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1 Level DWT Image Watermarking Algorithm for RGB Cover Images and Watermarks

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Abstract: *This paper proposes a new 1 level DWT (Discrete wavelet transform) robust image watermarking algorithm for RGB cover images and watermarks. In the proposed algorithm 1 level DWT is applied on RGB cover image. The DWT divides cover image into four bands namely a lower resolution approximation image (LL) as well as horizontal (HH), vertical (LH) and diagonal (HL) detail components and watermark is inserted into LL sub band. As high frequency sub-band is usually removed through noise attacks. The proposed algorithm is imperceptible as well as robust against wide variety of image processing attacks like Gaussian noise, Salt –pepper noise, Gaussian filter, Median filter, Histogram Equalization etc. The watermarked image is of good quality and achieves high PSNR. The proposed watermarking algorithm shows efficient detection of watermark. Extracted RGB watermark is same as that of original watermark with NC value as 0.99.*
Keywords: *DWT (Discrete Wavelet Transform), MSE (Mean Square Error), Normalized Correlation (NC), PSNR (Peak Signal to Noise), cover image, watermarked image*

I. Introduction

The desire for the availability of information and quick distribution has been a major factor in the development of new technology in the last decade. There is increased use of multimedia across the Internet. Multimedia distribution has become an important way to deliver services to people around the world. However, this advancement has also brought the challenge such as copyright protection for content providers [1, 5, 9].

Fig 1: Motivations behind digital watermarking

Figure 1 shows motivations behind digital watermarking. Copyright abuse is rampant among multimedia users who are rarely caught. This copyright abuse is the motivating factor in developing new encryption technologies. One such technology is digital watermarking. Suppose a person X creates a digital content and publish it on the web. A person Y with bad intentions steals that digital content, maybe modify it little bit and then start selling, as it was his own. X notices that Y is selling his digital content. But how can he prove that he is really the owner and make Y to pay him a lot of money? Many solutions are there to solve this problem like digital signatures. But these solutions need additional bandwidth. So, Due to limitations of the traditional copyright protection system, a new technique came in existence. This technique is known as digital watermarking [2]. The structure of typical digital watermarking system consists of mainly three parts watermark insertion unit, watermark extraction unit and watermark detection unit. Thus, process of digital watermarking technique includes three processes namely watermark insertion process, watermark extraction process and watermark detection process. Digital watermarking, sometimes called "fingerprinting", allows copyright owners to incorporate into their work identifying information invisible to the human eye [4]. "A pattern of bits inserted into a digital image, audio or video file that identifies the file's copyright information (author, rights)", is known as digital watermarking [5, 8, 13, 14].

