ISSN:0975-9646

A Hybrid DCT and DWT Color Image Watermarking in RGB Color Space

Jaya Jeswani[1], Tanuja Sarode[2]

[1] *Department of Information Technology, Xavier Institute of Engineering,*

[2]*Department of Computer Engineering,, Thadomal Shahani Engineering College*

***Abstract*- This paper presents a hybrid blind watermarking technique for color images based on DCT in wavelet transform. Advantages of two powerful transforms namely DCT and DWT are combined. Carrier image is first decomposed into 3 channels, namely R, G, B. Harr DWT is applied to Blue channel and HH band is selected for watermark insertion. HH band is divided into blocks of size 8×8. DCT is applied to each 8×8 sized block. Finally binary watermark bits are inserted into middle frequency coefficients by adjusting coefficients DCT(4,3) and DCT(5,2). Simulation results shows that the proposed technique is imperceptible as well as robust against wide variety of attacks like noise attacks and filtering attacks etc. It achieves PSNR as 66.26 dB and recovers watermark completely with NC value as 1. Results are compared with DCT watermarking algorithm, it is proved that hybrid watermarking results are better than implementing a single algorithm alone.**

Keywords —DCT (Discrete Cosine Transform), DWT(Discrete Wavelet Transform), MSE (Mean Square Error), PSNR (Peak Signal to Noise), Gaussian noise

1. INTRODUCTION

Nowadays thousands of images are being uploaded to the internet and are shared every day. Therefore copyright management on the internet becomes a complicated process. Copyright infringement occurs when someone other than the copyright holder copies the "expression" of a work. This invites need for digital watermarking. Watermarking [1-6] can be used for copyright protection. Many watermarking algorithms have been proposed some author's inserts watermark bits by directly modifying pixels of carrier image this type of watermarking is knows as spatial domain watermarking [7]. Some author's inserts watermark bits into frequency bands and this type of watermarking is known as frequency domain watermarking [8, 9, 10, 11, 12, 13, 14, 15, 16]. So in this research paper a hybrid watermarking technique is introduced. It combines two popular frequency domain transforms namely DCT [8, 9] and DWT. Harr DWT is applied to B channel and H band is selected for watermark insertion. Finally watermark is inserted by adjusting middle frequency coefficients DCT(4,3) and DCT(5,2). The results of proposed watermarking techniques are compared against results of DCT [5] and it proves that results of hybrid technique using DCT and DWT is more robust as well as imperceptible as compared to results of DCT.

The organization of the paper is given as follows: Section 1 presents introduction. Section. Section 2 depicts preliminaries used. Section 3 shows proposed algorithm with coefficients selection, watermark embedding and extraction algorithms. Experimental results are given in section 4. Finally conclusion of proposed algorithm is given in section 5.

2. PRELIMINARIES

A. The Discrete Cosine Transform

DCT is a popular frequency domain watermarking technique. Fig. 1 shows DCT Regions, F_L is used to denote the lowest frequency components of the block, F_M is used to denote the middle frequency components, F_H is used to denote the higher frequency components.

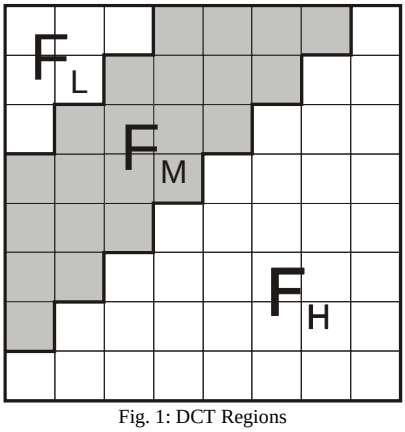


Fig. 1: DCT Regions

The definition of 2-D DCT can be given as follows:

$$c(u,v) = \alpha(u)\alpha(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (1)$$

For u, v = 0, l, 2,..., N-1

The definition of 2-D inverse DCT can be written as follows,

$$f(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v)C(u,v)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (2)$$

For x, y = 0, 1, 2,..., N-1

$$\alpha(u), \alpha(v) = \begin{cases} \sqrt{1/N} & \text{for u ,v=0} \\ \sqrt{2/N} & \text{for u, v=1, 2,....., N-1} \end{cases} \quad (3)$$

