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Hybrid color image watermarking using Multi Frequency Band

C.N. Sujatha, P. Satyanarayana

Abstract— In this paper we suggest a non blind watermarking technique in Discrete Wavelet Transform domain (DWT) based on Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD). In this method, the watermark data can be embedded in singular values of DCT coefficients of middle and high frequency subbands LH, HL, HH in DWT domain. And the watermark can be extracted by performing the inversion of embedding process. This watermarking technique is pertinent in broadcasting. Moreover it is secure in terms of integrity, authentication and robust. Experimental results show that the proposed method gives the watermarked image of better quality and its robustness by means of performance parameters Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Correlation Factor (CF). Recommended technique investigated on various image formats. Also, robustness of proposed algorithm is tested for assorted attacks like Gaussian noise, Salt & Pepper noise, Speckle noise, Median filtering, image sharpening, cropping, rotation and histogram equalization. PSNR value for an acceptable degradation level was regulated to be a greater than 25 dB. The maximum PSNR and CF values computed from the projected method are 67.0551 and 0.9894. The values attained in this method are compared with the values of DWT–SVD technique.

Index Terms—Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), Singular Value Decomposition (SVD), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Correlation Factor (CF)

1 INTRODUCTION

Nowadays, the drastic increase in the digital data such as multimedia services in the internet, the data can be accessed by using computer networks. So there is a need to protect the unauthorized distribution of data. As a solution digital watermarking technique has been proposed for copyright protection of multimedia data [1]. The watermarking technique describe that the embedded watermark does not distort the original image perception and should be invisible. The watermark also should be robust to image processing distortions such that it is difficult for the attacker to remove watermark.

So far various watermarking techniques have been proposed [2]. Some of these techniques embed the data in the spatial domain directly by modifying the pixel values of host image which are not strong to several image processing operations. Recent literature studies proposed transform domain watermarking techniques. based on SVD [3], DCT [4] and DWT [5, 6] which are more robust to image manipulations.

All the watermark embedding and extraction processes are performed in frequency domain. But the problems in frequency domain method are the ambiguity in selecting the coefficients to embed the watermark viz. embedding the watermark in low frequency coefficients of DCT could cause image distortions i.e. geometrical modifications, weakness to noise [7]. Wavelet based watermarking techniques have multi resolution property where high and middle frequency subbands include the edges and texture of the image and low frequency subband contains the important image data. As human eye is generally not very sensitive to high and middle frequency bands, such bands are chosen to embed the watermark without being perceived by human eye [8, 9]. And to have more stability, singular values of image in SVD domain are used for embedding watermark. The singular values of an image represent the intrinsic algebraic image properties and have good stability even when a small perturbation is added to an image.

In this paper we focused on non- blind color image watermarking based on hybrid technique using DWT, DCT and SVD transformations [10]. With the knowledge of advantages of DWT, DCT and SVD, we proposed a method to embed the singular values of DCT coefficients of middle and high frequency subbands of host image with that of watermark image. In this method, the original image data is required to extract the watermark.

- *Mrs. C. N. Sujatha, Associate Professor, ECE Departmet, SNIST, Hyderabad, Telangana, E-mail: cnsujatha@gmail.com*
- *Dr. P. Satyanarayana, Professor, ECE Department, AITS, Tirupati, Andhra Pradesh, India , E-mail: satyamp1@yahoo.com*

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The outline of the paper is the following. In section 2 the process of watermark embedding and detection method in hybrid domain is discussed . In section 3 we discuss the experimental results and in section 4 conclusion and future extensions of the proposed technique are presented.

2 WATERMARK EMBEDDING AND DETECTION

Let the host image as color image of size N x N and the watermark image can be either gray or color image of same size. The host image is first decomposed into four subbands: low frequency band LL, high frequency band HH, low high frequency band LH, high low frequency band HL using Daubechies wavelet. Among these, LH, HL and HH subbands are suitable for watermark embedding, as embedding watermark in LL subband causes the degradation of image quality. Here DWT can be applied on three middle and high frequency subbands plane wise. Then DCT coefficients are obtained by applying DCT on three subband DWT coefficients of R, G, B planes to have excellent energy compaction and decorrelation. Now SVD is applied to three DCT coefficient matrices in each plane to find three sets of singular value matrices (S1, S2 and S3). They are then modified with the scaled singular value matrices (SW1, SW2 and SW3) of DCT coefficients of DWT subband coefficients at chosen scaling factor using the following equations

for i = 1 to 3 planes

$$MS1 = S1 + \alpha * SW1 \quad (1)$$

$$MS2 = S2 + \alpha * SW2 \quad (2)$$

$$MS3 = S3 + \alpha * SW3 \quad (3)$$

end

Where α is a scaling factor used to define the strength of watermark

Finally inverse SVD, inverse DCT and inverse DWT are performed on all coefficients in R, G and B planes to obtain watermarked image. The flowchart for the watermark embedding process is shown in figure 1.Watermarked image is decomposed into four subbands using DWT for R, G and B planes. Apply DCT to selected subbands LH, HL and HH and SVD is applied to DCT coefficients of 3 planes to get modified singular value matrices for three bands of 3 planes.

