

# Digital Image Watermarking at Different Levels of DWT using RGB Channels



Dayanand G. Savakar, Shivanand Pujar

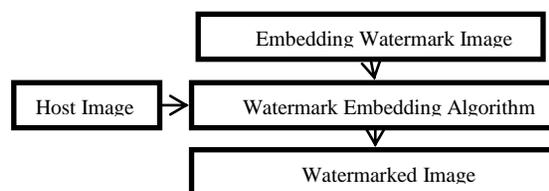
**Abstract**—This paper presents a digital image watermarking scheme comprising of DWT transformation. Due to the common practice of creating the copy, transmitting and spreading the data duplication of the original data occurs. Digital image watermarking has the ability to provide a solution for the unauthorized duplication problem. The scheme designed and presented in this paper comprises of mainly two modules one for embedding the watermark within the cover image and another for retrieving the watermark from the watermarked image. The process is carried out at different levels of the DWT transformation within different sub-bands of the DWT transformation. The extraction process involves the extraction of the watermark image form different channels of the RGB image mainly red, green and blue. The robustness and imperceptibility are tested. In each of the case, the corresponding PSNR and correlation values are noted and the results obtained concludes the scheme as the robust, semi-fragile and fragile digital image watermarking at different levels of the DWT transformation

**Keywords:** Discrete Wavelet Transformation (DWT), Peak-Signal to Noise ratio (PSNR), Fragile watermarking, Semi-fragile watermarking

## I. INTRODUCTION

The process of embedding a message or an image within another image is termed as digital image watermarking. This development of the various technologies concerned to computers, network as well as to the multimedia, the transmission of different forms of information related to the images has become reliable and convenient. The main applications concerned to Digital Image Watermarking techniques that are responsible to develop are copyright protection, ownership, and authenticity, etc. The various problems that are encountered during the transmission of the image containing one or more forms of information placed a challenge with respect to the protection of the intellectual properties of the images that are transformed.

To find a solution for these kinds of problems there established a technique that is capable to hide some kind of information within the images based upon which the owners of the concerned images are identified easily. Hence the process developed is known to be digital image watermarking. Then a various number of algorithms are developed to embed a given watermark and to extract the same watermark from a known cover image. Different forms of watermarks are identified which are categorized based upon the human perception some of them are (1) Visible, (2) Invisible- robust, (3) Invisible-fragile, (4) Dual watermark. A watermark which is perceptible or which can be notified by the human eye easily is referred as the visible watermark and a watermark which is imperceptible or cannot be identified by the human eye is known to be the invisible watermark. A watermark is said to be a fragile watermark which can be altered or destroyed easily when an host image is subjected to modification either through series of linear or nonlinear transformations and further whenever a watermark that is under consideration exhibits the characteristics of both visible and non-visible watermarks is termed as a dual watermark. The general process of watermarking is depicted in below Fig 1.



**Fig.1. Generic Block diagram of Image Watermarking Process**

For a digital watermarking technique to be effective it should consist of the following characters that are; the developed watermarking technique should be highly imperceptible and further it should have the characteristic of being robust for the operations it is going to carry out on the images.

Digital watermarking techniques are carried out mainly in a number of ways; one of them is in the spatial domain and the other is within the frequency domain. Figure 2 shows diagrammatic description of proposed methodology.

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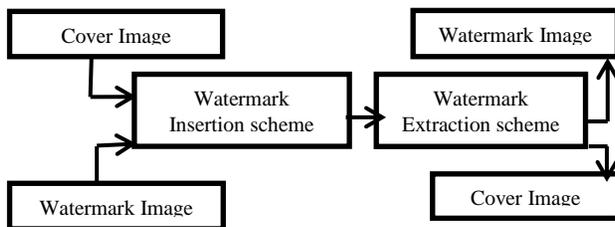
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**Fig.2. Proposed Methodology**

