ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING

National Conference on Advanced Innovation in Engineering and Technology (NCAIET-2015)

Alva's Institute of Engineering and Technology, Moodbidri

Vol. 3, Special Issue 1, April 2015

Comparative Analysis of Color Image Watermarking using DWT and DWT-SVD

Praveen Kumar M[1], Gandhimathinathan.A[2]

Department of Electronics and Communication, St. Joseph Engineering College, Vamanjoor, Mangaluru[1,2]

Abstract: Rapid development in computer technology makes images, audio, text and video can be more easily reproduced, processed and stored in digital devices. Digital watermarking is a technique which allows an individual to add hidden copyright notices or other verification messages to digital audio, video, or image and documents. In this paper the concept of color image watermarking technique is performed (i.e., both Host Image and Watermark Image are color images), using DWT based algorithm and DWT-SVD based algorithm. The performance metrics Peak Signal-to-Noise Ratio (PSNR) and Normalized Correlation (NC) are analyzed. In addition to the above analysis a robustness check is performed in a watermarked color image with an application of various attacks (Salt- Pepper Noise Attacks, Rotation (Clockwise), Blurring, Image Sharpening and Gaussian Noise) to illustrate the efficiency of the above algorithm.

Keywords: Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD), Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR) and Normalized Correlation (NC).

I. INTRODUCTION

Image processing is one of the forms of signal processing, in which input is an image. Image is considered as a 2-dimensional signal and standard signal processing techniques are applied to it. A digital watermarking is a process of embedding a marker such as audio or image. It is a technique providing copyright information in the images. Watermarks can be used to authenticate the signal which is carrying it or to identify its owners. Embedding is an algorithm in which the watermark is embedded into the host image or the carrier signal. Extraction is an algorithm used to extract the watermark from the host image or the original signal. Extraction algorithm must be able to extract the signal even if the modifications to the watermarked image is strong, then it is called a robust digital watermarking. In order to check the robustness of the algorithm, various attacks will be performed on it. If the watermark is extracted correctly, even after the attacks on the watermarked image, then the algorithm is called very robust. Discrete Wavelet Transform (DWT) [5] is obtained by passing the signal through a series of digital filters. Singular Value Decomposition(SVD)[1] is one of the tools to analyze the matrices.SVD is transformation in which the matrices are decomposed into 3 matrices U, D, V. U & V are the orthonormal matrices. D is the diagonal matrix.

II. DISCRETE WAVELET TRANSFORM

All most all natural images have smooth variations in color, having fine details being represented as sharp edges, between the smooth variations in the pixel values. The smooth variations in color are low frequency variations and the sharp variations are high frequency variations. The low frequency components (smooth variations) constitute the base of an image, and the high frequency components (the edges which give the detail) show the refine image, it gives a detailed image. So, the smooth variations are of more importance than the details (edges). Separating the smooth variations and details of the image can be done in many ways, one such way is that decomposing of the image using a Discrete Wavelet Transform (DWT) [5].

DWT procedure is that, a low pass filter and a high pass filter are chosen in such a way that they exactly halve the frequency range of the images between themselves. The resulting filter pair is called the Analysis Filter pair. Firstly, the low pass filter (LPF) is applied for all rows of data, by which the low frequency components of the row are obtained.

For the same row of data the high pass filter is applied, and in the same way, the high pass components are separated, placed nearby low pass components. Each column of the intermediate data will undergo the process of filtering. The resulting array of coefficients contains four bands of data, each labelled as LL (low-low), HL (high-low), LH (low-high) and HH (high-high),shown in Figure 1.

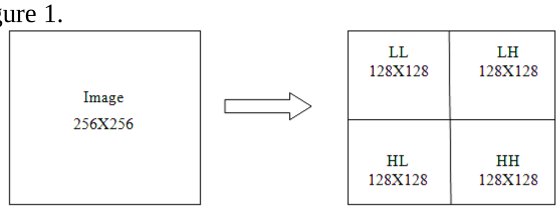

Figure 1.First Level Decomposition of an Image

The wavelet transform decompose image into set of different resolution sub images corresponding to various frequency bands. This process is termed as sub-band

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
National Conference on Advanced Innovation in Engineering and Technology (NCAIET-2015)
Alva's Institute of Engineering and Technology, Moodbidri
Vol. 3, Special Issue 1, April 2015

coding. Sub-band coding is a procedure in which the input signal is subdivided into several frequency bands. Sub-band coding can be implemented through a filter banks. A filter bank is a collection of filters either common input or a common output. When the filters are having common input, they form the Analysis bank shown in Figure 2. When they share the common output they form a synthesis bank.

