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A Comparative Study of DWT, DWT-SVD and IWT-SVD

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ABSTRACT

The demand of online trade and digital content, in the form of audio, video, text, images is increasing. But the problem arises that the digital data can easily be manipulated and duplicated. This increases the demand of securing the digital data for copyright protection, preventing unauthorized distribution, and ownership verification. Digital image watermarking is a powerful tool to secure digital image. In the present work, three digital image watermarking techniques (i.e. DWT, DWT-SVD and IWT-SVD) have been elaborated and compared with each other. The comparative study is based on the values of the PSNR & NCC and simulation results have been given in tabular forms. It has been observed that IWT-SVD gives comparable results and faster than the DWT & DWT-SVD.

KEYWORDS: Peak Signal to Noise Ratio (PSNR); Normalized Corelation Coefficient (NCC), Scaling Factor.

1. INTRODUCTION

In the era of internet, a ton of data is distributed or exchanged over the net and this data can be easily modified or replicated without any errors. Digital watermarking is an algorithm to protect such type of data. In the present work, a comparative study of digital image watermarking based on DWT, DWT-SVD and IWT-SVD has beencarried out. The values of PSNR and NCC have been compared.

2. METHODOLOGY

A. *Discrete Wavelet Transform (DWT)*

DWT is a mathematical tool for decomposing an image, hierarchically. It does not change the information content present in the signal. Wavelet transform provides both frequency and spatial description of an image.

The filters divide the input image into four non overlapping multi-resolution sub-bands LL, LH, HL and HH. The sub-band LL represents the coarse-scale DWT coefficients while the other sub-bands LH, HL and HH represent the fine-scale of DWT coefficients.

In general, most of the energy in image is concentrated at the lower frequency sub-bands LL and therefore embedding watermarks in other sub-bands may degrade the quality of image. Embedding in the LL sub-bands, could increase the robustness significantly.

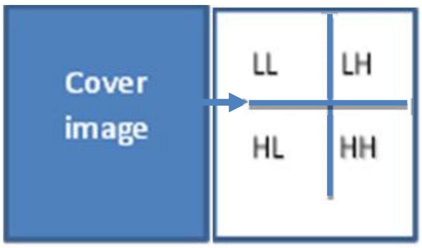

Fig 1: DWT Decomposition

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B. *Singular Value Decomposition (SVD)*

From the discernment of image processing an image can be viewed as a matrix with non-negative scalar entries. SVD is an effective numerical analysis tool to decompose a rectangular matrix “A” into an orthogonal matrix, diagonal matrix, and the transpose of an orthogonal matrix. SVD decomposes a given image A of size M×N as:

$$A = USV^T$$

Where, U is orthogonal matrix (M*M), V is transpose of orthogonal matrix (N*N) and S is a diagonal matrix (MxN) having singular values.

It is worth noting that, the singular vectors of an image specify the image “geometry” like, left singular vectors gives the horizontal details of an image and right singular vectors gives the vertical details of an image, while the singular values specify the “luminance” (energy) of the image. Slight variations in the singular values do not affect the visual perception of the quality of the image.

C. *Integer Wavelet Transform (IWT)*

IWT is used for lossless compression. Coefficients of this transform are represented by finite precision numbers and this allows for lossless coding.

IWT is much faster than the DWT because the floating point wavelet transforms demands for longer data length than the IWT. Reversibility is another benefit of IWT. All the coefficients are integers in IWT and can be stored without rounding off errors, so the image can be reconstructed without any loss. IWT is implemented using the lifting scheme (LS) [14].

Lifting Scheme

The lifting scheme is an effective way of implementation of the wavelet filtering operation and it is divided into three stages: Split, Predict and update.

Split: At this stage main signal is divided into two samples even and odd sets.

Predict: In this phase, the odd samples are predicted from the even samples. This step is also called dual lifting.

Update: This step is also called primal lifting. In this step, new even samples are generated by adding the original even samples to the predicted odd samples.

Inverse lifting transform is also carried out with the difference that its signs are reversed [15].

3. SIMULATION RESULTS AND DISCUSSIONS

A. *Performance Evaluation Parameters*

Two parameters have been used for evaluation i.e. Peak Signal to Noise Ratio (PSNR) and Normalized Correlation Factor (NCC). PSNR defines the similarity between Cover Image and Watermarked Image whereas NCC defines the similarity of the original Watermark and Recovered Watermark.Less the PSNR more will be degradation in the quality of the original image.

B. *Simulated and Experimental Results*

Here, the following images have been used for simulation and results of DWT, DWT-SVD and IWT-SVD have been given.

Cover Image - Pepper.jpg (512*512)

Watermark – Cameraman.jpg (512*512)

(a) (b)

Fig2: (a) Pepper as Cover image and (b) Cameraman as Watermark image

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1) DWT

Table 1 shows the PSNR and NCC values for DWT (Pepper as Cover & Cameraman as Watermark).