B. Discrete Wavelet Transform

DWT divides an image into 4 multi-resolution sub-bands. At level 1, DWT decomposes image into four non-overlapping sub-bands: LL1 (Approximate sub band), HL1(Horizontal sub band),LH1 (Vertical sub band) and HH1(Diagonal Sub band). Here, LL1 is low frequency component whereas HL1, LH1 and HH1 are high frequency (detail) components [11] [12] [13]. Embedding watermark in low frequency coefficients can increase robustness significantly but maximum energy of most of the natural images is concentrated in approximate (LL) sub-band. Hence modification in this low frequency sub band will cause severe and unacceptable image degradation. Hence watermark is not embedded in LL sub band. The good areas for watermark embedding are high frequency sub bands (HL, LH and HH), because human naked eyes are not sensitive to these sub bands. Thus we have selected HH1 band to embed watermark.

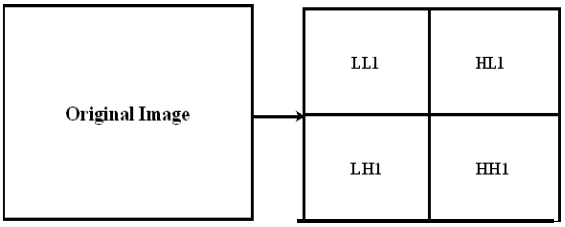


Fig. 2: 1 Level DWT

3. THE PROPOSED METHOD

In the paper a hybrid technique using DCT and DWT is proposed. Color cover image is divided into three channels R, G and B. B channel is selected for watermark insertion and harr DWT is applied on it. HH band is divided into 8×8 blocks then DCT is applied on each block. Watermark bits are inserted into 8×8 sized DCT blocks. Subsection A describes Coefficient Selection, Section B describes watermark insertion process and section C describes watermark extraction process.

A. Coefficient Selection

For watermark insertion DCT (4,3) and DCT(5,2) are selected. As DCT(4,3) and DCT(5,2) are middle frequency components and in JPEG quantization table having value as 22. The coefficients selection depends on JPEG quantization table given below in table 1.

Table 1: Quantization values in JPEG compression Scheme

16	11	10	26	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	**22**	29	51	87	80	62
18	**22**	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

B. Watermark Insertion Algorithm

Inputs: Color cover image and binary watermark image

Outputs: Watermarked color image

The steps are as follows:

1. Take cover image N×N and watermark image of size n×n as an input. Decompose the image into 3 color channels: red, green and blue.
2. Select blue channel and apply harr DWT
3. Select HH band and divide the image into 8× 8 sized blocks.
4. Determine maximum watermark size based on cover image and block size by :
   $\text{max\_watermark\_size} = N \times N / \text{block size}^2$
5. Check that the watermark isn't too large for cover image.
6. Pad the watermark out to the maximum watermark size with ones.
7. Transform block using DCT.
8. Embeds watermark bit=0 when DCT (5,2) is greater than or equal to DCT(4,3) and embeds watermark bit=1. when DCT (5,2) is less than DCT (4,3).
9. If watermark bit=0, then DCT(5, 2) should be greater than or equals to DCT(4, 3) and if DCT(5, 2) less than DCT(4, 3) then we need to swap them.
10. If watermark bit=1, then DCT(5, 2) should be less than DCT (4, 3) and if DCT (5, 2) greater DCT (4, 3) then we need to swap them.
11. Adjust the two values such that their difference = k, process, which is known as minimum coefficient difference of DCT blocks.
12. Transform block back into spatial domain by IDCT which gives us watermarked image