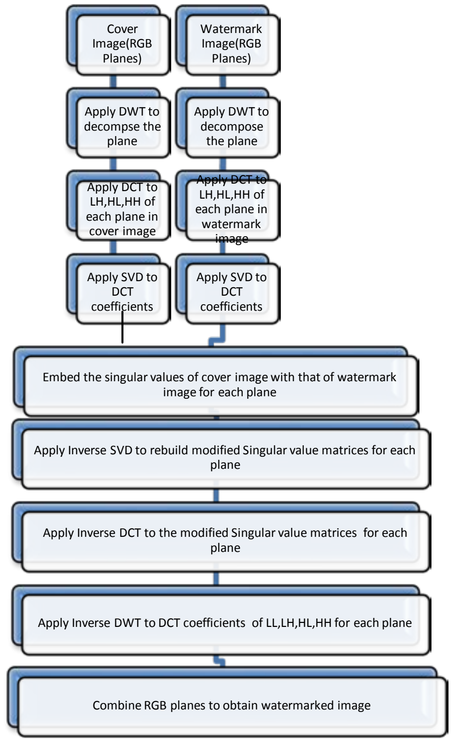

Fig 1. Flowchart for watermark embedding

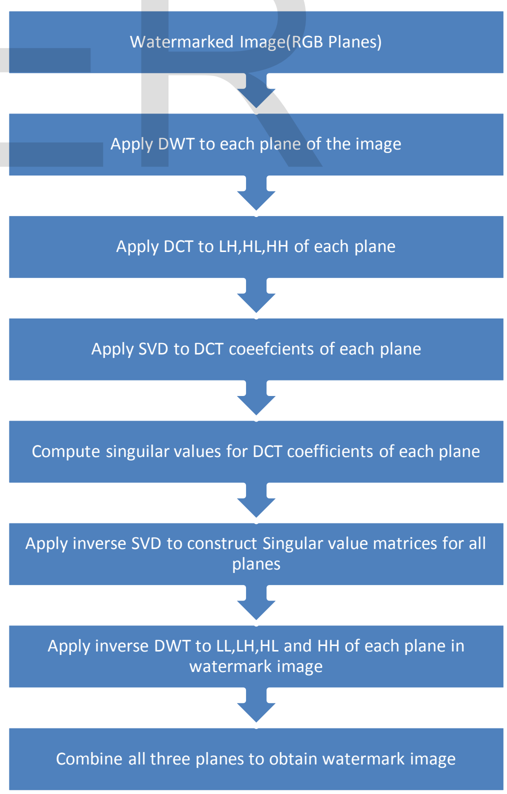

Fig 2. Flowchart for watermark extraction

Singular values of watermark are retrieved by using the following equations

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for i = 1 to 3 planes

SW1= (MS1 – S1) / α (4)

SW2= (MS2 – S2) / α (5)

SW3= (MS3 – S3) / α (6)

end

SVD matrix is constructed by applying inverse SVD on the retrieved singular values and inverse DCT and inverse DWT are applied on three matrices of 3 planes to get the watermark image. The flowchart of the watermark extraction is shown in figure 2.

3 EXPERIMENTAL RESULTS

The proposed watermarking technique is simulated by using MATLAB with AMD dual core processor 2.4 GHz and 4GB RAM. The proposed DWT-DCT-SVD method discussed in the previous sections and DWT-SVD technique are applied on different formats of test images (color images). Five images peppers.png, balloons.jpg, lena.bmp, autumn.tif, sunset.jpg are chosen as test images and SNIST AND SVU logos as watermark images. Figure 3 shows the insertion of SNIST logo into host image Peppers and Figure 4 shows the embedding of SVU logo as watermark in Autumn image.

Fig 3. Peppers image embedded with SNIST logo

In order to evaluate the proposed method, we first investigate the relation between host and watermarked images by calculating MSE and PSNR with respect to scaling factor which is shown in Table 1.

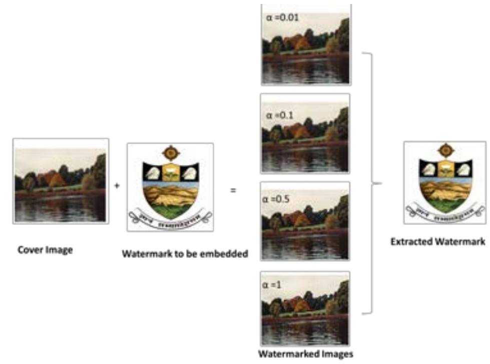

Fig 4. Autumn image embedded with SVU logo

The CF shows the similarity between original and extracted logo image. The comparison of results obtained by the proposed method with DWT-SVD technique by inserting the same watermark is shown in Table 2. Table 3 shows the correlation factors for various watermark images and Table 4 presents performance metrics after applying attacks on watermarked image.