The wavelet transform decompose image into set of different resolution sub images corresponding to various frequency bands. This process is termed as sub-band coding. Sub-band coding is a procedure in which the input signal is subdivided into several frequency bands. Sub-band coding can be implemented through a filter banks. A filter bank is a collection of filters either common input or a common output. When the filters are having common input, they form the Analysis bank shown in Figure 2. When they share the common output they form a synthesis bank.

The new images are named according to the filter (low-pass or high-pass) which is applied to the original image in horizontal as well as vertical directions. As shown in above figure, the LH image is a result of applying the low-pass filter in horizontal direction and high-pass filter in vertical direction of the image data. The four images produced from first decomposition level are LL, LH, HL, and HH. LL image is considered to be a reduced version of the original, since it retains all most details of the original image. The LH image contains information of horizontal edge features, while the HL contains details of vertical edge features. The HH image contains high frequency information and is typically noisy and not useful because of that. In wavelet decomposition, only the LL image is used for the processing [5].

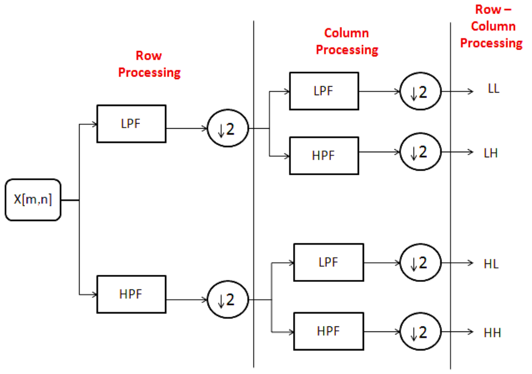

Figure 2.Analysis Filter Bank

III. SINGULAR VALUE DECOMPOSITION

SVD [6] is one of the transform which is having very high application in image processing.SVD is the matrix decomposition technique, in which highest energy is packed into the coefficients. Singular value decomposition (SVD) is a stable and effective method to split the system into a set of linearly independent components.SVD is a numerical analysis technique. One of the advantages of this is highest energy packing which is mainly used in image compression. Watermarking is also one of the applications.

IV. IMPLEMENTATION OF ALGORITHMS

A) Algorithm based on Discrete Wavelet Transform

1. Embedding Process

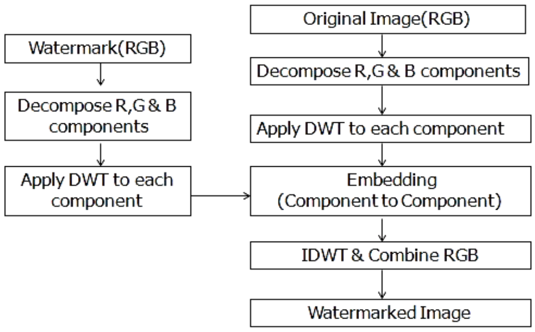

Figure3. Block Diagram for embedding

In the process of embedding both the host and watermark image should be decomposed into their respective individual components of R, G & B. Then the DWT algorithm is applied to individual component of both original and watermark image. After the application of DWT algorithm the process of embedding between component to component of both original and watermark image is performed on LL. In order to get the watermarked image after the embedding process IDWT is performed and R, G & B components and are combined.

2) Extraction Process

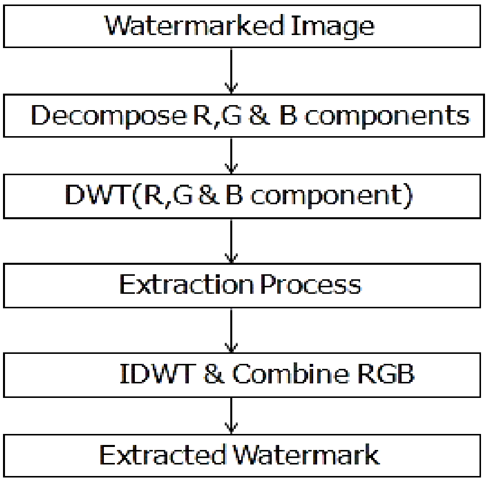

Figure4.Block Diagram for Extraction

In the process of extraction watermarked image should be decomposed into their respective individual components of R, G & B. Then the DWT algorithm is applied to individual component of the watermarked image. In the extraction process host image is used. By performing IDWT followed by combining the R, G & B components, the extracted watermark image will be obtained.

