

# Bit Plane Slicing based Digital Watermarking Technique in DWT Domain

Mayank Mishra, Nirmal Kumar Rout, Nageswara Rao Budipi



**Abstract:** Authenticity of image and its copyright protection are one of the essential application of watermarking. In this paper, a hybrid technique for watermarking in DWT domain is presented for its application in the field of providing authentication to images. In this work binary image is used as watermark and is embedded in the 'host image'. Before embedding the watermark in the host, the host image is splitted into 8 bit planes using bit plane slicing. Followed that DWT is applied to the least significant bit plane which partitions the respective plane into low frequency (LL subband) and high frequency (HH, HL and LH subbands). The SVD is applied to HH subband of least significant bit plane and watermark is embedded on the singular matrix part of SVD. To analyse the robustness of the scheme proposed in this paper, watermarked image is attacked by different image processing attacks. Original watermark and extracted watermark is compared on the scale of normalized correlation to measure the robustness of the scheme against various attacks.

**Index Terms:** Bit plane slicing, SVD, DWT, digital image watermarking, robust.

## I. INTRODUCTION

Digital watermarking is a procedure in which a client determined signal (watermark) is covered or implanted into another signal (cover data), like electronics data, pictures, sounds and video [1]. Right around 90% of data are being transmitted in 'image' and 'video', various methods have been produced for these two gatherings [2].

Image watermarking is an efficient answer for confirmation and copyright security of images in famous correspondence like web, which is vulnerable to illicit issue [3]. Image watermarking technique can be discriminated into two spaces: spatial domain and transform domain. Image watermarking in transform domain are better due to its superb execution in contrast with an image watermarking in a spatial domain. As of late a few techniques are presented in transform domain, among which wavelet transform domain show up as best technique because of its property of 'frequency localization' [4-8]. Gaurav Bhatnagar et. al puts forward a scheme of wtaermarking i.e semi-blind reference watermarking. In his proposed scheme the watermark is a visually meaningful gray scale image in place of noise type

Gaussian sequence [9]. Ali Al-Haj described a combined technique of DWT and DCT for watermarking. Experimental results of this work shows that the combination of these two transforms improved the performance of watermarking considerably in comparison to the DWT only watermarking approach. [10]. Li Hui-Fang presented the study on digital image watermarking in wavelet transform domain. The experimental results of this work shows that the digital watermark's invisibility is effective [11]. Mohammad-Reza et. al presents a block based image watermarking in DWT domain and is robust as well as dynamic. This scheme is appropriate for maps and natural images which have better edges [12]. Nasrin M. Makhbol et. al. presented the robust blind image watermarking scheme based on Redundant DWT and SVD. The experimental results of this scheme was found to be robust against various geometrical and non-geometrical attack. This paper presents the hybrid watermarking scheme in DWT domain to provide the authentication to the images.

## II. DISCRETE WAVELET TRANSFORM DOMAIN

Wavelets are extraordinary functions, which, in a frame practically equivalent to Sines and Cosines in 'Fourier Analysis' are utilized as 'basal function' for characterising signals [10].

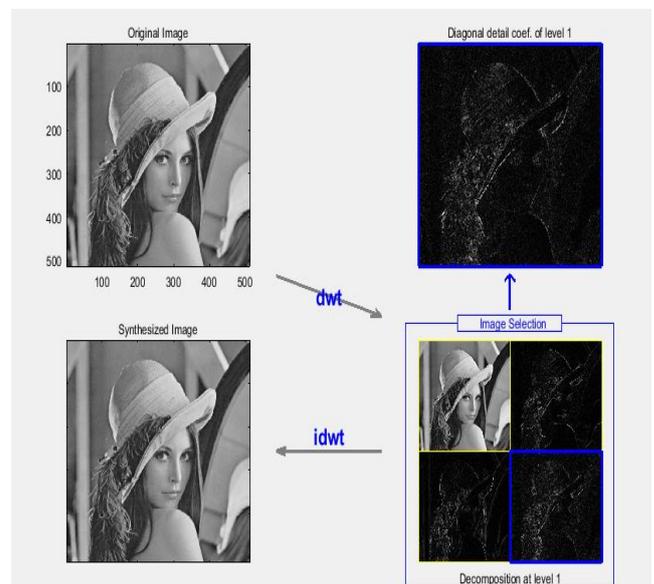


Fig. 1. DWT of Host Image

DWT is tremendously preferred on the grounds that it provides spatial localization as well as frequency spread of the image to be embedded, i.e watermark inside the host image.