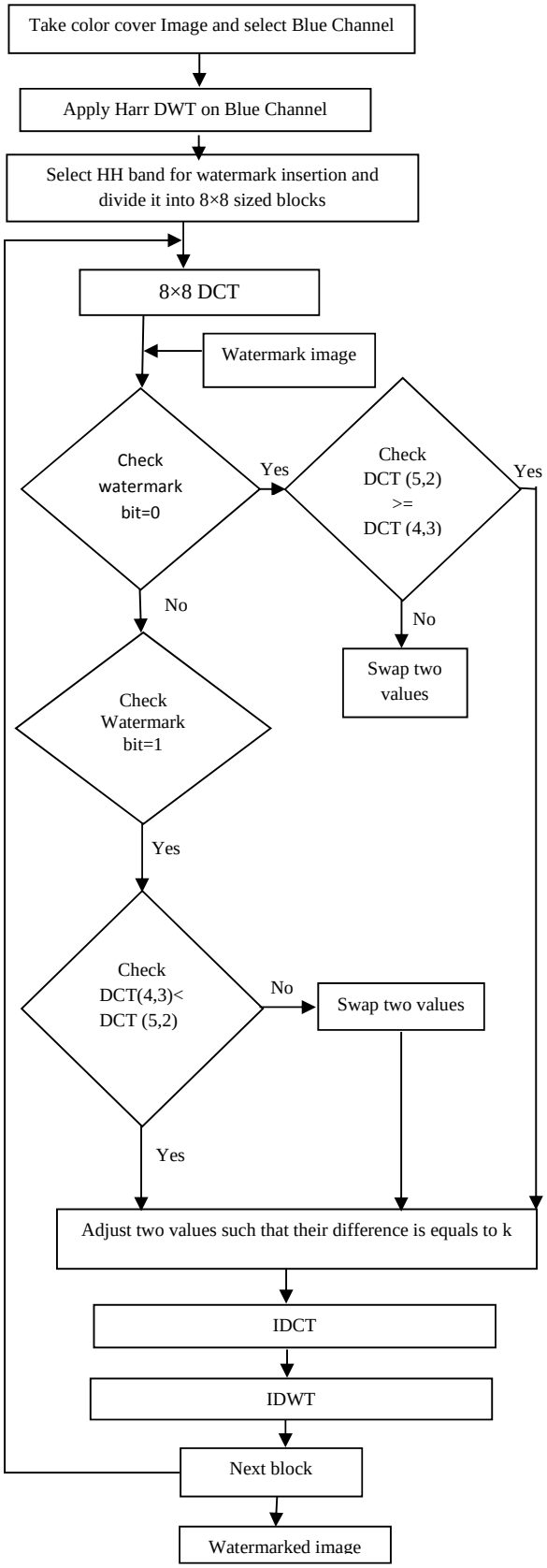


Fig. 3: Flow chart of Watermark Insertion Algorithm

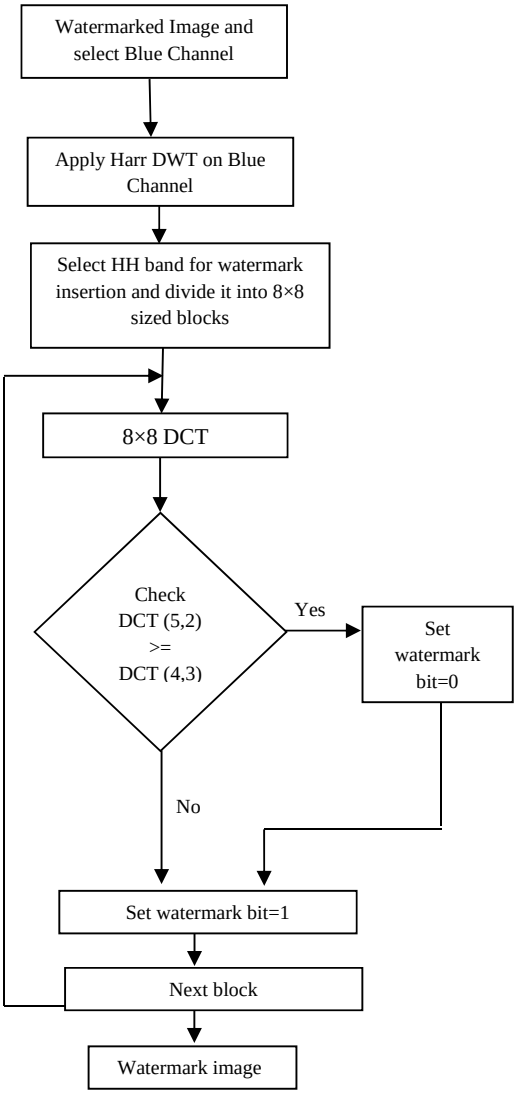


Fig. 4: Flow chart of Watermark Extraction Algorithm

C. Watermark Extracting Algorithm

Input: Watermarked image
Output: Binary watermark image
The steps are as follows:

1. Take watermarked image of size N×N as an input. Decompose the image into 3 color channels: red, green and blue.
2. Select Blue channel and apply harr DWT.
3. Select HH band and divide it into 8× 8 sized blocks.
4. Apply DCT on each 8× 8 sized blocks.
5. If coefficient at DCT (5, 2) is greater than or equals to coefficient at DCT(4, 3), make watermark bit=0 else watermark bit=1.
6. Reshape the recovered watermark image into n×n.

