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On Choice of Wavelet for DWT-DFT-SVD based Image Watermarking Scheme

[1]Mehak Saini, [2]Dr. Priyanka
[1,2]Dept. of ECE, D.C.R. University of Sci. & Tech., Murthal, Sonepat, Haryana, India

Abstract
Watermarking has been identified as a promising solution to provide protection to the digital media from illegal manipulations by the hackers. Watermarking techniques in frequency domain are more robust as compared to spatial domain techniques. In frequency domain, many watermarking techniques based on disrete fourier transform, discrete cosine transform, singular value decomposition, discrete wavelet transform etc. have been reported inliterature. In this work, the effect of type of wavelet on a DWT-DFT-SVD based scheme has been examined with respect to image quality and robustness of the water marking schemes against various attacks.

Keywords
Digital Watermarking, Wavelet, Discrete Wavelet Transform (DWT), Discrete Fourier Transform (DFT), Singular Value Decomposition (SVD), YCbCr Color Space

I. Introduction

Information hiding has become an important research area in the fields of computer aided manufacturing systems and electronics and communication engineering [1]. In recent times, manipulation, distribution and duplication of digital data has become very easy due to huge developments in the field of information technology.

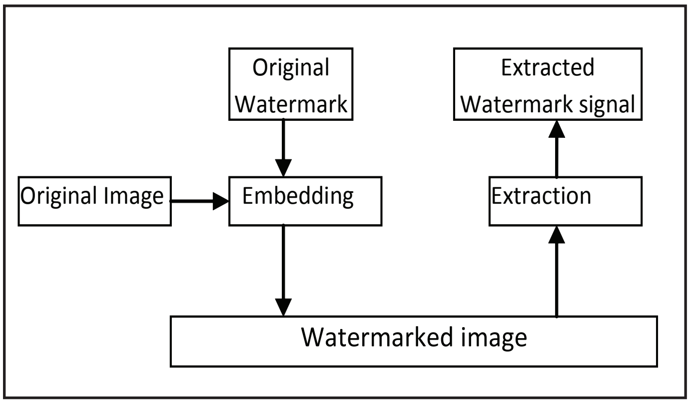

Fig. 1: Block Diagram of Watermarking Scheme [3]

This necessitates a technique to ensure copy right protection of digital data and to prevent illegal tampering of digital data by unauthorized users.
Digital watermarking is a solution to these problems. It has emerged as a simple technique to retrieve the right owner information, thus, to ensure content authentication. Basic block diagram of watermarking scheme (as shown in the fig. 1), illustrates that it includes the insertion of information (watermark) into the digital image and later its extraction for authentication and owner identification [2]. Other applications of digital watermarking includes broadcast monitoring, finer printing, in field of telemedicine and indexing etc [4]. Main constraints for watermarking schemes are to maintainrobustness of the watermark information while keeping the quality of the original image intact.

Digital watermarking is mostly addressed in either spatial or frequency domain. Spatial domain methods involve the embedding of data directly by manipulation of pixel values, code values of the host image/signal or bit stream. Inspite of being straight forward and simple, these methods are not robust in the presence of attacks [2]. To improve the robustness, most of the present work in this area is inspired by the manipulation of the frequency domain of the multimedia objects. In frequency domain, researchers have selected different transformation methods for embedding and extracting watermark objects. These includes Discrete Cosine Transform (DCT) [5], Discrete Fourier Transform (DFT) [6-8] and discrete wavelet transform [9-10] etc. Use of DCT results in a robust scheme (with respect to JPEG compression), but, it is sensitive to geometrical distortions [8]. This disadvantage is overcome by the use of DFT, which is rotation invariant and translation resistant [8].
Many hybrid image watermarking schemes have been developed by the researchers to get the benefit of two or more techniques. In a hybrid scheme based on DWT and SVD, the watermark is embedded on the elements of singular values of the DWT sub-bands of cover image [11]. This technique is further enhanced by adding the concept of Discrete Cosine Transform (DCT) [2]. To further improve the robustness and efficiency of watermarking scheme, DWT-DFT-SVD based scheme is used [12] and is extended to YCbCr colour space [8].
In this work, the effect of type of wavelet, i.e., Haar, Biorthogonal 1,Coiflets 1 and Daubecies 3 on the performance of a DWT-DFT-SVD based scheme [8] has been examined with respect to image quality and robustness of the water marking schemes against various attacks. Rest of the paper is organized as follows:A brief introduction to the watermarking scheme is given in the next section. Performance measures are elaborated in section III, Simulation results are presented in section IV followed by conclusion & list of references.