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING

National Conference on Advanced Innovation in Engineering and Technology (NCAIET-2015)

Alva's Institute of Engineering and Technology, Moodbidri

Vol. 3, Special Issue 1, April 2015

B) Algorithm based on DWT-SVD

1. Embedding Process

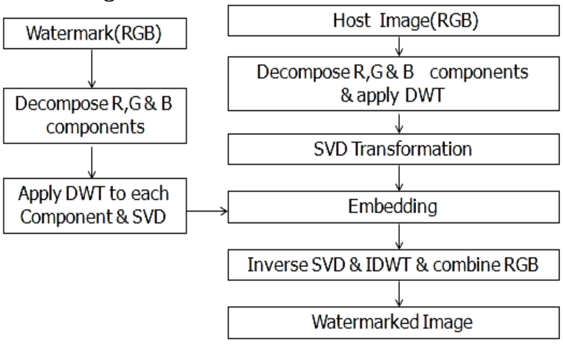

Figure5.Block Diagram for Extraction

In the process of embedding both the host and watermark image should be decomposed into their respective individual components of R, G & B. Then the DWT algorithm is applied to individual component which are already decomposed of both original and watermark image. To LL band, the SVD transformation will be applied. Diagonal Coefficient of SVD in both host and watermark image is used for embedding. In order to get the watermarked image after the embedding process IDWT and Inverse SVD is performed and R, G & B components are combined [2].

2) Extraction Process

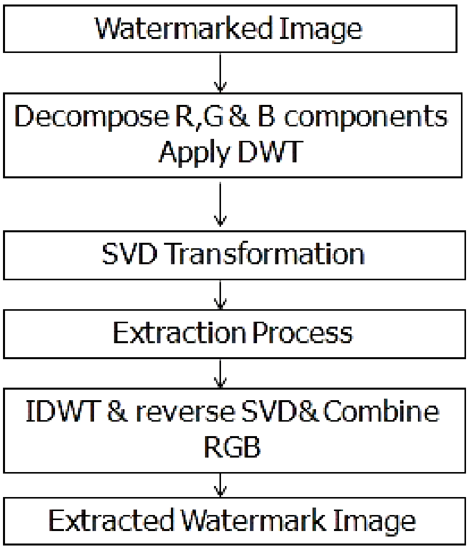

Figure6.Block Diagram for Extraction

In the process of extraction watermarked image should be decomposed into their respective individual components of R, G & B. Then the DWT algorithm is applied to individual component of both original and watermark image. The SVD transformation will be applied to LL band of both host and watermarked image. Host image is used for extraction. After the extraction process IDWT and Inverse SVD is performed and R, G & B components are combined.

V. PERFORMANCE METRICS

A) Mean Square Error (MSE)

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

MSE-Mean Square Error,
A_i-Original Image, B_j-Watermarked Image, M-Row size, N- Column size.

B) Peak Signal to Noise Ratio (PSNR)

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

PSNR- Peak Signal to Noise Ratio,
MSE- Mean Square Error,
MAX- Maximum Intensity

C) Normalized Correlation (NC)

$$NC = \left(\sum_{i=0}^{M-1}\cdot\sum_{j=0}^{N-1} Figure1 * Figure2\right) \Big/ \left(\sum_{i=0}^{M-1}\cdot\sum_{j=0}^{N-1} Figure1 * Figure1\right) \quad (3)$$

NC- Normalized correlation,
Figure1- Host Image when embedding, Original Watermark when Extraction.

Figure2- Watermarked Image in embedding, Extracted Watermark when extraction.