Fig. 4, Fig. 5 gives flow charts of watermark insertion and extraction process respectively.

4. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed technique is tested on different images namely Leaf, Candle, Animal, Waterlili, Titanic, Peppers, Hibiscus of size (512×512) and W.bmp as watermark of size (32×32). For evaluating the performance of proposed technique we have used Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Normalized correlation (NC).

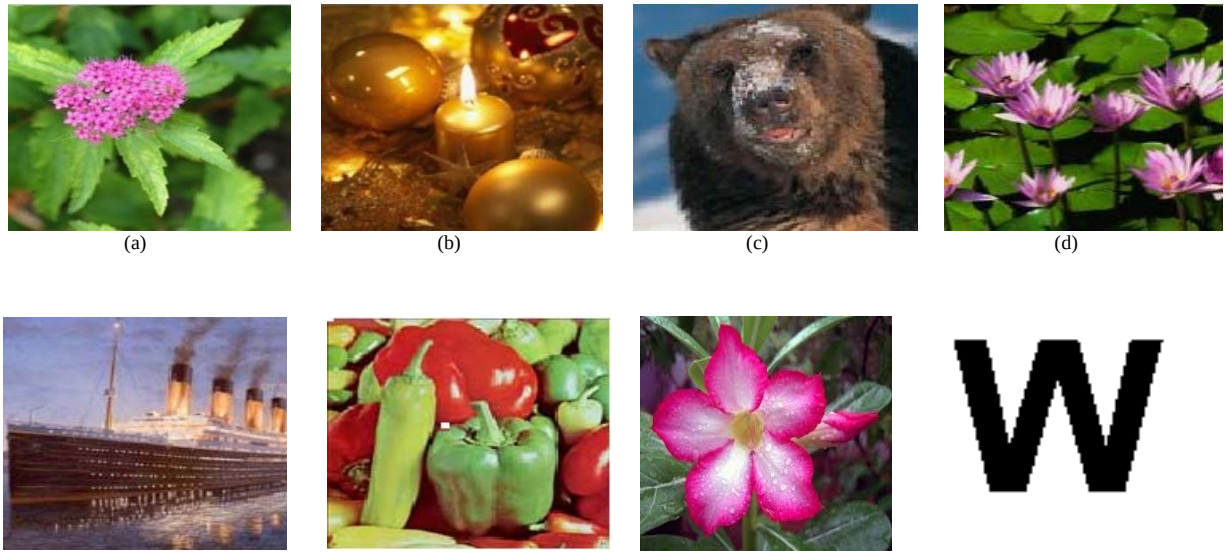
$$\mathbf{MSE}=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[I(i,j)-I'(i,j)]^2 \quad (5)$$

$$\mathbf{PSNR} = 10\,log_{10}\left(\frac{255^2}{MSE}\right) \quad (6)$$

Where, M, N = size of the original image,
I(i, j) = pixel values at location (i, j) of the original image,
I'(i, j) = pixel values at location (i, j) of watermarked image

$$\mathbf{NC}=\frac{\sum_i\sum_j w(i,j)w'(i,j)}{\sum_i\sum_j w(i,j)^2} \quad (7)$$

W(i,j) = pixel values at location (i, j) of the original watermark,
W'(i,j) =pixel values at location (i, j) of the extracted watermark



(a) (b) (c) (d)

(e) (f) (g) (h)

Fig. 5: Cover Images (a) Leaf (b) Candle (c) Animal (d) Waterlili (e) Titanic (f) Peppers (g) Hibiscus (h) W (Binary watermark)

Original Image (512×512) | Binary Watermark (32×32) | Watermarked Image (512×512)