II. DWT-DFT-SVD based Water Marking Scheme [8]

In this section, a brief summary of the steps involved in the embedding and extraction of watermark for the DWT-DFT-SVD based water marking scheme [8] (analyzed in this paper) is presented withhelp of flowchart as shown in fig. 2 and 3 respectively. Main features of thisscheme are as follows [8]:

1. Use ofYCbCr colourspace helps to achieve better correlation between theactualandextractedwatermark.
2. With help of Discrete Wavelet Transform (DWT), the image can be decomposed into four wavelets and any of thesub bands can be chosen as per individual requirements.
3. Use of Discrete Fourier Transform (DFT) helps to make the scheme resistant to geometric attacks as DFT is rotation invariant and translation resistant.
4. Singular Value Decomposition (SVD) helps to get a smaller set of values that have maximum signal content. Use of SVD results in reduced truncation error. The robustness (resistance to attacks) of the scheme is also improved by the use of SVD.

5. The performance of the scheme isexamined[8] for seven different pairs of standard images. Also, the performance evaluation has been made in the presence of various attacks, like, motion, averaging,cropping etc.

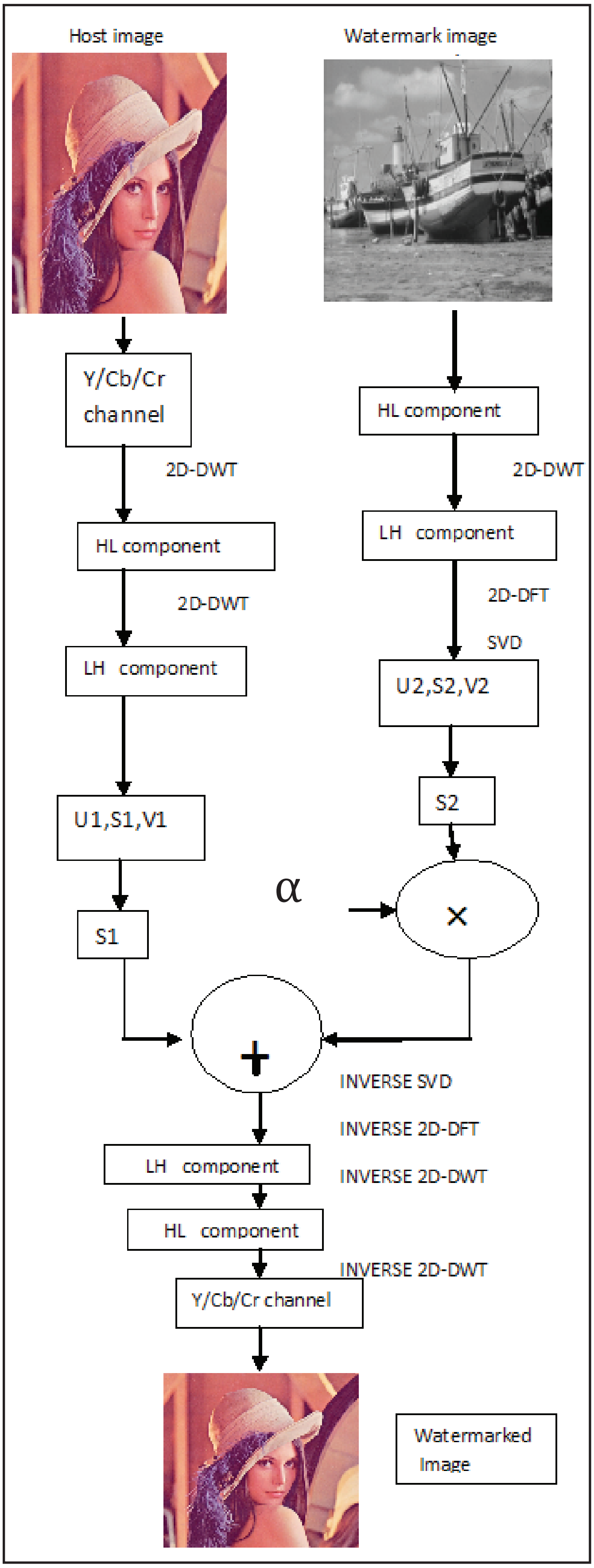

Fig. 2: Insertion of Watermark

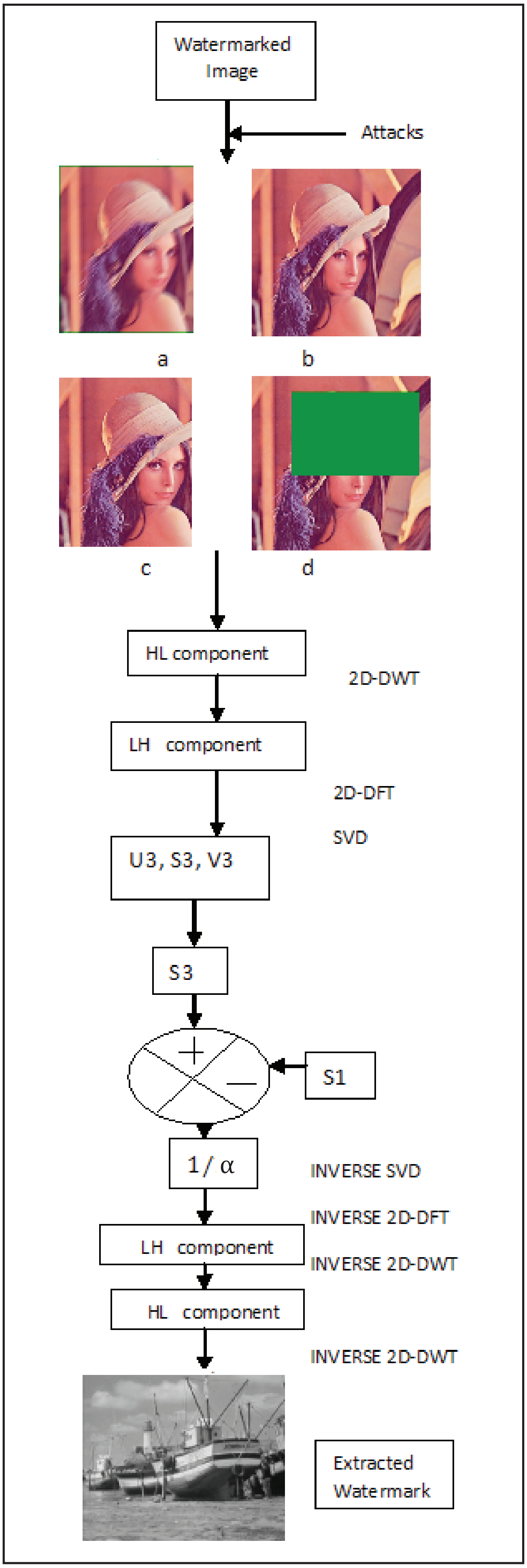

Fig. 3: Extraction of Watermark

III. Performance Measures

The imperceptibility and robustness of the watermarking schemegiven in section II is tested in this paper for different types of wavelets, i.e., Haar, Biorthogonal 1, Coiflets 1 and Daubecies3. Peak signal to noise ratio (PSNR) (calculated by using eqn.1) between the cover image & watermarked image is used to test the imperceptibility of scheme.

$$PSNR = 20\ log_{10}\frac{255}{RMSE}\quad \text{dB} \qquad (1)$$

Here, RMSE stands for root mean square error and is calculated by using eqn. (2).

$$RMSE = \sqrt{\frac{1}{X\times Y}\sum_{i=1}^{X}\sum_{j=1}^{Y}\left(A_{ij}-B_{ij}\right)^2} \qquad (2)$$

A_{ij} is a pixel of the host image of size X×Y and B_ij is a pixel of watermarked image of size X×Y.