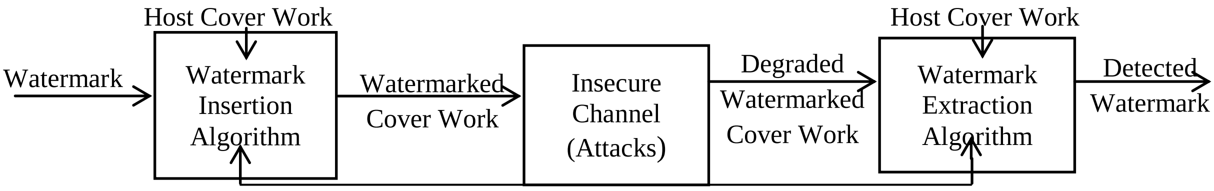


Fig 2: General watermarking system

Above figure 2 shows general watermarking system. In the above figure host cover work can be an image, video, audio or a text file. The watermark insertion algorithm is having two inputs namely, cover work and watermark and its output is watermarked work which is input to watermark detector. Then after performing some operations detector gives detected watermark. Now a day's people are highly dependent on network technology, the users of networks especially over the Internet are increasing enormously. The increased importance of digital content invites new challenges for securing the distribution of digital media. This copyright misuse is the motivating factor in developing new watermarking techniques. Spatial domain watermarking refers to directly modifying pixel values of carrier signal to embed watermark. The spatial domain is the normal image space, in which a change in position I directly projects to a change in position in image space. A watermark technique based on the spatial domain, spread watermark data to be embedded in the pixel value. These approaches use minor changes in the pixel value intensity. Darshana et al. [4] proposed LSB algorithm, a spatial domain watermarking algorithm and compared it with frequency domain watermarking algorithms namely DCT and DWT. Frequency domain watermarking is more secure and robust as compare to spatial domain watermarking. Akhil et al. [5] proposed a robust image watermarking technique for grey scale images based on 1 level DWT. This method embeds invisible watermark into the original image by using alpha blending technique. Experimental result shows that the insertion and extraction of watermark depends only on the value of alpha. As mentioned earlier, digital watermarking techniques are useful for insertion metadata in multimedia content. There are alternate mechanisms like using the header of a digital file to store meta-information [6].

The paper is organized as follows: Section 1 is on introduction. An introduction to DWT is given in section 2. Section 3 explains proposed algorithm based on 1 level DWT watermark insertion and extraction algorithms. Section 4 depicts experimental results on 10 cover images and 5 watermarks before and after application of various different attacks. Section 5 presents the conclusion.

II. Preliminaries

Discrete Wavelet Transform (DWT)

Discrete wavelet transform (DWT) [5] is a mathematical tool for hierarchically decomposing an image. The DWT decompose an image into a lower resolution approximation image (LL) as well as horizontal (HH), vertical (LH) and diagonal (HL) detail components [6].

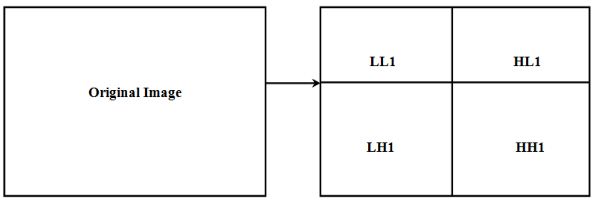


Fig 2: 1 level DWT

After the first level of decomposition, there are 4 sub-bands: LL1, LH1, HL1, and HH1. In this paper for watermark embedding LL1 sub-band is selected. As high frequency sub-band is usually removed through noise attacks.

III. Proposed Method

Proposed method is divided into two subsections section A describes 1 Level DWT Watermark insertion algorithm and B describes watermark extraction process.

A. 1 Level DWT Watermark Insertion Algorithm

Inputs: Cover image and colored watermark
Output: Watermarked image
The steps are as follows:

1. Take color cover image and decompose color image into R, G and B planes.
2. Apply 1 level DWT on R, G and B planes of cover image as well as color watermark.
3. Color watermark is embedded using alpha blending technique, given in equation 1,
   WMI = (LL1) +α × (WM1) (1)
   Where, WM1 denotes low frequency approximation of watermark,
   LL1 denotes low frequency approximation of the original image,
   WMI denotes watermarked image,
   α denotes quality factor
4. Apply inverse 1 level DWT on WMI of each plane separately.
5. Combine modified R, G and B planes to get watermarked image.
6.

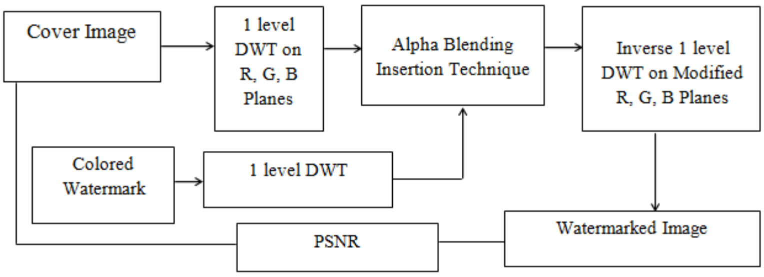


Fig 3: Block diagram of 1 level DWT watermark insertion algorithm

B. 1 Level DWT Watermark Extraction Algorithm

Inputs: Watermarked image and cover image
Output: Extracted colored watermark
The steps are as follows:

1. Take color watermarked image and decompose watermarked image into R, G and B planes.
2. Apply 1 level DWT on R, G and B planes of cover image as well as watermarked image.
3. Watermark is extracted using alpha blending technique from R, G and B planes separately and is given in equation 2,
   WM1 = WMI - (LL1) /α (2)
   Where, WM1 denotes low frequency approximation of watermark,
   LL1 denotes low frequency approximation of the original image,
   WMI denotes watermarked image,
   α denotes quality factor
4. Apply Inverse 1 level DWT on WM1 of R, G and B planes.
5. Combine watermark extracted from each plane R, G and B plane to get color watermark image.