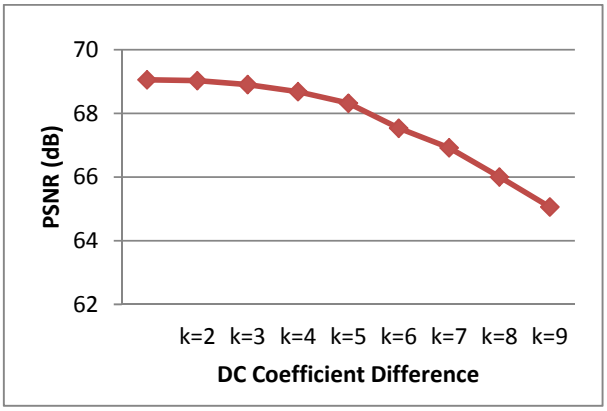
Fig. 6 Watermark Insertion Process

Watermarked Image (512×512) | Recovered Watermark (32×32)

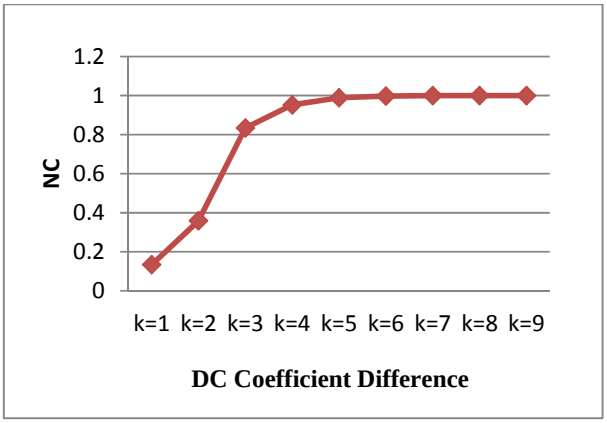
Fig. 7: Watermark Extraction ProcessTable 2. PSNR and NC values of watermark embedding and extraction on leaf image at different values of k

DC Coefficient Difference k	PSNR	MSE	NC
1	69.0549	0.00814692	0.134068
2	69.0272	0.00819906	0.359065
3	68.9037	0.00843557	0.834003
4	68.681	0.00887934	0.952299
5	68.3184	0.00965246	0.988766
6	67.5334	0.0115649	0.997178
7	**66.9199**	**0.0133197**	**1**
8	66.0021	0.0164541	1
9	65.058	0.0204493	1

Table 2



(a)



(b)

Fig.8: (a) Peak Signal to Noise Ratio Chart at different values of k (b) Mean Square Error chart at different values of k

Fig.5 above shows various jpeg cover images namely Leaf, Candle, Animal, Waterlili, Titanic, Peppers, Hibiscus of size (512×512) and W.bmp as watermark of size (32×32). Fig. 6 and Fig. 7 shows watermark insertion and extraction process on leaf image. In the proposed hybrid technique k is a secrete key for watermark insertion and is DC coefficient difference between DCT (5,2) and DCT (4,3) and is known as DC coefficient difference for watermark insertion. Different values of k are tried on leaf cover image. Table 2 shows PSNR and NC value of leaf image at different values of k, different values of k are in the range from 1 to 9. From Table 2 it can be seen that the as the value of k increases value of PSNR decreases and value of NC increases up to certain value of k and after reaching that value NC value remains constant. Fig. 8 shows PSNR and NC chart of leaf cover image at different values of k. Value of k selected for leaf image is 7 as it gives optimal results. When PSNR is higher than 30, it is considered that watermarked image has a very good quality. The extracted watermark is considered as valid one. Table 3 shows that the average PSNR achieved is 66.26 dB and NC value without applying of any attack achieved is 1.

Table 4 shows experimental results of common image processing attacks like noise, filtering attacks etc. From table 4 it can be seen that in almost all the attacks PSNR achieved is higher than 30. Table 5 shows results of different watermarking attacks on all test cover images. Table 6 below shows comparison of proposed method with DCT [5]. Thus a hybrid method is proposed using DCT and DWT. From table it can been seen that average PSNR of DCT watermarking is 58.90dB and that of DCT and DWT is 66.26 dB. Thus, proposed hybrid technique is more imperceptible and robust against variety of noise and filtering attacks like Gaussian filter and median filter attacks.