Correlation coefficient (as calculated by eqn. (3)) between the original and extracted watermark is used as a measure of robustness of the scheme. It's ideal value is one, yet, 0.7 is acceptable.

$$CF = \frac{\sum_{i=1}^{X}\sum_{j=1}^{Y}\left(W_{orgij}-W_{extij}\right)}{\sum_{i=1}^{X}\sum_{j=1}^{Y}\left(W_{orgij}\right)^2} \qquad (3)$$

W_{orgij} is a pixel of the host image of size X×Y and W_{extij} is a pixel of recovered watermarked image of size X×Y.

IV. Simulation Results

The performance of the proposed watermarking scheme for different types of wavelets is tested by simulation in MATLAB. Seven different Image pairs of size 512×512 are used as cover & watermark images respectively. The perceptual quality of the scheme is tested by calculation of peak signal to noise ratio (PSNR) between cover image and watermarked image. As shown in Tables 1& 2, peak signal to noise ratio values (between original and watermarked image) is sameor almost same for all the four types of wavelets in the absence of attacks and in the presence of motion blur, averaging and cropping and Gaussian blur attack for all the image pairs.

Table 1: PSNR Values (Between Original and Watermarked Image) for Different Types of Wavelets (Without Attack)

S.no.	Host Image/ Watermark image	Wavelet type	Without attack
1.	Airplane/ Boat	Coif 1	57.0476
		Db3	57.0476
		Bior1	57.0476
		Haar	57.0476
2.	Pepper/ Airplane	Coif 1	57.1144
		Db3	57.1144
		Bior1	57.1144
		Haar	57.1144
3.	Tulips/ House	Coif 1	57.0957
		Db3	57.0957
		Bior1	57.0957
		Haar	57.0957
4.	Lena/ Cameraman	Coif 1	56.9806
		Db3	56.9806
		Bior1	56.9806
		Haar	56.9806
5.	Baboon/ Hunter	Coif 1	57.0559
		Db3	57.0559
		Bior1	57.0559
		Haar	57.0559
6.	Airplane/ Barbara	Coif 1	57.0476
		Db3	57.0476
		Bior1	57.0476
		Haar	57.0476
7.	Lena/ Boat	Coif 1	56.9806
		Db3	56.9806
		Bior1	56.9806
		Haar	56.9806

Table 2: PSNR Values (Between Original and Watermarked Image) for Different Types of Wavelets (in Presence of Attacks)

S.no.	Host Image/ Watermark image	Wavelet type	Attack 1 Motion blur	Attack 2 Average	Attack 3 Gaussian blur	Attack 4 Crop
1.	Airplane/ Boat	Coif 1	23.5983	31.7678	31.8349	14.8141
		Db3	23.5983	31.7678	31.8355	14.8141
		Bior1	23.5983	31.7678	31.8357	14.8141
		Haar	23.5983	31.7678	31.8357	14.8141
2.	Pepper/ Airplane	Coif 1	25.7255	35.4609	34.5524	17.4514
		Db3	25.7255	35.4609	34.5517	17.4514
		Bior1	25.7255	35.4609	34.5526	17.4514
		Haar	25.7255	35.4609	34.5526	17.4514
3.	Tulips/ House	Coif 1	24.6416	33.0382	31.6160	17.1263
		Db3	24.6416	33.0382	31.6154	17.1263
		Bior1	24.6416	33.0382	31.6143	17.1263
		Haar	24.6416	33.0382	31.6143	17.1263
4.	Lena/ Cameraman	Coif 1	25.9175	33.6678	32.9426	16.4888
		Db3	25.9175	33.6678	32.9429	16.4888
		Bior1	25.9175	33.6678	32.9405	16.4888
		Haar	25.9175	33.6678	32.9405	16.4888
5.	Baboon/ Hunter	Coif 1	24.1040	31.3807	30.7088	17.0504
		Db3	24.1040	31.3807	30.7087	17.0504
		Bior1	24.1040	31.3807	30.7080	17.0504
		Haar	24.1041	31.3807	30.7081	17.0504
6.	Airplane/ Barbara	Coif 1	23.5983	31.7678	31.8350	14.8141
		Db3	23.5983	31.7678	31.8353	14.8141
		Bior1	23.5983	31.7678	31.8356	14.8141
		Haar	23.5983	31.7678	31.8355	14.8141
7.	Lena/ Boat	Coif 1	25.9175	33.6678	32.9423	16.9175
		Db3	25.9175	33.6678	32.9429	16.4888
		Bior1	25.9175	33.6678	32.9403	16.4888
		Haar	25.9175	33.6678	32.9403	16.4888