### II. REVIEW CRITERIA

[1](Dayanand G. Savakar and Anand Ghuli, 2019) have proposed an invisible hybrid watermarking scheme which is based upon blind and no-blind watermarking techniques. DWT is mainly used to insert a secret binary image which is taken as a watermark and is embedded within the inner cover image using the blind watermarking scheme with the contribution of predefined binary sequence block and gain factor to obtain the inner watermarked image. The extraction process involves non-blind watermark extraction and then blind watermark extraction techniques. [2](Shuming Jiao, et.al, 2019) have proposed a paper that provides a comprehensive review of the research works concerned to the optical image hiding and watermarking techniques. The previous research works mainly focused on two major aspects they are systems concerning to image hiding, and the methods concerned to embedding the optical system output within host image.

[3](Hangqi Ge and Jin Sha, 2019) have presented a technique that is based upon FPGA-based hardware accelerator for the purpose of robust watermarking. The presented technique involves the application of some novel transformation techniques mainly DCT/IDCT algorithm that is simplified within a hardware-friendly way.

[4](Heri Prasetyo and Chih-Hsien Hsia, 2019) have proposed a new scheme known as progressive secret sharing. The proposed method comprises of two different approaches based upon secret image that is converted into a set of shared images. The first approach utilizes the general grids that are random. Further the second approach uses mainly the exclusive-OR (XOR) operation whose purpose is to generate a set of shared images.

[5](P. Lefevre, P. Carre and P. Gaborit, 2019) have proposed a new digital image watermarking algorithm that involves studying of the resistance against various attacks with the usage of error correcting codes. By the usage of the Lattice QIM within the spatial domain the proposed technique is established to use a different form of error correcting codes known as rank metric codes. The technique involves how the metric helps to correct errors within a specific structure and also how it is adapted to a specific image attacks whenever it is combined with a given watermarking technique.

[6](Sunesh Malik and Ram Kishore Reddlapalli, 2019) have proposed an algorithm based on digital image watermarking that is based upon entropy of the blocks along with the histogram. The scheme involves the division of the host image into a number of blocks and then these blocks are culled based upon the basis of entropy values for the purpose of embedding a watermark. Then the watermark is embedded within the selected blocks using the histogram shape method.

[7](Sangeetha N and Anita X, 2018) have proposed a novel linear weighted watermarking technique comprising of normalized principal components, DWT and SVD. The experimental results mainly obtain the PSNR, SSIM values, and correlation coefficient values based upon which the performance of the algorithm is estimated. The proposed method is subjected to various geometrical as well as non-geometrical attacks over the watermarked images.

[8](Ratnakirti Roy, et.al, 2018) have proposed a watermarking scheme which is based on image geometry change tracking. The proposed scheme mainly contributes to the state of the art by proposing this scheme which attempts to model the geometric attacks like cropping, scaling and rotation. The proposed watermark embedding method is a blind approach and key based. The experimental results show that the proposed scheme is too robustness against any of the attacks.

[9](Dayanand G Savakar and Shivanand Pujar, 2018) have proposed a robust digital image watermarking scheme which is based upon the DWT and FWHT transformations. The scheme is subjected different forms of attacks to check the robustness and imperceptibility of the proposed scheme and by the side the PSNR values along with the respective correlation values are noted down to observe the robustness and quality of the original image.

[10](Lusia Rakhmawati, et.al, 2018) have proposed an image fragile watermarking scheme having two authentication components for tamper detection and recovery. The scheme utilizes mainly the image feature as a watermark component. There are mainly two watermark components for the purpose of tamper detection and for recovery. The scheme carries out the process by splitting the original image into multiple blocks which are of uniform size and lookup tables for generation of the random blocks those are generated using the 1-D transformation algorithm.

