Implementation and performance analysis of DCT-DWT-SVD based watermarking algorithms for color images

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***Abstract*-Digital image watermarking is one such technology that has been developed to protect digital content (text, images, audio, and video) from illegal manipulations. In this paper we proposed implementation and performance analysis of two different watermarking schemes based on DCT-DWT-SVD. Both are non blind techniques. One is based on SVD of DC coefficients using second level DWT decomposition and other is consider SVD of all DCT values of second level DWT composition of cover image. To check effectiveness of both techniques for Imperceptibility and robustness PSNR and NCC parameters are used.**

Keywords – Watermark; DWT; DCT; SVD; PSNR; NCC

I. INTRODUCTION

The fast growth of internet and applications using digital multimedia technologies has put the accent on the need to provide copyright protection to multimedia data. A digital watermark can be described as a visible or preferably invisible identification code that is permanently embedded in the data. So it can remain present within the cover media after any decoding process.

Watermarking algorithms can be classified on several criteria are, according to domain of watermark insertion like Watermarks can be embedded in the pixel/spatial domain or a transform domain [11]. Second is according to visibility of watermark(visible and invisible) and according to watermark detection and extraction which contain blind and non blind techniques.

Watermarking scheme quality is determined using robustness, transparency and capacity. Transparency means after insertion of watermark the original image should not be distorted [13, 14]. Robustness is related to attacks. If watermark removal is difficult to various attacks like rotation, scaling, compression, noise then watermarking scheme is robust[15,16]. Capacity means amount which are inserted to cover image. More capacity means one can hide large amount of information.

II. RELATED WORK

Authors proposed watermarking algorithm based on DWT-DCT and SVD. They apply one level DWT decomposition of cover image and select LL band for watermarking. They apply Arnold transform to get good robustness and imperceptibility[1]. In this paper DC coefficient based watermarking scheme for color image is suggested. They apply wavelet decomposition one level to color image. Then divide the selected band into 4X4 sub blocks and DCT is applied. First DCT value is selected from all sub blocks. Then SVD is performed on that. The method is tested against various attacks and result is good for LL band in compare to other band[2]. Robust watermarking scheme is proposed by Navas. In that they combine advantage of three techniques(DCT-DWT-SVD).scheme is very robust for different kind of image processing attacks[3]. Middle band coefficient of DCT based watermarking scheme is given for image authentication. DWT is applied then after DCT of LL is computed. Then mid band coefficient is selected and SVd is applied on it. It is very robust against JPEG compression[4]. R. Mehul has suggested that to get robustness for vast range of attacks watermark insertion can be performed in both low and high value coefficients[5]. Authors proposed color image watermarking using second level DWT decomposition and block base DCT. First they divide color image into three channels Red, Green and Blue and then apply DWT to selected color and select HL or LH band for further decomposition. They selected low and high frequency band so robustness and imperceptibility result is very good[6]. A hybrid block based technique is proposed by V. Santhi. In that First singular value is selected for watermark embedding in all different band after first level decomposition[7]. A hybrid technique based on SVD and DCT is proposed. More transparency is obtained using only Singular values of a recognized pattern and LPSNR is

adopted to achieve high robustness[8]. Author proposed watermarking scheme based on DCT-DWT-SVD. They apply second level decomposition of cover image. DCT is apply to second level HL coefficient and divide it into four quadrant using zigzag sequence. SVD is applied to each quadrant and modified with SVD of watermark. Algorithm gives good PSNR and also robust to various attacks. Quadrant B1 gives good results compare to other three[9]. Author proposed watermarking scheme based on DWT and SVD using all four frequency bands. Singular values of watermark is inserted into all four frequency bands singular values after first level DWT. Experimental results shows that LL gives highest magnitude of wavelet coefficient as well as of singular values[10].

Most of watermarking scheme mentioned above is used gray scale image as cover image and binary or gray scale watermark. In proposed scheme colour image is used as cover image and as watermark image. Therefore capacity is increased. To achieve robustness against different attacks watermark is embedded in lower band and to get good transparency modification is done in singular values. DCT gives best result against compression therefore to overcome problems of compression attacks in existing techniques in second technique we apply DCT to both cover image as well as watermark.