Table 3: Correlation Coefficient Values Between Original and Extracted Watermark Image for Different Types of Wavelets (Without Attack)

S.no.	Host Image/ Watermark image	Wavelet type	Without attack
1.	Airplane/ Boat	Coif 1	0.9989
		Db3	0.9988
		Bior1	0.9987
		Haar	0.9987
2.	Pepper/ Airplane	Coif 1	0.9999
		Db3	0.9999
		Bior1	0.9996
		Haar	0.9996
3.	Tulips/ House	Coif 1	1.0000
		Db3	1.0000
		Bior1	1.0000
		Haar	1.0000
4.	Lena/ Cameraman	Coif 1	0.9999
		Db3	1.0000
		Bior1	0.9998
		Haar	0.9999
5.	Baboon/ Hunter	Coif 1	1.0000
		Db3	1.0000
		Bior1	1.0000
		Haar	1.0000
6.	Airplane/ Barbara	Coif 1	0.9980
		Db3	0.9977
		Bior1	0.9979
		Haar	0.9974
7.	Lena/ Boat	Coif 1	0.9988
		Db3	0.9988
		Bior1	0.9990
		Haar	0.9990

Table 4: Correlation Coefficient Values Between Original and Extracted Watermark Image for Different Types of Wavelets (In Presence of Attacks)

S.no.	Host Image/ Watermark image	Wavelet type	Attack 1 Motion blur	Attack 2 Average	Attack 3 Gaussian blur	Attack 4 Crop
1.	Airplane/ Boat	Coif 1	0.9988	0.9988	0.9988	0.9988
		Db3	0.9988	0.9988	0.9988	0.9988
		Bior1	0.9985	0.9985	0.9985	0.9985
		Haar	0.9985	0.9985	0.9985	0.9985
2.	Pepper/ Airplane	Coif 1	0.9997	0.9988	0.9998	0.9998
		Db3	0.9998	0.9998	0.9997	0.9998
		Bior1	0.9993	0.9995	0.9995	0.9994
		Haar	0.9993	0.9995	0.9995	0.9994
3.	Tulips/ House	Coif 1	0.9999	0.9999	0.9999	0.9999
		Db3	0.9999	0.9999	0.9999	0.9999
		Bior1	0.9998	0.9998	0.9998	0.9998
		Haar	0.9998	0.9998	0.9999	0.9998
4.	Lena/ Cameraman	Coif 1	0.9999	0.9999	0.9999	0.9999
		Db3	1.0000	1.0000	1.0000	1.0000
		Bior1	0.9998	0.9998	0.9998	0.9998
		Haar	0.9998	0.9998	0.9998	0.9998
5.	Baboon/ Hunter	Coif 1	1.0000	1.0000	1.0000	1.0000
		Db3	1.0000	1.0000	1.0000	1.0000
		Bior1	0.9999	0.9999	0.9999	0.9999
		Haar	0.9999	0.9999	0.9999	0.9999
6.	Airplane/ Barbara	Coif 1	0.9978	0.9978	0.9978	0.9978
		Db3	0.9977	0.9977	0.9977	0.9977
		Bior1	0.9977	0.9977	0.9977	0.9978
		Haar	0.9972	0.9972	0.9972	0.9973
7.	Lena/ Boat	Coif 1	0.9988	0.9989	0.9989	0.9988
		Db3	0.9988	0.9988	0.9988	0.9989
		Bior1	0.9985	0.9985	0.9987	0.9986
		Haar	0.9985	0.9985	0.9987	0.9986

Thus, the perceptibility of the watermarking scheme [8], remains almost unaffected by usage of any of the four types of wavelets used in this work. To test the effect of type of wavelet used on the robustness of the scheme, correlation coefficients between original and extracted watermark is calculated for all the four types of wavelets for seven different image pairsagainst four types of attacks, i.e., motion blur, average, Gaussian blur and cropping.
As shown in Table 3 & 4, maximum value of correlationcoefficients is obtained by the use of coiflet 1 wavelet (in the presence and absence of all types of four attacks). Results are almost equal forDaubecies3 type of wavelet. But, use of biorthogonal and Haar wavelet results in slightly reduced robustness as correlation coefficients for these wavelets are less as compared to coiflet1 and Daubecies3 types of wavelets.