VI. SIMULATION RESULTS

In our experiment, we used image size of 256X256 for the process. Host and Watermark images are color images of the same size. The algorithm is subjected to possible watermark attacks. Results are tabulated. Experiment is also tried for image size of 512X512. Results are tabulated by varying α value. Here α is the intensity of the pixel of the watermark image. Detailed results are shown below. Algorithm works for .jpg images. It is also tried for .bmp images.

A) DWT Algorithm

1) Embedding Process

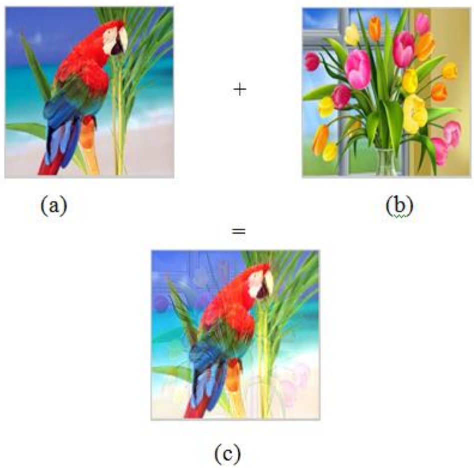

Figure7. (a)Host or Original image (b) Watermark Image (c) Watermarked Image

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING

National Conference on Advanced Innovation in Engineering and Technology (NCAIET-2015)

Alva's Institute of Engineering and Technology, Moodbidri

Vol. 3, Special Issue 1, April 2015

2) Extraction Process

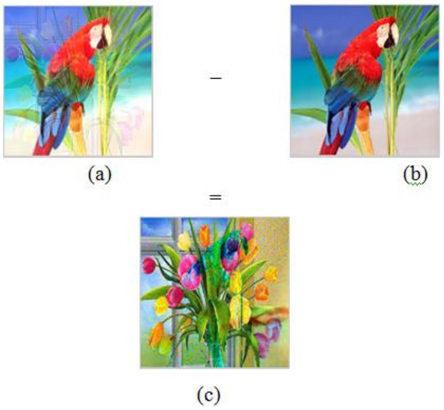

Figure8. (a)Watermarked image (b) Host or Original Image (c) Extracted Watermark Image

The above results are shown for DWT algorithm. The result for DWT-SVD algorithm is shown below.

B) DWT-SVD Algorithm

1) Embedding Process

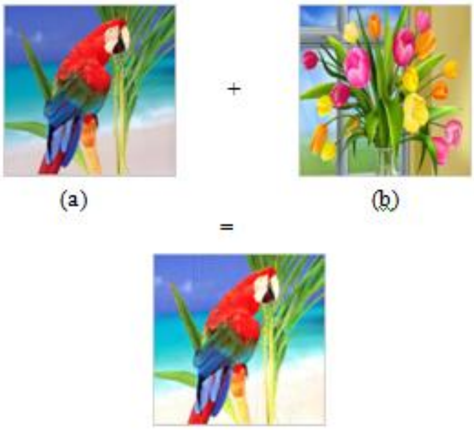

Figure9. (a)Host or Original image (b) Watermark Image (c) Watermarked Image

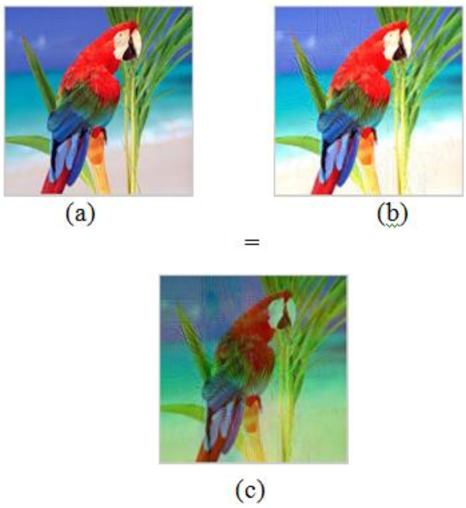

Figure10. (a)Watermarked image (b) Host or Original Image (c) Extracted Watermark Image

C) Tabulation of PSNR and NC

Table1.P SNR values of Embedding Process

	DWT			DWT-SVD		
	PSNR			PSNR		
α	R	G	B	R	G	B
0.01	31.54	31.46	31.06	31.62	31.49	31.06
0.05	28.11	28.14	29.04	28.55	28.27	29.05
0.2	24.81	24.58	25.86	25.12	24.71	25.64
0.4	24.43	24.21	25.19	24.55	24.33	25.13
0.8	24.32	24.11	24.74	24.38	24.18	24.81
1.2	24.31	24.09	24.55	24.34	24.14	24.67