[11](Xiao-Long Liu, et.al, 2018) have presented a blind dual watermarking scheme for the sake of digital color images (RGB) which comprises of embedding an invisible robust watermarks within the cover image. Further fragile watermarking technique is carried out using an improved LSBs replacement approach within the RGB components of the color image for the purpose of image authentication. The technique involves verification of the authenticity and integrity of a suspicious image.

[12](Abdulaziz Shehab, et.al, 2018) have proposed a new scheme of fragile digital watermarking. The process involves breaking up of the host image into 4x4 blocks and then SVD technique is applied with the insertion of the traces of block wise SVD within the least significant bit (SVD) of the image pixels.

[13](Neena Raj N.R and Shreelekshmi R, 2018) have proposed a scheme known as block wise fragile watermarking scheme. The paper presented consists of two fragile watermarking schemes which are further divided into 8x8 blocks and 128bit hash value is calculated for each of the block with the usage of the MD5 algorithm.

These values are embedded within the two LSBs of the pixel values in the cover image. [14](Yang Liu, et.al, 2018) have proposed a new scheme known as digital image watermarking which is mainly model based upon scrambling algorithm Logistic along with the RSA asymmetric encryption algorithm. The usage of these two algorithms is mainly due to guarantee the security of the data which is hidden. The experiments results obtained describes the application of the encryption algorithms of Logistic along with the RSA for the watermark image and carrying out the hybrid decomposition of the Discrete wavelet transform (DWT) as well as Singular Value Decomposition (SVD) over the host image.

[15](Zhengwei Zhang, et.al, 2017) have proposed a methodology known as adaptive reversible image watermarking for the purpose of improving the robustness, imperceptibility, and anti-malicious extraction capability. The algorithm is mainly based upon the IWT and level set. At the beginning the proposed algorithm involves the extraction of the stable edge profile with the usage of the Laplace operator along with the level set methods. In the second step the unit circle within the stable edge profile is notified.

[16](Wen-Chuan Wu, 2017) have proposed a digital image watermarking technique known as quantization-based image authentication scheme using QR error correction. The proposed scheme is mainly based upon quantization-based image authentication scheme using two-dimensional barcodes mainly to protect important features. The method involves incorporating VQ-compressed code within the 2D barcodes and embedding those barcodes within the image itself. Thus it is observed that the scheme provides higher degree of quality authenticated and recovered images as compared with the existing methods.

### III. METHODOLOGY

**Discrete Wavelet Transform:** The wavelet is referred as a small wave. The image that is under consideration is divided into four non-overlapping multiresolution sub-bands at the beginning and are mainly cD1, cV1, cH1, and cA1 were the sub-bands cA1 signifying the coarse-scale DWT coefficients and the sub-bands cD1, cV1, and cH1 signifies the fine-scale of the DWT coefficients. Further to obtain the different fine-scale of wavelet coefficients the obtained sub-band cD1 is further divided. Selection of a particular wavelet mainly depends upon the application that is about to develop. Wavelet transform is responsible to provide both temporal as well as providing the frequency information.

**PN-Sequence generator:** PN-Sequence generator a block used mainly to generate a sequence of pseudorandom binary numbers that uses a linear-feedback shift register (LFSR). This block is built mainly using the LFSR that is responsible for a simple shift register generator configuration. Thus the obtained pseudo-noise sequences can also be used within a given pseudorandom scrambler and also within a descrambler. It is also possible to utilize the same within a direct-sequence spread-spectrum system.

### Method for embedding a watermark image into the cover image

Algorithm1: Watermark Embedding

Start

- Step 1: Read the cover image
- Step 2: Read watermark image
- Step 3: Set the gain factor  $k=1$
- Step 4: Resize the cover image to  $512 \times 512$
- Step 5: Determine the size of cover image
- Step 6: Determine the size of watermark image
- Step 7: Reshape the watermarked image
- Step 8: Generate the random numbers
- Step 9: Apply 2-level DWT to the cover image
- Step 10: Apply 2-level DWT to the CD band
- Step 11: Perform the operation over the first element of the message vector until the last element of the message vector
- Step 12: Generate pn\_sequence with dimensions quarter to the size of the cover image
- Step 13: Apply the control statement  
 If(message1(kk)==0)  $cD2=cD2+k*pn\_sequence\_v$ ;  
 end
- Step 14: Apply 2-idwt
- Step 15: Apply 2-idwt to cD11
- Step 16: Calculate the PSNR and correlation
- Step 20: Repeat the steps from Step10 to Step16 by changing the sub-band of the DWT