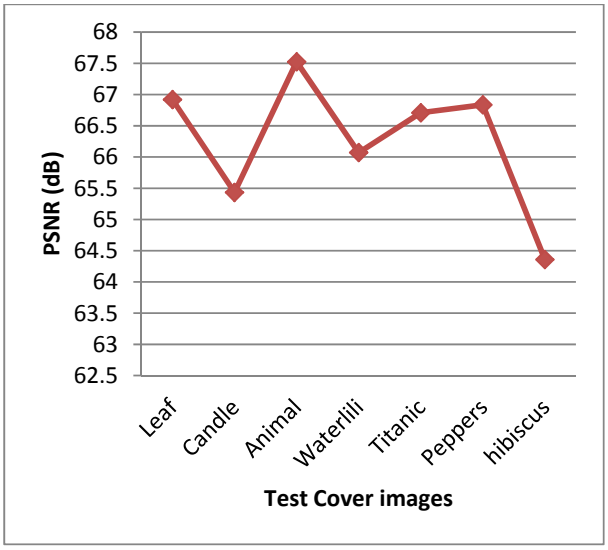


Fig.9: Peak Signal to Noise Ratio Chart of different test cover images

Table 3. PSNR and NC values of watermark insertion and extraction

Sr.No	Image	PSNR	MSE	NC
1	Leaf	66.9199	0.013319	1
2	Candle	65.4326	0.018759	1
3	Animal	67.5234	0.011591	1
4	Waterlili	66.0711	0.016194	1
5	Titanic	66.7079	0.013986	1
6	Peppers	66.8357	0.013580	1
7	Hibiscus	64.3577	0.0240275	1

Table 4. Results of common attacks on leaf image

Attacks	Performance Evaluators	Leaf	Candle	Animal	Waterlili	Titanic	Peppers	Hibiscus
Gaussian Noise (0.0001)	PSNR (dB)	43.0578	43.0526	43.0082	43.312	43.0467	43.1547	43.3004
	NC	0.607975	0.607975	0.624523	0.597428	0.589452	0.580425	0.57879
Salt-pepper (0.005)	PSNR (dB)	56.6195	57.0994	56.7046	57.5703	56.7088	57.1745	57.4252
	NC	0.796619	0.776785	0.743133	0.793383	0.781707	0.769738	0.813346
Speckle Noise (0.0004)	PSNR (dB)	43.3548	44.3896	45.9035	45.3441	42.7921	42.8093	47.4609
	NC	0.718563	0.541447	0.786804	0.769625	0.564088	0.544774	0.84618
Gaussian Filter (3×3)	PSNR (dB)	47.7264	45.6799	48.3454	50.0024	46.5644	45.4065	46.4161
	NC	0.980225	0.939254	0.96081	0.920965	0.941067	0.94744	0.963531
Median Filter (3×3)	PSNR (dB)	47.8213	45.2774	49.6825	48.9512	47.2822	49.0297	48.2049
	NC	0.544082	0.385303	0.539343	0.606798	0.449382	0.595967	0.414803

Table 5. Results of attacks on all considered cover images

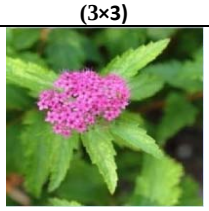
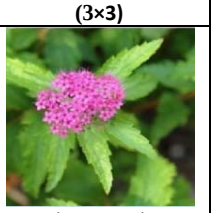
Attacks	Gaussian Noise (0.0001)	Salt-Pepper Noise(0.005)	Speckle Noise (0.0004)	Gaussian Filter (3×3)	Median Filter (3×3)
Attacked images	 (512×512)	 (512×512)	 (512×512)	 (512×512)	 (512×512)
PSNR(dB)	43.0578	56.6195	43.3548	47.7264	47.8213
Extracted Watermark	 (32×32)	 (32×32)	 (32×32)	 (32×32)	 (32×32)
NC	0.606146	0.796619	0.718563	0.980225	0.544082

Table 6: Results of video watermarking on different test videos

Method	Domain	PSNR(dB)	Color Image	Watermark
Proposed Method	DCT and DWT	66.26(dB)	512	32×32
Jaya and Tanuja et al [5]	DCT	58.90(dB)	512	64×64

