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IWT-SVD based Image Watermarking under Various Attacks

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Abstract— Watermarking is used for protection of Rights, authentication and lots of other applications. The work deals with implementation of combined watermarking technique based on Integer Wavelet Transform (IWT) and Singular Value Decomposition (SVD). This combined technique utilizes the benefits of both transforms; IWT and SVD. Here, the cover image is decomposed into four sub bands (LL, LH, HL and HH) using IWT; then SVD was applied to LL sub band. After embedding, IWT-SVD technique is tested under various attacks such as: noise addition, resizing filtering etc. and simulation results demonstrated that this combined technique is robust against those attacks. All simulation results display in tabular forms.

Keywords— Digital Image Watermarking, IWT, SVD, PSNR,NCC

I. INTRODUCTION

The combination of SVD with IWT provides ease in watermark retrieval, improves the intactness of watermark, spreads the watermark throughout the spectrum, etc. In addition to this, it reduces the half of the computational complexity as compared to DWT.

In this paper, SVD and IWT has been combined to develop a hybrid watermarking technique for images. The proposed watermark algorithm can be divided into two processes; embedding and extraction. IWT–SVD based watermarking techniques were tested under a number of geometrical (i.e. resize) and non-geometrical (i.e. noise addition) attacks.

II. METHODOLOGY

A. Integer Wavelet Transform (IWT)

Integer Wavelet Transform is a flexible watermarking technique which was introduced by Sweldens. IWT stores the multimedia content in integer value instead of floating value hence it reduces the computation time. Hence IWT is much faster than other transforms. The other property of IWT is less memory requirements because all computations for lifting wavelets are performed in integer domain unlike traditional wavelets (DWT).

The lifting wavelets increases the smoothness and reduces aliasing effects.

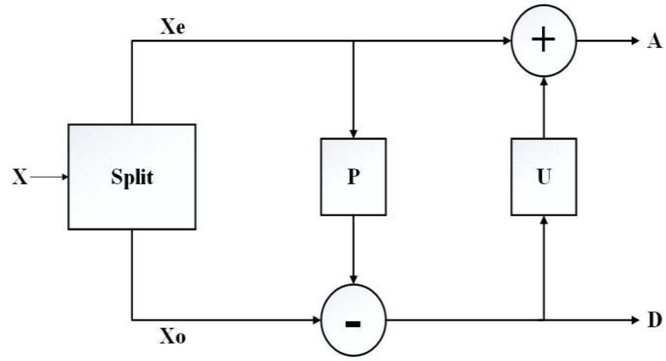


Figure 1. One lifting Step Illustration

A single lifting step can be described by the following three basic steps:

Split: The signals are split into two subsets: the even sample set Xe and the odd sample set Xo, then modifying these values using alternating prediction and updating steps.

Predict (P): In this step, the odd sample Xo is replaced by the difference between the odd component and the predicted value.

Update (U): The update step is also known as primal lifting step.

B. Singular Value Decomposition (SVD)

SVD is a numerical tool which is used for diagonalizable matrices in numerical evaluation. 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 known as orthogonal matrices

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

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

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

Columns of U= Left singular vectors of M

Columns of V = right singular vectors of M.

S = diagonal matrix carrying non-negative singular values of matrix M.

III. IWT-SVD BASED WATERMARKING ALGORITHM

A. Embedding process

It contains following steps:

Step 1: Input the images; Cover and Watermark.

Step 2: Decomposition of both the images into four sub-bands with IWT.

Step 3: After IWT, apply SVD on lower band of both the images, respectively.

For Cover Image,

$$[LL\ LH\ HL\ HH]=IWT\ (Cover);$$
$$[U_c,\ S_c,\ V_c] = SVD\ (LL);$$

and for Watermark,

$$[LLa\ LHa\ HLa\ HHa]=IWT\ (Watermark);$$
$$[U_w,\ S_w,\ V_w] = SVD\ (LLa);$$

where,
U_c, V_c = Orthogonal Matrices of Cover Image,
S_c= Diagonal Matrix of Cover Image,
LL=lower band of Cover image
U_w, V_w = Orthogonal Matrices of Watermark,
S_w= Diagonal Matrix of Watermark,
LLa=lower band of Watermark

Step 4: Then new sigma matrix is computed by combining of both sigma matrix.

$$S_{wm} = S_c + (\alpha * S_w);$$
$$new\_LL = U_c * S_{wm} * V_c';$$

where,
S_{wm} = Diagonal matrix of Watermarked Image,
S_C = diagonal matrix of Cover Image,
S_W = diagonal matrix of Watermark,
new_LL=lower band of Watermarked Image,
α=scaling factor.

Step 5: New LL band is computed with inverse SVD by using new computed sigma matrix.

Step 6: After following the above steps, **Watermarked** image obtained by applying inverse IWT using new_LL band and remaining sub bands of Cover image.

B. Extraction process

It contains following steps:

Step 1: Input the obtained **Watermarked** image in standard format in MATLAB. Split the image into four quadrants by applying IWT.