III. PROPOSED ALGORITHM I

Proposed algorithm combines merits of three different techniques DCT, DWT and SVD. First one level DWT is applied to original cover image. To achieve imperceptibility LL band is select for second level decomposition and HH band is selected. It is divided into 4X4 sub blocks. DCT is applied to each sub blocks and first DC coefficient of each block is selected and formed it in matrix. SVD is applied to this matrix and singular values are modified with singular values of watermark. Inverse SVD, inverse DCT and inverse DWT is performed to get watermarked image.

The procedure for embedding and extracting the watermark is given below.

A. Watermark embedding process

The embedding process is divided into following steps and is briefly described as given below:

1. Let OI be the Original image of size N x N. Select color channel and apply DWT to decompose it into four N/2 x N/2 sub-bands LL , HL , LH and HH .
2. Select LL band and Apply DWT to decompose it into four N/4 x N/4 sub-bands LL_LL , LL_HL , LL_LH and LL_HH .
3. Select LL_HH band, divide it into 4X4 square blocks and apply DCT to it, select first DCT value of each block and get DCT coefficient matrix B.
4. Apply SVD to B, $B=U1*S1*V1^T$, and obtain U1, S1 and V1.
5. Let OW of size N/16 x N/16 to represent watermark. Apply SVD to it, OW= W_U*W_S*W_V' and obtain W_U, W_S and W_V.
6. Modify S1 with watermark such that $S=S1 + \alpha * WS$.
7. Obtain B* using $B^*= U^*S^*V^T$.
8. Apply inverse DCT to B* to produce LL_HH*.
9. Apply inverse DWT to LL_LL, LL_HL, LL_LH and LL_HH* to get matrix LL*.
10. Apply inverse DWT to LL*, HL, LH and HH, set it to selected color channel to get watermarked image WI.

B. Watermark Extraction Process

The extraction process is divided into following steps and is briefly described as given below:

1. Select color channel and apply DWT to WI to get LL*, HL, LH and HH.
2. Apply DWT to WI to get LL_LL, LL_HL, LL_LH and LL_HH*
3. Select LL_HH* band and divide it into 4X4 square blocks.
4. Apply DCT to each block of sub band LL_HH*, select first dct values and get matrix A.
5. Apply SVD to A, $A= WU*WS*WV^T$ and obtain WU,WS,WV
6. Obtain $SW=(S-WS)/\alpha$.
7. Obtain $EW= W_U*SW*W_V^T$

IV. PROPOSED ALGORITHM II

In this algorithm first level decomposition of wavelet is applied to cover image then LL band is selected for second level decomposition and its HH band is selected. Now DCT is applied to this band and get DCT coefficient matrix. SVD is performed on this DCT coefficient matrix. Watermark image is decomposed at first level and HH band is selected. DCT is applied to this HH band and we get DCT coefficients of watermark then SVD is applied to it. Singular values of cover image DCT coefficients is modified with singular

values of watermark. Perform inverse transform and we get watermark image.

A. *Watermark embedding process*

The embedding process is divided into following steps and is briefly described as given below:

1. Let OI be the Original color image of size N x N.
2. Select Color Component any one among R,G,B(1,2,3). Suppose for Red color select (:,:,1) from original image.
3. Apply DWT to decompose it into four N/2 x N/2 sub-bands LL , HL , LH and HH .
4. Select LL band and Apply DWT to decompose it into four N/4 x N/4 sub-bands LL_LL , LL_HL , LL_LH and LL_HH .
5. Select LL_HH band and apply DCT to it and get DCT coefficient matrix B.
6. Apply SVD to B, B=U*S*VT, and obtain U, S and V.
7. Let OW of size N/2 x N/2 to represent watermark. Apply DWT to decompose it into four N/4 x N/4 sub-bands WLL , WHL , WLH and WHH .
8. Select WHH band and apply DCT to it and get DCT coefficient matrix D.
9. Apply SVD to D, D=U1*S1*V1T, and obtain U1, S1 and V1.
10. Modify S with watermark such that S2=S + α* S1.
11. Obtain B* using B*= U*S2*VT.
12. Apply inverse DCT to B* to produce LL_HH*.
13. Apply inverse DWT to LL_LL, LL_HL, LL_LH and LL_HH* to get LL*.
14. Apply inverse DWT to LL*, HL, LH and HH to get watermarked image colorname_WI for selected color component.
15. Set value of that component to Original color image.
16. Get color watermarked image WI.

