	 0.9419
Gaussian Noise (Variance = 0.001)	 0.7589	 0.7226
Resize (512→256 →512)	 0.8755	 0.8226
Filter (3,3)	 0.5860	 0.5170
Filter (5,5)	 0.2106	 0.1450

Tables II and III summarize the simulation results for DWT-SVD and IWT-SVD based image watermarking techniques under various attacks when the watermark is embedded in the selected LL sub band. Several non-geometrical and geometrical attacks have been applied to Lena (512 × 512) test image. Non-geometrical attacks such as noise addition (e.g., salt and pepper, Gaussian and poison noise) have been applied. Resize attack is chosen as geometrical attacks.

1) Imperceptibility Test

Imperceptibility test has been performed with the help of PSNR value which is shown in Tables I and II for DWT-SVD and IWT-SVD both. IWT-SVD gives high PSNR value in both cases with and without attacks in comparison to DWT-SVD, as shown in Tables I-II.

So, from Tables I-II, it can be observed that IWT-SVD has high imperceptibility in comparison to DWT-SVD.

2) Robustness Test

Robustness is described as the resistance against non-geometrical and geometrical attacks and measured by NCC value. Robustness varies from one operation to another and from one watermarking technique to another. All techniques cannot resist all attacks, and hence, their robustness is application dependent.

Table III shows the values of NCC along with recovered watermark. The proposed technique IWT-SVD gives comparable results with DWT-SVD with and without attacks.

IV. Conclusions

In present work, performance analysis of digital image watermarking based on IWT-SVD and DWT-SVD has been carried out on the basis of their imperceptibility and robustness with and without attacks. All the simulations have been carried out in MATLAB.

The popular test image Lena (512 × 512) and Cameraman (256 x 256) have been used as cover and watermark images, respectively. Two tests; imperceptibility and robustness have been performed to evaluate the performance of IWT-SVD and DWT-SVD. Imperceptibility and robustness are measured by the values of Peak Signal to Noise Ratio (PSNR) and Normalized Correlation Coefficient (NCC), respectively as given in tabular forms.

The combination of IWT with SVD gives high stability and perfect reconstruction of image. It has been observed that IWT-SVD based algorithm gives comparable results with DWT-SVD. From Tables I-II, it can be observed that IWT-SVD is more imperceptible in comparison to DWT-SVD in both the cases; with and without attacks. In robustness test, IWT-SVD gives comparable results with DWT-SVD, as shown in Tables I and III.

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