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The fundamental thought of DWT in image handling is to multi-separated decay the image into sub image of various 'spatial domain' and independent frequency locale [12]. The proposed scheme applies DWT using Haar wavelet transform as shown in Fig. 1.

### III. SINGULAR VALUE DECOMPOSITION (SVD)

Any real or complex matrix  $M$  of dimension  $m \times n$  can be splitted into two orthogonal matrices  $A$  and  $B$  and a diagonal matrix  $D$ . The data values in the diagonal matrix are known as singular value of matrix  $M$ . This process of splitting is known as Singular Value Decomposition of matrix  $M$ . It can be expressed as:

$$M = ADB' \quad [1]$$

SVD is commonly used because of its importance in image processing. Firstly, the size of the matrices is not permanent, it can be a rectangle or a square. Furthermore, in an image, singular values are not affected by the general processing, as higher singular values preserve maximum energy of an image and also it resist against various attacks [9].

### IV. BIT PLANE SLICING

Image is represented digitally in terms of pixels, which can be further expressed in terms of bits. An 8 bit image contains eight 1-bit planes. 'Variant of intensity level' is visualised in Bit plane slicing. It results in splitting of 8 bit image into the eight 1-bit planes to represent the contribution of each bit as shown in Fig.2. Plane 1 contains the lowest order bit of all the pixels in the image, and contribution of lower order would be to more precise intensity details in the image. After splitting the image into 8 bit plane, it can be reconstructed by multiplying the pixels of the  $p^{\text{th}}$  plane by the constant  $2^{p-1}$ . The image so formed have pixel intensity values either 1 or 0 i.e. binary images [13].

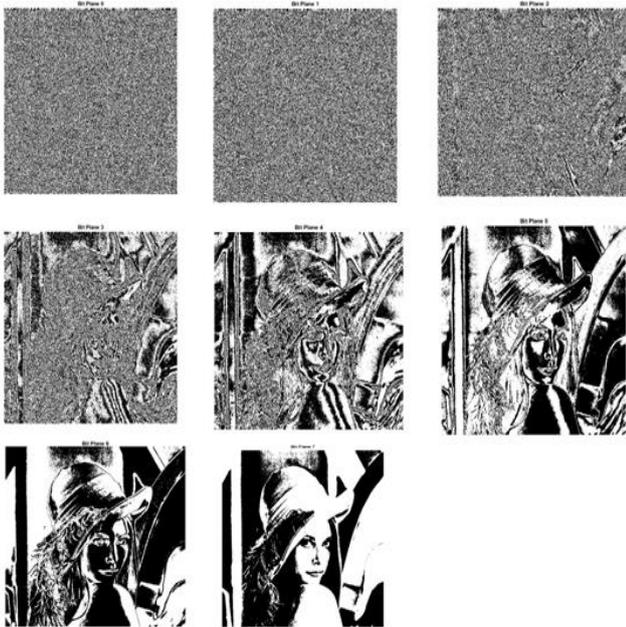


Fig. 2. Bit plane slicing of an host image

## V. PROPOSED SCHEME

This section covers the description of the proposed scheme of this paper. It involves two basic path, watermark embedding and extraction of watermark

### A. Watermark Embedding

This step is further divided into 5 major steps such as,

- i) Splitting of the grayscale host image into 8 bit binary plane.
- ii) DWT is applied to the plane 1 after splitting of the image.
- iii) As a result of DWT, plane 1 is splitted into 4 different subbands i.e, HH subband, HL subband, LH subband and LL subband.
- iv) After resulting to HH subband, SVD is applied in this particular subband. As a result of SVD, HH subband is splitted into three matrices: [8]:

$$I = (M).(N).(O)^T \quad (1)$$

where  $N$  is the diagonal matrix having singular values, whereas  $I$  shows the HH subband. The watermark ' $W$ ' is embedded into the matrix  $N$ . This results to matrix  $H$ , and is defined as [8]:

$$H = N + KW \quad (2)$$

where  $K$  is the scaling factor.

SVD is applied again on the matrix  $H$ , and can be defined as: [8]:

$$H = (M_f).(N_f).(O_f)^T \quad (3)$$

Using matrix  $H$ , watermarked image  $I_f$  is obtained as follows [8]:

$$I_f = IDWT (I_s) \quad (4)$$

where IDWT represents Inverse DWT process.