V. Conclusion

Simulation results show that perceptibility of the scheme is unaffected by the type of wavelet used. But, maximum robustness of the scheme can be achieved by the use of Coiflet 1 wavelet.

References

[1] Mahendra Kumar, Poma Rewani, Aman,"Digital Image Watermarking using Fractional Fourier transform via image compression", In Proceedings of IEEE International Conference on Computational Intelligence and Computing Research, pp. 1-4, 2013.

[2] Amit Kumar Sin, Mayank Dave, Anand Moan,"Hybrid Technique for Robust and Imperceptible Image Watermarking in DWT-DCT-SVD Domain", National Academy Science Letters, Vol. 37, No. 4, pp. 351-358, 2014.

[3] Mehak Saini, Dr. Priyanka,"Digital Image Water Marking Techniques: State of the Art", International journal of Research in Electronics and Computer Engineering, Vol. 4, Issue 4, pp. 55-59, 2016.

[4] Mohammad Ibrahim Khan, Md. Maklachur Rahman, Md. Iqbal Hasan Sarker,"Digital Watermarking for Image Authentication Based on Combined DCT, DWT and SVD Transformation", IJCSI International Journal of Computer Science Issues, Vol. 10, No. 1, pp. 1-8, 2013.

[5] Huang-Chi Chen, Yu-Wen Chang, Rey-Chue Hwang,"A water-marking technique based on the frequency domain," Journal of Multimedia, Vol. 7, No. 1, pp. 82-89, 2012.

[6] Ante Poljicak, Lidija Mandic, Darko Agic,"Discrete Fourier transform based watermarking method with an optimal implementation radius", Journal of Electronic Imaging, Vol. 20, No. 3, pp. 033008-1 to 033008-8, 2011.

[7] Awanish Kr. Kaushik,"A novel approach for digital watermarking of an image using DFT", International Journal of ECSE, Vol. 1, No. 1, pp. 35-41, 2012.

[8] Advith J, Varun K R, Manikantan K,"Novel digital image watermarking using DWT-DFT-SVD in YCbCr color space", In Proceedings of IEEE Conference on Emerging Trends in Engineering, Technology and Science, pp. 1-6, 2016.
[9] Anurada, Rudresh Pratap Singh,"DWT based watermarking algorithm using Haar wavelet technique for digital images", International Journal of Electronics and Computer Science Engineering, Vol. 1, No. 1, pp. 1-6, 2012.
[10] Pallavi Patil, D.S. Bormane,"DWT based invisible watermarking technique for digital images", International journal of engineering and advanced technology, Vol. 2, No. 4, pp. 603-605, 2013.
[11] Chih-Chin Lai, Cheng-Chih Tsai,"Digital image watermarking using discrete wavelet transform and singular value decomposition", IEEE transactions on instrumentation and measurement, Vol. 59, No. 11, pp. 3060-3063, 2010.
[12] Rahim Ansari, Mrutyunjaya, M. Devanalamat, S. Ramacand, "Robust digital image watermarking algorithm in DWT-DFT-SVD domain for color images", In Proceedins of IEEE conference on communication, information and computing technology, Mumbal, pp. 1-6, 2012.

Mehak Saini is B.Tech (ECE) and pursuing M.Tech from Deenbandhu Chhotu Ram University of Science and Technology Murthal, Sonepat (Haryana), India. She is a young Technocrat and Researcher. She has published 6 research papers in National/ International Journals. Her areas of Interest are Digital Water Marking Techniques, Optical Communication and Advanced Communication System.

Dr. Priyanka is Ph.D in Electronics & Communication Engineering. Currently, She is Associate Professor in Deenbandhu Chhoturam University of Science and Technology Murthal, Sonepat (Haryana), India. Her Research area and areas of interest are Image Processing, Signal Processing, SAW filter Design and Multimedia Communication. She has published more than 50 research papers in various reputed international journals, international conferences and national conferences. She has guided Dissertation of more than 15 M.Tech. students and 2 Ph.D. scholars.