Table 1: MSE and PSNR values for various images

Host image	Scaling Factor	Watermark image			
		SNIST logo		SVU logo	
		MSE	PSNR	MSE	PSNR
Peppers	0.01	0.0214	64.8281	0.0141	66.6472
	0.05	0.3069	53.2608	0.1751	55.6990
	0.1	1.0145	48.0682	0.5985	50.3604
	0.5	5.9239	40.4047	4.7998	41.3186
	1.0	9.8757	38.1851	8.5157	38.8286
Balloons	0.01	0.0287	63.5530	0.0205	65.0188
	0.05	0.3695	52.4548	0.1949	55.2331
	0.1	1.1923	47.3670	0.6775	49.8217
	0.5	9.1190	38.5313	7.5354	39.3597
	1.0	7.3171	35.7461	15.7991	36.1445
Sunset	0.01	0.0271	63.8058	0.0183	65.5135
	0.05	0.3624	52.5393	0.1913	55.3144
	0.1	1.1419	47.5546	0.6584	49.9460
	0.5	7.8930	39.1584	6.5037	39.9992
	1.0	14.1882	36.6115	12.8315	37.0480
Lena	0.01	0.0294	63.4503	0.0186	65.4399
	0.05	0.3778	52.3585	0.1937	55.2586
	0.1	1.3491	46.8304	0.6948	49.7123
	0.5	10.6825	37.8441	6.7697	39.8251
	1.0	18.1157	35.5503	12.8682	37.0356
Autumn	0.01	0.0165	65.9654	0.0128	67.0551
	0.05	0.2581	54.0125	0.1694	55.8425
	0.1	0.8349	48.9147	0.6230	50.1856
	0.5	5.2912	40.8952	5.0381	41.1081
	1.0	7.9017	39.1536	7.8155	39.2012

Table 2: Comparison of DWT-SVD and DWT-DCT-SVD

Host image	Scaling factor	Watermake image (SNIST logo)			
		DWT-DCT-SVD		DWT-SVD	
		MSE	PSNR	MSE	PSNR
Peppers	0.01	0.0214	64.8281	0.1097	57.7293
	0.05	0.3069	53.2608	0.9221	48.4831
	0.1	1.0145	48.0682	1.8155	45.5408
	0.5	5.9239	40.4047	5.0941	41.0601
	1.0	9.8757	38.1851	6.2729	40.1561
Balloon	0.01	0.0287	63.5530	0.1586	56.1282
	0.05	0.3695	52.4548	2.1232	44.8608
	0.1	1.1923	47.3670	4.5513	41.5494
	0.5	9.1190	38.5313	10.9652	37.7306
	1.0	17.3171	35.7461	12.4881	37.1658
Sunset	0.01	0.0271	63.8058	0.1500	56.3707
	0.05	0.3624	52.5393	1.7653	45.6625
	0.1	1.1419	47.5546	3.7821	42.3535
	0.5	7.8930	39.1584	10.6495	37.8575
	1.0	14.1882	36.6115	12.3519	37.2135
Lena	0.01	0.0294	63.4503	0.1589	56.1184
	0.05	0.3778	52.3585	1.8017	45.5740
	0.1	1.3491	46.8304	3.5505	42.6279
	0.5	10.6825	37.8441	8.9300	38.6223
	1.0	18.1157	35.5503	10.8436	37.7791
Autumn	0.01	0.0165	65.9654	0.0909	58.5457
	0.05	0.2581	54.0125	0.7736	49.2458
	0.1	0.8349	48.9147	1.3688	46.7673
	0.5	5.2912	40.8952	3.2872	42.962
	1.0	7.9017	39.1536	4.0283	42.0796

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Table 3: Correlation factor for different watermarks in Lena image with α =0.01

Watermark image	MSE	PSNR	CF
SNIST	0.0294	63.4503	0.9488
SVU	0.0186	65.4399	0.9724
JNTU	0.0100	68.1177	.9894
MAHAL	0.0112	67.6354	0.9610
SBU	0.0135	66.8164	0.9688

Table 4: Results of Attacks on watermarked image (α =0.01)

Attacks	Parameters		
	MSE	PSNR	CF
Gaussian Attack	19.9389	35.1338	0.5956
Salt & Pepper noise	1.0195	48.0468	0.6757
Speckle noise	11.5468	37.5062	0.5883
Median filtering	0.9682	48.2710	0.6639
Sharpening	0.4248	51.8493	0.6738
Cropping	20.1687	35.0840	0.6078
Rotation	20.3212	35.0513	0.5741
Histogram equalization	0.4186	51.9131	0.6326

4 Conclusion

This paper presents a hybrid color image watermarking using DWT-DCT-SVD transforms to embed either gray or color image into middle and high frequency bands of host image. The proposed technique can embed the maximum amount of watermark while the watermark is imperceptible. PSNR values are computed to find out the imperceptibility between host and watermarked color images. From the experimental results, we proved that the proposed algorithm achieved the two desirable characteristics imperceptibility and robustness and the PSNR values of DWT-DCT-SVD based method are improved than that of DWT-SVD method. We can extend the proposed method to videos in future.

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