End

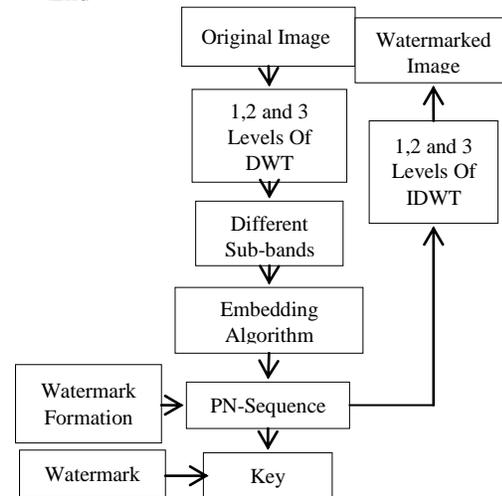


Fig.3. Block diagram For Watermark Embedding

The proposed methodology involves reading the original cover image and the determination of the size of the original image and storing the dimension values within the variables. The step is followed by reading the watermark image and determining the size. The methodology involves the generation of the random numbers with the seed being the state. Apply two levels of DWT to the cover image. Generate the pn-sequence values with the usage of the dimensions of the random number being equal to the quarter size of the cover size. Embed the watermark with the usage of the pn-sequence numbers. Finally, apply two-dimensional idwt to obtain the watermarked image and write the image into another image.

## Method for extracting the watermark image from the cover image

### Algorithm 2: Watermark Extraction

Start

- Step 1: Read the watermarked image
- Step 2: Determine size of watermarked Image
- Step 3: Read the original watermark image
- Step 4: Determine size of original watermark image
- Step 5: Generate random numbers
- Step 6: Create a message vector of ones

Step 7: Apply 2-DWT to watermarked image to find four sub-bands

Step 8: Apply 2-DWT to the cD1 sub-band

Step 9: Apply conditional loop

```

(kk=1:length(message_vector))
pn_sequence_v=round(2*(rand(Mw/4,Nw/4)-0.5))
correlation_h1(kk)=corr2(cD2(:, :, 1), pn_sequence_v)
Correlation(kk)=(correlation_h1(kk))
    
```

Step 10: Repeat step 9 by changing the condition

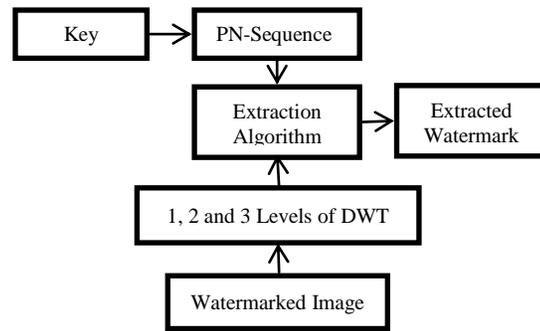
Step 11: Repeat the Steps from step 7 to step 11 by changing 2-DWT to 1-DWT and 3-DWT and by changing the sub-bands and by changing the different channels (R, G and B) form the RGB color images.

Step 14: Calculate the PSNR values and obtain the Correlation values in all of the cases

End

The extraction procedure within the proposed scheme involves reading of the watermarked image into a variable and finding the dimensions of the watermarked image. The proposed scheme also involves reading the original image and notifying its dimensions too. The extraction process involves the generation of the message vector consisting of ones which are of the size equal to the original watermark image. Further application of the two dimensional DWT is carried-out to the watermarked image followed by generation of the PN-sequence. Then correlating method is established between the values of the HH2 sub-bands and pn-sequence for each of the planes within the watermarked image. Finally, a conditional statement is established i.e if the correlated values of the message vector are greater than the mean (correlation) then values of the message vector is set to zero else it will be set to 1.