Step 2: After taking IWT, apply SVD on LL band of decomposed Watermarked Image.

$$[wmLL\ wmLH\ wmHL\ wmHH] = IWT\ (Watermarked);$$
$$[U_{wm},\ S_{wm},\ V_{wm}] = SVD\ (wmLL)$$

where,
S_{wm} = Diagonal matrix of Watermarked Image,
U_{wm}, V_{wm} = Orthogonal Matrices of Watermarked Image,
wmLL= Lower band of Watermarked Image

Step 3: Input the **Cover** image and **Watermark** in standard format in MATLAB. Split the images into four quadrants by applying IWT and apply SVD on Lower band of decomposed images, respectively.

Step 4: Then, new sigma matrix is computed by combining both sigma matrix using scaling factor work.

$$S_{rw}= (S_{wm}-S_c)/ \alpha;$$
$$new\_LLa=U_w * S_{rw} * V_w';$$

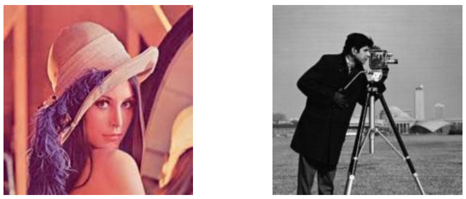
where,
S_{rw} = Diagonal matrix of Recovered Watermark,
S_C = diagonal matrix of Cover Image,
$S_{wm,}$ = diagonal matrix of Watermarked Image,
new_LLa=lower band of Recovered Watermark,
α=scaling factor.

Step 5: New LL band is computed with inverse SVD by using new computed sigma matrix S_{rw}.

Step 6: After following the above steps, **Recovered Watermark** obtained by applying inverse IWT using new_LLa band and reaming sub bands.

IV. Simulation Results

In simulation, proposed watermarking algorithm is applied on test image; Lena (size of 512×512) and Cameraman used as watermark image (size of 256 × 256). To evaluate the performance of the proposed IWT-SVD method, PSNR (Peak Signal to Noise Ratio) and NCC (Normalized Cross Correlation) values have been calculated.



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

Figure 2. Input Images for Simulation

A. Simulations Results without Attacks

TABLE I. VALUES OF PSNR AND NCC FOR IWT-SVD AT DIFFERENT SCALING FACTOR; ALPHA (LENA (512X512) AS COVER AND CAMERAMAN (256X256) AS WATERMARK)

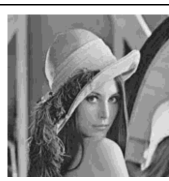
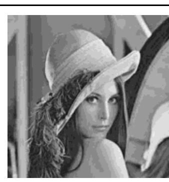
Scaling Factor α	PSNR (Watermarked Image)	NCC (Recovered Watermark)
0.01	 47.6244 dB	 0.9834
0.02	 40.7072 dB	 0.9957
0.025	 **38.5990 dB**	 **0.9977**
0.03	 36.8684 dB	 0.9983
0.04	 34.1787 dB	 0.9990
0.05	 32.1506 dB	 0.9994

Table I, shows the values of PSNR and NCC without applying any attacks. The values of scaling factor; α has been varied from 0.01 to 0.05 and corresponding results are shown in figures, as given in Table I.

B. Simulations Results against Attacks

From Table-I, the value of Scaling factor α=0.025, has been chosen according to requirement. Table II shows the attacked watermarked and recovered watermark images along with the values of PSNR and NCC.

TABLE II. VALUES OF PSNR AND NCC FOR IWT-SVD AGAINST VARIOUS ATTACKS (LENA (512X512) AS COVER AND CAMERAMAN (256X256) AS WATERMARK)

Attacks	PSNR (Watermarked Image)	NCC (Recovered Watermark)
Noiseless Image	 38.5990 dB	 0.9977

Poisson Noise	 27.1854 dB	 0.5650
Salt & Pepper Noise (density = 0.001)	 35.9663 dB	 0.9419
Gaussian Noise (Variance = 0.001)	 30.0371 dB	 0.7226
Resize (512 → 256 → 512)	 40.2763 dB	 0.8226
Filter (3,3)	 34.4897 dB	 0.5170
Filter (5,5)	 30.0625 dB	 0.1450

V. CONCLUSIONS

The work deals with performance analysis of robust digital image watermarking method based on IWT-SVD. Two properties; good stability of SVD and ability to perfect reconstruction of IWT have been utilized by this combined watermarking technique.

Firstly this analysis has been performed without applying any attacks by varying scaling factor from 0.01 to 0.05. From Table-I, it can be seen that it gives high PSNR and NCC values.

Thereafter, this analysis has been performed under various geometrical and non-geometrical attacks, such as; Noise addition, resizing of image and filtering. From Table-I, value of scaling factor 0.025 has been set for applying various attacks. From the results of Table-II, it can be seen that IWT-SVD based watermarking technique has resistance and good imperceptibility against geometrical and non-geometrical attacks.

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