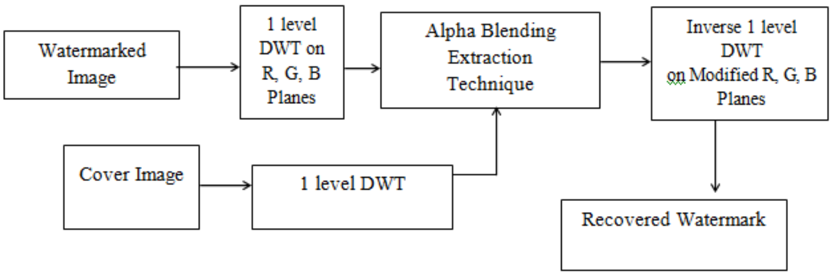


Fig 4: Block diagram of 1 level DWT watermark extraction algorithm

IV. Experimental Results

The proposed image watermarking algorithm is implemented on Intel Core i5 processor, 4GB RAM machine and Matlab R2011b.The proposed method is tested on five cover images like Waterlili, Leaf, Bear Peacock, Red Roses and on five watermarks like C-img1, C-img2, C-img3, C-img4, C-img5 of size 512×512 and type jpeg. For evaluating the performance of proposed algorithm Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Normalized correlation (NC) performance evaluators are used.

$$\mathbf{MSE}=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[I(i,j)-i,j]2 \quad (3)$$

$$\textbf{PSNR} = 10\ \mathbf{log_{10}}\left(\frac{255^2}{\mathbf{MSE}}\right) \qquad (4)$$

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

$$\textbf{NC} = \frac{\sum_i \sum_j \mathbf{w(i,j)w'(i,j)}}{\sum_i \sum_j \mathbf{w(i,j)^2}} \qquad (5)$$

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

Equation 3, 4 and 5 represents MSE, PSNR and NC evaluator's parameters respectively.

A. Ten Test Color Cover Images.jpg

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

Fig 3: Test Cover Images (a) Waterlili (b) Bear (c) Leaf (d) Peacock (e) Red Roses

Above figure 3 shows five RGB test cover images namely Waterlili, Bear, Leaf, Peacock and Red Roses. All the test cover images are of size 512×512 and type jpeg.

B. Five Test Color Watermark Images.jpg

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

Fig 4: Test Watermark Images (a) C-img1 (b) C-img2 (c) C-img3 (d) C-img4 (e) C-img5

Above figure 4 shows five RGB watermark images namely C-img1, C-img2, C-img3, C-img4, C-img5.All the test watermark images of size 512×512 and type jpeg.

C. Results of 1 Level DWT Color Image Watermarking

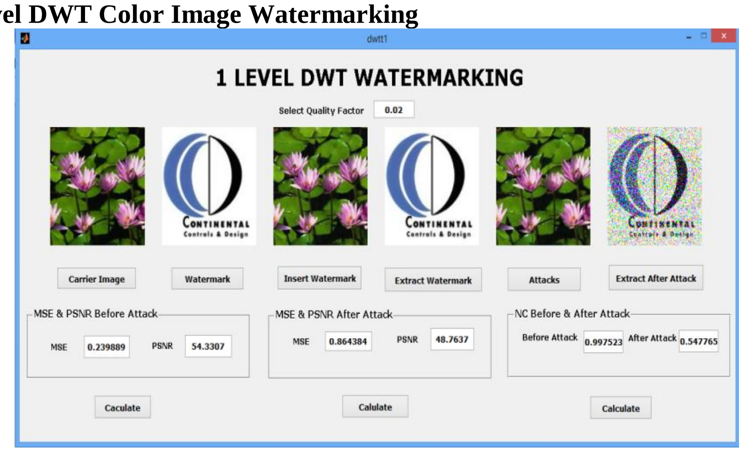


Fig 5: Main GUI of 1 level DWT image watermarking algorithm

Figure 5 represents GUI of 1 level DWT image watermarking algorithm with PSNR and NC values before and after application of image processing attacks.