B. *Watermark Extraction Process*

The extraction process is divided into following steps and is briefly described as given below:

1. Selected watermarked image color component.
2. Apply DWT to WI to get LL*, HL, LH and HH.
3. Apply DWT to WI to get LL_LL, LL_HL, LL_LH and LL_HH *
4. Select LL_HH* band and Apply DCT to sub band HH* and get matrix A.
5. Apply SVD to A, A= WU*WS*WVT and obtain WU,WS,WV
6. Obtain Sr=(S-WS) /α.
7. Obtain Wr= U1*Sr*V1T
8. Apply inverse DCT to Wr and get W.
9. Apply inverse DWT to LL, HL, LH and W and get extracted watermark EW.

V. EVALUATION PARAMETERS

The PSNR and NCC are used as evaluation parameter.

Peak Signal to Noise Ratio (PSNR), is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation.

Let A is the original image & B is the watermarked image of size m x n then MSE(Mean Square Error) & PSNR will be

$$MSE = \frac{1}{MN}\left(\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(|A-B|)\right)^2 \quad (1)$$

$$PSNR = 10.\log_{10}\left(MAX^2 A / MSE\right) \quad (2)$$

Normalized Cross Correlation is calculated to evaluate the robustness of algorithm. NCC is defined as follows where OW is original watermark and EW is Extracted watermark

$$NC = \left(\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} OW * EW\right) / \left(\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} OW * OW\right) \quad (3)$$

VI. EXPERIMENT RESULTS

To check the efficiency of proposed algorithm different size of images are considered for numerical simulation. It is tested using the tool MATLAB 7.8.0. Here results are given using 512 x 512 color image "LENA","PEPPER","MANDRIL","KIDS" and HUNNAR" as cover image and 32 x 32 color football as watermark in algorithm one and 256x256 color lena and hunnar as watermark in second algorithm.

Fig. 1. Image Database

Fig. 2. Original color image, watermark, watermarked image and extracted watermark for algorithm I.

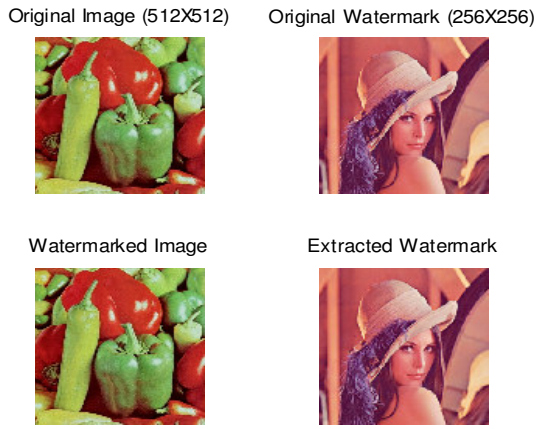

Fig. 3. Original color image, watermark, watermarked image and extracted watermark for algorithm II.

PSNR and NCC value and elapsed time for proposed algorithm I and II are shown in Table 1 and Table 2 respectively.

Table 3 and Table 4 shows results of proposed algorithm I and II respectively after various attacks on watermarked image.

TABLE 1:
Result of existing DWT+DCT+SVD based scheme.