Table4. NC values for Extraction

	DWT			DWT-SVD		
	NC			NC		
α	R	G	B	R	G	B
0.01	0.1347	0.1799	0.152	0.3527	0.3893	0.1014
0.05	0.4763	0.5669	0.4706	0.6846	0.5602	0.2886
0.2	0.6825	0.8565	0.8224	0.6959	0.5284	0.2831
0.4	0.5704	0.6835	0.807	0.6633	0.4635	0.2466
0.8	0.5408	0.4565	0.599	0.5808	0.3659	0.2207
1.2	0.5547	0.4324	0.4602	0.5175	0.3025	0.2045

Table5.PSNR values for Attacks

	DWT			DWT-SVD		
	PSNR			PSNR		
Attacks	R	G	B	R	G	B
Salt & Pepper Noise	30.47	29.23	28.59	31.19	28.6	27.43
Rotation: Clockwise	30.35	29.44	29.41	50.26	36.75	38.56
Image Sharpening	29.65	28.93	28.52	30.91	28.71	27.54
Blurring Attack	28.95	28.45	27.88	30.3	28.36	27.59
Gaussian Noise	30.06	26.53	27.55	33.6	27.88	27.26

Table6: NC values for Attacks

	DWT			DWT-SVD		
	NC			NC		
Attacks	R	G	B	R	G	B
Salt & Pepper Noise	0.672	0.793	0.807	0.706	0.557	0.293
Rotation: Clockwise	0.333	0.411	0.323	0.201	0.194	0.245
Image Sharpening	0.481	0.503	0.599	0.418	0.351	0.164
Blurring Attack	0.383	0.311	0.369	0.388	0.381	0.157
Gaussian Noise	0.510	0.539	0.687	0.652	0.571	0.289

VII. CONCLUSION

In this paper, the scheme of color image watermarking is performed using DWT and DWT-SVD. The experiment is done only for first level decomposition of DWT. The results show that, DWT-SVD during embedding and extraction process of watermarking is better than DWT in our experiment. The PSNR and NC values were satisfactory in both embedding and extraction process of both algorithms. Visual quality is good for DWT than DWT-SVD; because extraction is done from diagonal element of watermarked image. Watermarking is also tried for different sizes of watermark images.

Table 5 & 6 represents the attack results for PSNR and NC values of the original watermark and extracted watermark image using DWT and DWT-SVD algorithm. The results shows that DWT-SVD outer perform than DWT.

REFERENCES

[1] Cheng-qun Yin, Li Li, An-qiang Lv and Li Qu," Color Image Watermarking Algorithm Based on DWT-SVD", Proceedings of the IEEE International Conference on Automation and Logistics , August 18 - 21, 2007, Jinan, China, pp. 2607-2611, 2007 IEEE.

[2] Rashedul Islam & Jong-Myon Kim, "Reliable RGB Color Image Watermarking using DWT and SVD", 3rd International Conference on Informatics, Electronics & Vision 2014 IEEE.

[3] Rakhi Dubolia,Roop Singh & Sarita Singh, Rekha Gupta, "Digital Image Watermarking By Using Discrete Wavelet Transform And Discrete Cosine Transform And Comparison Based On PSNR "2011 International Conference on Communication Systems and Network Technologies, pp. 593-596, 2011 IEEE

[4] Radhika v. Totla, K.S.Bapat ,"Comparative Analysis of Watermarking in Digital Images Using DCT & DWT", International Journal of Scientific and Research Publications, Volume 3, Issue 2, February 2013 1 ISSN 2250-3153, pp. 1-4.

[5] Darshana Mistry, Asim Banerjee," Discrete Wavelet Transform Using Matlab", International Journal of Computer Engineering and Technology (IJCET), vol 4, Issue 2, March – April (2013), pp. 252-259.

[6] Soo-Chang Pei, Hsin-Hua Liu, Tsung-Jung Liu, and Kuan-Hsien Liu " Color Image Watermarking Using SVD" , ICME 2010 IEEE, pp. 122-126.