Cover Image (512×512) **Watermark (512×512)** **Watermarked Image (512×512)**

Fig 6: 1 level DWT watermark insertion process

Watermarked Image (512×512) **Cover Image (512×512)** **Watermark (512×512)**

Fig 7: 1 level DWT watermark extraction process

Above figure 6 and figure 7 shows 1 level DWT watermark insertion and extraction process. Watermark insertion process takes cover image and watermark as input and gives watermarked image as output. Watermark extraction process takes watermarked image and cover image as input and returns watermark image.

Table 1: Results of 1 level DWT algorithm on Waterlili image and C-img3 watermark under attacks

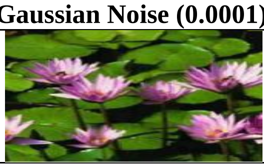
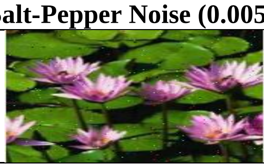
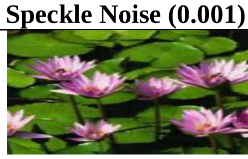
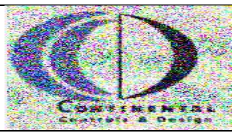
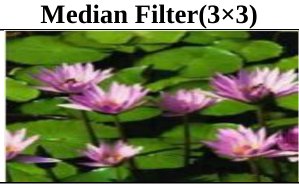
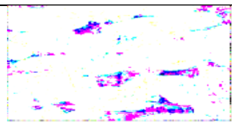
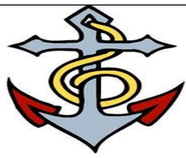
Attacks	**Gaussian Noise (0.0001)**	**Salt-Pepper Noise (0.005)**	**Speckle Noise (0.001)**
Attacked Image (512×512)			
PSNR(dB)	**48.7637**	**49.4357**	**45.7471**
Extracted Watermark (512×512)			
NC	**0.5478**	**0.2644**	**0.5168**
Attacks	**Gaussian Filter(3×3)**	**Median Filter(3×3)**	**Histogram Equalization**
Attacked Image (512×512)			
PSNR(dB)	**51.2931**	**51.6994**	**52.4032**
Extracted Watermark (512×512)			
NC	**0.6006**	**0.5989**	**0.0916**

Table 2: Results of 1 level DWT on four cover images and five colored watermarks

Color Cover Image (512×512)	Colored Watermark (512×512)	Watermarked Image (512×512)	Extracted Image (512×512)
 **Bear**	 **C-img1**	 **PSNR =53.1653**	 **NC=0.9978**
 **Leaf**	 **C-img2**	 **PSNR =52.0435**	 **NC=0.9938**
 **Peacock**	 **C-img4**	 **PSNR =50.5008**	 **NC=0.9988**
 **Red Roses**	 **C-img5**	 **PSNR =54.8034**	 **NC=0.9978**

Above table 1 shows Results of 1 level DWT algorithm on Waterlili image and C-img3 watermark under various attacks like Gaussian noise, Salt –pepper noise, Gaussian filter, Median filter, Histogram Equalization. Table 2 shows results of 1 level DWT on four cover images and watermarks wit PSNR and NC values.

V. Conclusion

Various image watermarking algorithms have been proposed in spatial and frequency domains but very few watermarking algorithms are proposed which embeds RGB watermark in RGB cover image. This paper presents a frequency domain color image watermarking algorithm based on 1 level DWT. Proposed method is robust and secure because watermark is inserted in only LL sub-band. The performance of proposed algorithm is measured using performance evaluators such as Peak Signal to Noise Ratio (PSNR) and Normalized correlation (NC). The proposed method achieves average PSNR of 51.94 dB and NC as 0.99. Based on experimental results the proposed 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 etc.

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