The extraction process from the below figure 4 is carried out by using the above extraction algorithm.



**Fig.4. Block diagram for extracting the Watermark**

## IV. RESULTS AND DISCUSSION

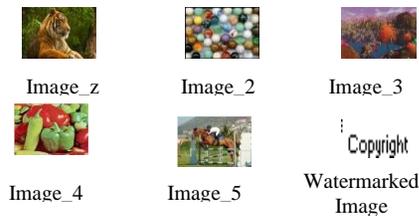
**PSNR:** The term PSNR is referred as the peak signal-to-noise (PSNR) which can be mentioned using an expression that is capable to describe the ratio existing between the power of maximum possible values associated with an image and the power of distortion of the noise which affects the quality of the images. The units associated with PSNR will be in terms of the logarithmic decibel scale and the associated equation can be given as:

$$PSNR = 20 \log_{10} \frac{2^8 - 1}{\sqrt{MSE}} \dots \dots \dots (1)$$

**Correlation** The correlation technique of processing image results to the comparison of the image before it is processed and after it is processed. The formula for the correlation process can be given as:

$$r = \frac{\sum_i (x_i - x_m)(y_i - y_m)}{\sqrt{\sum_i (x_i - x_m)^2} \sqrt{\sum_i (y_i - y_m)^2}} \dots \dots \dots (2)$$

The test images are shown below:



**Fig.5. Test Images**

The experiment is carried out on a set of images having the bitmap format. Table numbered 1, 2 and 3 show the results obtained when the watermark is inserted within the CD band of the DWT transformation for the 1-level.

**TABLE I PSNR and correlation for 1-Level of DWT cD1 sub-band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0481	1
	Copyright	37.0127	1

	Copyright	36.9127	1
	Copyright	36.9860	1
	Copyright	36.9629	1

**TABLE II PSNR and correlation for 1-Level of DWT cD1 band when extracted from green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0481	1
	Copyright	37.0127	1
	Copyright	36.9129	1
	Copyright	36.9860	1
	Copyright	36.9629	1

**TABLE III PSNR and correlation for 1-Level of DWT cD1 sub-band when extracted from blue channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0481	1
	Copyright	37.0127	1
	Copyright	36.9129	1
	Copyright	36.9860	1
	Copyright	36.9629	1

The experiment is further carried-out by inserting the watermark image within the cV1 sub-band and extracting the same watermark image from the red, green and blue channel of the RGB color images. The table numbered 4, 5 and 6 outputs the results in all of the cases. Based upon the results obtained again it is declared that the scheme turns to be robust in all of the cases.

**TABLE IV PSNR and Correlation for 1-Level of DWT cV1 sub- band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0480	1
	Copyright	37.0133	1
	Copyright	36.9125	1

	Copyright	36.9855	1
	Copyright	36.9631	1

**TABLE V PSNR and Correlation for 1-Level of DWT cV1 sub-band when extracted from green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0480	1
	Copyright	37.0133	1
	Copyright	36.9125	1
	Copyright	36.9855	1
	Copyright	36.9631	1

**TABLE VI PSNR and correlation for 1-Level of DWT cV1 sub-band when extracted from blue channel**

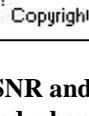
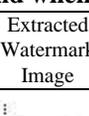
Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0480	1
	Copyright	37.0133	1
	Copyright	36.9125	1
	Copyright	36.9855	1
	Copyright	36.9631	1

The experiment is carried out by inserting the watermark image within the cH1 sub-band by retrieving the watermark image from all of the channels red green and blue. The results are obtained in all of the cases from the table numbered 7, 8 and 9 which show the scheme still lies as the robust image watermarking.