5. CONCLUSION

In this paper a hybrid color image watermarking using DCT and DWT in frequency domain is proposed. The performance of proposed algorithm is measured by computing the Peak Signal to Noise Ratio (PSNR) and Normalized correlation (NC). The proposed method achieves PSNR average as 66.26 dB and NC as 1. Experimental results show that method is imperceptible as well as robust against variety of attacks like salt- pepper noise, Gaussian noise, Speckle noise and filtering attacks like Median filter, Gaussian filter and can be used as a blind watermarking technique as it doesn't require original cover image at the time of watermark extraction. Results of proposed watermarking technique are compared with DCT watermarking, proposed hybrid technique is better than DCT.

REFERENCES

[1] C.I. Podilchuk, E.J. Delp "Digital watermarking: algorithms and applications," *Signal Processing Magazine, IEEE*, Vol 18, pp.33-46 July 2001.

[2] G. Langelaar, I. Setyawan, and R. Lagendijk, "Watermarking Digital Image and Video Data: A State of - Art Overview," IEEE Signal Processing Magazine, vol. , pp. 20-46, Sep. 2000.

[3] Smitha Rao, Jyothsna A. N, Pinaka Pani. R, "Digital watermarking: applications, techniques and attacks", International Journal of Computer Applications Volume 44, No. 7, pp. 29-34, April 2012.

[4] M. Natarajan , G. Makhdumi1,"Safeguarding the Digital Contents: Digital Watermarking," DESIDOC Journal of Library & Information Technology, Vol. 29, pp. 29-35, May 2009.

[5] Jaya Jeswani,Dr. Tanuja Sarode, "An Improved Blind Color Image Watermarking Using DCT in RGB Color Space", International Jounrnal of Computer Applications (IJCA), Vol 92, No. 14,2014.

[6] J. R. Hemandez, M. Amado, "DCT domain watermarking techniques for still images as detector performance analysis and a new structure," *in IEEE Transactions on Image Processing*, vol. 9, pp. 55-68,2000.

[7] Manik Mondal, Debalina Barik, "Spatial domain robust watermarking scheme for color image," *International Journal of Advanced Computer Science*, vol.2, no.1, pp. 24-27, Jan 2012.

[8] R. Eswaraiah & E. Sreenivasa Reddy, "Robust Watermarking Method for Color Images Using DCT Coefficients of Watermark", *Global Journals Inc (US*) 2012.

[9] Dr. K. Ramanjaneyulu , Dr. P. Pandarinath and B. Rakesh Reddy , "Robust and Oblivious Watermarking based on Swapping of DCT Coefficients", *International Journal of Application or Innovation in Engineering & Management*, vol. 2, issue 7, July 2013.

[10] S. Feng, D. Lin, S. C. Shie, J. Y. Guo, "Improving the robustness of DCT based image watermarking against JPEG compression",*Computer Standards & Interface*, vol. 32, pp. 54–60, 2010.

[11] BaiseL. Gunjal and Suresh N. Mali, "Secured Color Image Watermarking Technique In DWT-DCT Domain", International Journal of Computer Science, Engineering and Information Technology 2011.

[12] Mahasweta J. Joshi, Prof. ZankhanaH. Shah, KeyurN. Brahmbhatt, "Watermarking in DCT-DWT Domain", International Journal of Computer Science and Information Technology 2011.

[13] Mei Jiansheng, Li Sukang and Tan Xiaomei, "A Digital Watermarking Algorithm Based On DCT and DWT", Academy Publisher, 2009.

[14] Tsai M, H. Hung, "DCT and DWT based Image Watermarking Using Subsampling", IEEE Fourth International Conference on Machine Learning and Cybernetics, pp: 5308-5313, China 2005.

[15] N. Kaewkamnerd ,K.R. Rao, "Wavelet Based Image Adaptive Watermarking Scheme", IEEE Electronic Letters, Vol. 36, pp: 312-313, Feb.2000.

[16] Jaya Jeswani, Dr. Tanuja sarode, "A New DCT based Color Video Watermarking using Luminance Component", *IOSR Journal of Computer Engineering, (IOSR-JCE)* ,Volume 16, Issue 2, Ver. XII PP 83-90, Mar-Apr. 2014.