Table 1.PSNR and NCC Values for DWT at different values of alpha (Pepper as Cover & Cameraman as Watermark)

S. No.	Scaling Factor	DWT	
	α	PSNR	NCC
1	0.01	44.9447 dB	0.9053
2	0.02	39.6755 dB	0.9526
3	0.025	37.7243 dB	0.9691
4	0.03	36.1194 dB	0.9745
5	0.04	33.6143 dB	0.9805
6	0.05	31.6909 dB	0.9863

(a) (b)

Fig 3: (a) Watermarked image and (b) Recovered Watermark image at α=0.01

Figure 3 shows the results of Watermarked image and Recovered Watermark image at α=0.01 for Pepper and Cameraman images. The value of scaling factor α has been varied from 0.01 to 0.05 and as the value of scaling factor decreases, the value of PSNR increases but at the same time the value of NCC decreases.

2) DWT-SVD

Table 2 shows the PSNR and NCC values for DWT-SVD (Pepper as Cover & Cameraman as Watermark).

Table 2.PSNR and NCC Values for DWT-SVD at different values of alpha (Pepper as Cover & Cameraman as Watermark)

S. No	Scaling Factor	DWT-SVD	
	α	PSNR	NCC
1	0.01	45.2655 dB	0.9932
2	0.02	39.6398 dB	0.9975
3	0.025	37.6282 dB	0.9982
4	0.03	36.0937 dB	0.9987
5	0.04	33.6141 dB	0.9991
6	0.05	31.6812 dB	0.9992

(a) (b)

Fig 4: DWT-SVD (a) Watermarked image and (b) Recovered Watermark image at α=0.01

Figure 4 shows the results of Watermarked image and Recovered Watermark image at α=0.01 for Pepper and Cameraman images. The value of scaling factor α has been varied from 0.01 to 0.05 and as the value of scaling factor decreases, the value of PSNR increases but at the same time the value of NCC decreases.

3) IWT-SVD

Table 3 shows the PSNR and NCC values for IWT-SVD (Pepper as Cover & Cameraman as watermark).

Table 3.PSNR and NCC Values for IWT-SVD at different values of alpha (Pepper as Cover & Cameraman as Watermark)

S. No.	Scaling Factor	IWT-SVD	
	α	PSNR	NCC
1	0.01	47.5455 dB	0.9692
2	0.02	40.6808 dB	0.9962
3	0.025	38.5686 dB	0.9968
4	0.03	36.8295 dB	0.9973
5	0.04	34.1552 dB	0.9983
6	0.05	32.1111 dB	0.9988

(a) (b)

Fig 5: IWT-SVD (a) Watermarked image and (b) Recovered Watermark image at α=0.01

Figure 5 shows the results of Watermarked image and Recovered Watermark image at α=0.01 for Pepper and Cameraman images. The value of scaling factor α has been varied from 0.01 to 0.05 and as the value of scaling factor decreases, the value of PSNR increases but at the same time the value of NCC decreases.

C. Comparative Study of DWT, DWT-SVD and IWT- SVD

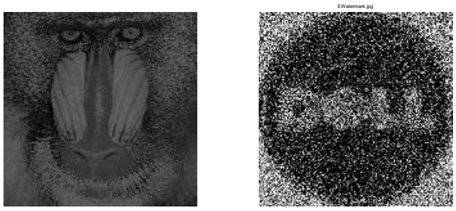
(a) (b)

Fig 6: Mandrill as Cover image and DELL Logo as Watermark image

The Mandrill as Cover and Dell logo as Watermark images have been used for comparison among DWT, DWT-SVD and IWT-SVD.

Table 4.Comparison of PSNR and NCC among DWT, DWT-SVD and IWT-SVD (Mandrill as Cover and DELL as Watermark)

Scaling Factor	DWT		DWT-SVD		IWT-SVD	
α	**PSNR**	**NCC**	**PSNR**	**NCC**	**PSNR**	**NCC**
0.01	44.38	0.4495	45.06	0.9954	46.74	0.9823
0.02	39.15	0.6756	39.07	0.9987	40.03	0.9964
0.025	37.48	0.7599	37.14	0.9990	37.92	0.9976
0.03	35.40	0.8428	35.57	0.9993	36.21	0.9983
0.04	33.15	0.8917	33.08	0.9996	33.56	0.9991
0.05	31.06	0.9334	31.14	0.9997	31.53	0.9993



(a) (b)

Fig7: DWT (a) Watermarked Image and (b) Recovered Watermark at α= 0.01

(a) (b)

Fig8: DWT-SVD (a) Watermarked Image and (b) Recovered Watermark at α= 0.01

(a) (b)

Fig9: IWT-SVD (a) Watermarked Image and (b) Recovered Watermark at α =0.01

4. CONCLUSIONS

The comparative study of DWT, DWT-SVD and IWT-SVD has been carried out. To illustrate these algorithms, Pepper as cover and Cameraman as watermark images have been considered and simulation results are given. For comparison of these algorithms Mandrill as cover and Dell as watermark images have been taken. The results of watermarked and recovered watermark at scaling factor of α=0.01 have been given. The comparative study is based on the values of PSNR and NCC.It is been observed from comparative study

that IWT-SVD based algorithm gives comparable results in terms of PSNR and NCC values.Also, IWT-SVD takes less computation time than other watermarking techniques.

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