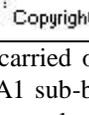
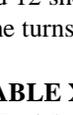
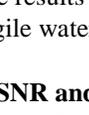
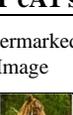
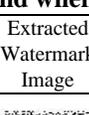
**TABLE VII PSNR and Correlation for 1-Level of DWT cH1 sub- band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	37.0436	1
	Copyright	37.0085	1
	Copyright	36.9080	1
	Copyright	36.9799	1
	Copyright	36.9579	1

**TABLE VIII PSNR and Correlation for 1-Level of DWT cH1 sub-band when extracted from green channel**

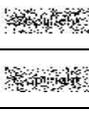
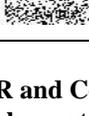
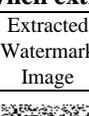
Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		37.0436	1
		37.0085	1
		36.9080	1
		36.9799	1
		36.9579	1

**TABLE IX PSNR and Correlation for 1-Level of DWT cH1 sub-band when extracted from blue channel**

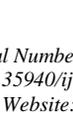
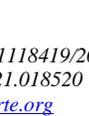
Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		37.0436	1
		37.0085	1
		36.9080	1
		36.9799	1
		36.9579	1

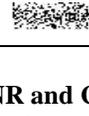
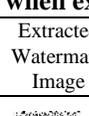
The experiment is carried out by inserting the watermark image within the cA1 sub-band. Table numbered with 10, 11 and 12 shows the results obtained based upon which the scheme turns to fragile watermarking.

**TABLE X PSNR and Correlation for 1-level of DWT cA1 sub-band when extracted from red channel**

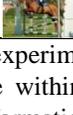
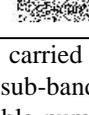
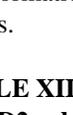
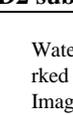
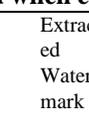
Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		37.0461	0.2963
		37.0126	0.3494
		36.9128	0.3759
		36.9875	0.4844
		36.9630	0.3742

**TABLE XI PSNR and Correlation for 1-level of DWT cA1 sub-band when extracted from green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		37.0461	0.4533
		37.0126	0.3336

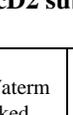
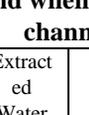
		36.9128	0.5810
		36.9857	0.3151
		36.9630	0.3864

**TABLE XII PSNR and Correlation for 1-level of DWT cA1 sub-band when extracted from blue channel**

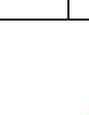
Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		37.0461	0.4930
		37.0126	0.2537
		36.9218	0.4799
		36.9857	0.4771
		36.9630	0.3590

The experiment is carried out by inserting the watermark image within the sub-bands of the 2- level of the DWT transformation. Table numbered 13, 14 and 15 shows the results.

**TABLE XIII PSNR and Correlation for 2-level of DWT cD2 sub-band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		42.8913	1
		42.9236	1
		42.8396	1
		42.9015	1
		42.8721	1

**TABLE XIV PSNR and Correlation for 2-levels of DWT cD2 sub-band when extracted from green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		42.8913	1
		42.9236	1

	Copyright	42.8396	1
	Copyright	42.015	1
	Copyright	42.8721	1

**TABLE XV PSNR and Correlation for 2-levels of DWT cD2 sub-band when extracted from blue channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8913	1
	Copyright	42.9236	1
	Copyright	42.8396	1
	Copyright	42.9015	1
	Copyright	42.8721	1

The process involves embedding of the watermark image within the cA2 sub-band of the DWT transformation. The results obtained thus declare that the scheme is turned to be fragile digital image watermarking. Table numbered from 16, 17 and 18 shows the results and the corresponding images.