And,

$$I_s = (M).(H).(O)^T \quad (5)$$

### B. Watermark Extraction

After embedding of watermark in the host image, it is necessary to test the robustness of the scheme for embedding. To do that, watermarked host image undergoes various attacks i.e image processing as well as geometrical attacks, which results the attacked watermarked image  $I_f^*$ . This section includes following major steps:

- i) Splitting of the watermarked host image into 8 bit binary plane.
- ii) DWT is applied to the plane 1 of the splitted watermarked image.
- iii) As a result, watermarked plane 1 is splitted into 4 different subbands i.e, HH subband, HL subband, LH subband and LL subband.
- iv) After resulting to HH subband, SVD is applied in this particular subband. As a result of SVD, HH subband is splitted into three matrices: [8]:

$$I_f^* = (M^*).(N^*).(O^*)^T \quad (6)$$

SVD is applied again on the matrix  $N^*$  as: [8]:



$$N^* = (M_f) \cdot (N_f^*) \cdot (O_f)^T \tag{7}$$

$$W = (N^* - N) / K \tag{8}$$

W is the extracted watermark after various attacks and '\*' shows the 'after attack condition'.

**VI. RESULT AND DISCUSSION**

In this paper, gray scale images are used for the proposed scheme. All the simulation needed for this scheme is done using MATLAB R2015a and 'Haar' wavelet is used in case of DWT. Invisibility of watermark after embedding can be analysed by observing the host image and watermarked image. Similarly, reversibility can also be justified, as watermark can be extracted after embedding. To examine the feature of robustness for the proposed scheme, the watermark after extraction is compared with the original watermark as shown in Fig. 4(a) and Fig. 4(b) on the parameter of 'Normalised Correlation (NC)' value which can be expressed as [1]:

$$\text{Normalised Correlation} = \frac{\sum_{i=1}^{S1} \sum_{j=1}^{S2} A(i,j) \cdot Ae(i,j)}{\sqrt{\sum_{i=1}^{S1} \sum_{j=1}^{S2} A(i,j)^2 \cdot \sum_{i=1}^{S1} \sum_{j=1}^{S2} Ae(i,j)^2}} \tag{9}$$

where A is the original watermark and Ae is the extracted watermark. S1 and S2 are the size of watermark, where (i, j) are the coordinates of the pixel of watermark.

Experimental results as mentioned in Table 1 on the scale of NC is closer to 1 in different attacks as shown in Fig. 3(c)-Fig.3(g). It validates the robustness feature of the proposed hybrid scheme of digital watermarking. Invisibility feature is also justified by observing host image and watermarked image shown in Fig. 3(a) and Fig. 3(b) i.e no visual difference between both the images.



Fig. 3(a) Host image



Fig. 3(b) Watermarked image



Fig. 3(c) Salt and pepper noise attack (density=0.1)



Fig. 3(d) Rotation attack (20°)



Fig. 3(e) Histogram Equalisation attack



Fig. 3(f) Median Filtering attack (3x3)



Fig. 3(g) Motion Blur attack (70 pixel, 100°)



Fig. 4(a) Original Watermark

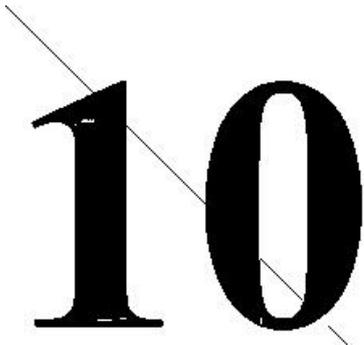


Fig. 4(b) Extracted Watermark (without attack)

Table I: NC Value at various Attacks

Attacks	NC Value
Salt and pepper noise :density (d)= 0.1	0.9973
Salt and pepper noise :density (d)= 0.5	0.9973
Gaussian Noise: mean = 0, variance =0.1	0.8616
Gaussian Noise: mean = 0, variance =0.3	0.8615
Median Filtering: 3 x 3	0.8804
Motion Blur: 70 pixel, 80°	0.8663
Motion Blur: 70 pixel, 90°	0.8693
Motion Blur: 70 pixel, 100°	0.8664
Histogram Equalisation	0.9132
Sharpening	0.8787
Rotation: 3°	0.8645
Rotation: 10°	0.8714
Rotation: 20°	0.8782

## VII. CONCLUSION

In this paper, hybrid technique of watermark embedding is proposed. It not only provide a new way of embedding the watermark but also satisfy important features: reversibility, invisibility and robustness. Reversibility feature is analysed by the fact that in the proposed scheme, watermark can be extracted from watermarked host image. Similarly, invisibility is justified by visualising the host image before

watermark embedding and after embedding of watermark i.e no visual differences between both the images. Robustness feature is judged on the parameter scale of NC values. Experimental results validates the robustness of the proposed scheme, as in different attacks NC values comes closer to 1. The scheme proposed in this paper has few limitations, directly this scheme is not applicable to coloured images. Future work will be engaged to conquer this restriction.

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