	Results of some existing DWT+DCT+SVD based method		
	Ben Wang[1]	***S S Bedi[4]***	***S. Murty[9]***
Without attack	0.9473		
Jpeg	0.9439	9887	0.9982
Cropping	0.8286	0.842	0.999
Rotation	0.8819	0.518	0.9597
Gaussian noise	0.9502		0.9628
Low pass filter	0.9335	0.8849	
Contrast adjustment	0.9666		0.9869
Gamma Correction (less than 1-for brighter)			0.9998
Salt n Pepper	0.9312		
Sharpened			0.8297

TABLE 2:
Result of proposed algorithm Iwith NCC values for different attacks ,PSNR and elapsed time for watermark embedding.

Result of Algorithm I	**Image database**				
	lena	***Pepper***	***mandril***	***kids***	***hunnar***
Elapsed Time	1.5132	1.248	1.2636	1.2792	1.2948
PSNR	53.3126	53.1406	53.3126	53.3126	53.3126
NCC without attack	1	1	1	1	1
	NCC	NCC	NCC	NCC	NCC
JPEG 50%	0.2915	0.6272	0.2609	0.6748	0.391
Crop	0.9756	0.596	0.9101	0.8383	0.9682
Rotation 45	0.9168	0.58	0.0962	0.0395	0.2442
Gaussian noise	0.9481	0.987	0.9673	0.9546	0.9216
Low Pass filter 3x3	-3.621	-1.0942	-6.6589	-8.5204	0.0651
Contrast Adjust	1	1	1	1	1
Gamma Correction 0.8	0.9417	0.9932	0.9424	0.9934	0.9734
Gamma Correction 1.2	0.8836	0.9191	0.9569	0.9752	0.9538
Salt n Pepper	0.859	0.9467	0.8298	0.8328	0.8075
Sharpen	0.1701	0.1128	0.1861	0.192	0.2229

TABLE 3:
Result of proposed algorithm II with NCC values for different attacks ,PSNR and elapsed time for watermark embedding.

Result of Algorithm II	**Image database**				
	lena	***pepper***	***mandril***	***kids***	***hunnar***

Elapsed Time	0.7176	0.9048	0.7644	0.702	0.9984
PSNR	50.8039	50.4547	50.2827	50.4547	50.4547
NCC without attack	0.9994	0.9991	0.9991	0.9991	0.9991
	NCC	NCC	NCC	NCC	NCC
JPEG 20%	0.9995	0.9995	0.9997	0.9994	0.9992
Crop	0.9994	0.9992	0.9995	0.9991	0.9991
Rotation 45	0.9991	0.9988	0.9995	0.9988	0.9983
Gaussian noise	0.9895	0.985	0.9878	0.9847	0.9849
Low Pass filter 3x3	0.9999	1	0.9981	1	0.9998
Contrast Adjust	0.9994	0.9991	0.9991	0.9991	0.9991
Gamma Correction 0.8	0.9994	0.999	0.9993	0.9991	0.9994
Gamma Correction 1.2	0.9993	0.9991	0.999	0.9991	0.999
Salt n Pepper	0.9961	0.994	0.9961	0.9939	0.9818
Sharpen	0.9963	0.9952	0.9879	0.9956	0.9963

VII. CONCLUSIONS

As per experimental results, proposed algorithm I gives NCC value 1 for no attack. PSNR values for all five images are higher in algorithm I than algorithm II. So imperceptibility in algorithm I is better than algorithm II. Various attacks are performed and experiment result shows that robustness of algorithm II is higher than algorithm I.

Algorithm II gives best results in comparison with existing techniques results.

Algorithm I is not robust again jpeg as we embed watermark in DC values of HH band of LL band after second level decomposition. Also for low pass filter this method does not give good results.

Algorithm II gives quiet better results in all listed attacks. It gives good NCC value for jpeg up to 20% quality factor.

In both algorithm extraction of watermark is done using original cover image so both are non blind scheme.

in future we will try to develop algorithm which do not depends on original cover image at the time of extraction using DCT+DWT+SVD.

VIII. ACKNOWLEDGMENTS

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VIIII. REFERENCES

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