**TABLE XVI PSNR and Correlation for 2-level of DWT cA2 sub-band when extracted from red channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
		42.8800	0.0962
		42.9067	0.0858
		42.8186	0.1084
		42.8808	0.1465
		42.8513	0.09632

**TABLE XVII PSNR and Correlation for 2-level of DWT cA2 sub-band when extracted from green channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
		42.8880	0.1548
		42.9067	0.1154
		42.8186	0.1698
		42.8808	0.0877
		42.8513	0.0746

**TABLE XVIII PSNR and correlation for 2-level of DWT cA2 sub-band when extracted from blue channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
		42.8800	0.1617
		42.9067	0.1030
		42.8186	0.1183
		42.8808	0.1511
		42.8513	0.0806

The process of insertion within the cV2 sub-band is carried out. Table numbered from 19, 20 and 21 shows the results which lie within the acceptable range of values.

**TABLE XIX PSNR and correlation for 2-level of DWT cV2 sub-band when extracted red channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8890	0.8336

## Digital Image Watermarking at Different Levels of DWT using RGB Channels

	Copyright	42.9257	1
	Copyright	42.8390	0.9189
	Copyright	42.9008	0.9455
	Copyright	42.8717	0.8031

**TABLE XX PSNR correlation for 2-level of DWT cV2 sub-band when extracted from green channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8890	0.8923
	Copyright	42.9257	1
	Copyright	42.8390	0.9743
	Copyright	42.9008	0.9410
	Copyright	42.8717	0.8062

**TABLE XXI PSNR and correlation for 2-level of DWT cV2 sub-band when extracted from blue channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8890	0.9549
	Copyright	42.9257	1
	Copyright	42.8390	0.9743
	Copyright	42.9008	0.9693
	Copyright	42.8717	0.8284

The procedure is carried out with the usage of the cH2 sub-band by the application of the proposed scheme. The results are obtained along with the respective

images. Table numbered from 22, 23 and 24 shows the analysis.

**TABLE XXII PSNR and Correlation for 2-level of DWT cH2 sub-band when extracted from red channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8876	0.9895
	Copyright	42.9203	1
	Copyright	42.8368	0.9844
	Copyright	42.8985	0.9693
	Copyright	42.8696	0.9364

**TABLE XXIII PSNR and Correlation for 2-level of DWT cH2 sub-band extracted from green channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8876	0.9947
	Copyright	42.9203	1
	Copyright	42.8368	0.9947
	Copyright	42.8985	0.9693
	Copyright	42.8696	0.9455

**TABLE XXIV PSNR and correlation for 2-level of DWT cH2 sub-band extracted from blue channel**

Watermarked Image	Extracted Water mark Image	PSNR	Correlation
	Copyright	42.8876	0.9895
	Copyright	42.9203	1
	Copyright	42.8368	1

	Copyright	42.89 85	0.9549
	Copyright	42.86 96	0.9410

The experiment is carried out by inserting the watermark image within the 3-level of the DWT transformation. Table numbered 25, 26 and 27 show the results when the watermark image is inserted and extracted.

**TABLE XXV PSNR and Correlation for 3-level of DWT cD3 sub-band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	48.6250	0.9104
	Copyright	48.6682	0.9693
	Copyright	48.6063	0.9549
	Copyright	48.6585	0.9596
	Copyright	48.6240	0.9021

**TABLE XXVI PSNR and Correlation for 3-level of DWT cD3 sub-band when extracted from Green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	48.6250	0.9146
	Copyright	48.6682	0.9693
	Copyright	48.6063	0.9549
	Copyright	48.6585	0.9645
	Copyright	48.6240	0.9104

**TABLE XXVII PSNR and Correlation for 3-level of DWT cD3 sub-band when extracted from Blue channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
	Copyright	48.6250	0.9181
	Copyright	48.6682	0.9645
	Copyright	48.6063	0.9455
	Copyright	48.6585	0.9596
	Copyright	48.6240	0.9232

	Copyright	48.6250	0.9181
	Copyright	48.6682	0.9645
	Copyright	48.6063	0.9455
	Copyright	48.6585	0.9596
	Copyright	48.6240	0.9232

The 3- level of the digital image watermarking is carried out within the cV3 sub-band of the DWT. The table numbered from 28, 29 and 30 shows the behavior of the scheme.

**TABLE XXVIII PSNR and correlation for 3-level of DWT cV3 band within red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6239	0.4041
		48.6707	0.6947
		48.6043	0.4864
		48.6617	0.4907
		48.6242	0.3668

**TABLE XXIX PSNR and Correlation for 3-level of DWT cV3 sub-band when extracted from green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6239	0.4413
		48.6707	0.6995
		48.6043	0.5615
		48.6614	0.4427
		48.6242	0.3792

**TABLE XXX PSNR and Correlation for 3-level of DWT**

**cV3 sub-band when extracted from Blue channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6239	0.5532
		48.6707	0.6960
		48.6043	0.6112
		48.6614	0.5133
		48.6242	0.3732

The 3-level of the digital image watermarking is carried out within the cH3 sub-band of the DWT transformation and the corresponding extracted images are analyzed with the correlation results obtained. The table numbered from 30, 31 and 32 clearly shows the behavior of the scheme.

**TABLE XXXI PSNR and Correlation for 3-level of DWT cH3 sub-band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6230	0.6463
		48.6686	0.8560
		48.6039	0.5984
		48.6586	0.6478
		48.6241	0.5010

**TABLE XXXII PSNR and Correlation for 3-level of**

**DWT cH3 sub-band when extracted from Green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6230	0.6861
		48.6686	0.8560
		48.6039	0.7291

		48.6586	0.6059
		48.6241	0.5240

**TABLE XXXIII PSNR and Correlation for 3-level of**

**DWT cH3 sub-band when extracted from blue channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6230	0.7429
		48.6686	0.8489
		48.639	0.7759
		48.6586	0.6349
		48.6241	0.5549

The table numbered from 33, 34 and 35 clearly shows the behavior of the scheme to insert a watermark image within the cA3 sub-band of the DWT and the extraction process from the various channels of the RGB images.

**TABLE XXXIV PSNR and Correlation for 3-level of**

**DWT cA3 sub-band when extracted from red channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6657	0.0668
		48.7051	-0.0333
		48.6355	0.00050
		48.6931	-0.0191
		48.6515	-58926e-04

**TABLE XXXV PSNR and Correlation for 3-level of DWT cA3 sub-band when extracted from Green channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6657	0.0362

		448.7051	-0.0408
		48.6355	0.0823
		48.6931	0.0370
		48.6515	-0.0026

**TABLE XXXVI PSNR and Correlation for 3-level of DWT cA3 sub-band when extracted from Blue channel**

Watermarked Image	Extracted Watermark Image	PSNR	Correlation
		48.6657	0.0362
		48.7051	0.0071
		48.6355	0.0702
		48.6931	-9.5096e-04
		48.6515	-0.0083

**V. CONCLUSION**

The proposed scheme of digital image watermarking is analyzed at different levels of the DWT transformation. The method is also analyzed by inserting the watermark image at different sub-bands of the DWT. The experimental results obtained as above thus conclude that the proposed scheme of digital image watermarking is capable enough to maintain its robustness behavior for certain cases for a given fixed size of the cover image and again by analyzing certain results at different levels of DWT for different forms of sub-bands it is declared that the robustness behavior of the proposed scheme gradually shifts from robustness to semi-fragile digital image watermarking. By analyzing the results obtained for the third-level of DWT watermark insertion and extraction clearly shows that the proposed scheme gradually shifts from the semi-fragile behavior to completely fragile digital image watermarking. Hence the paper establishes a comparison test between insertion and extraction of a watermark image.

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