ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

# Analysis of Digital Watermarking Schemes in Frequency Domain for Security Enhancement

**Silky Pareyani**

Asst Professor, Electronics & Communication Department, Gyan Ganga College of Technology, Jabalpur, India

**Abstract**: Digital watermarking has been widely used for copyright protection of multimedia data. It is a process to provide authenticity by hiding a data into an image or audio or document. Hiding of data in an image can be done in frequency domain or spatial domain. In this paper we have made a comparative analysis on two frequency domain watermarking schemes. The first digital image watermarking algorithm utilizes texture block and edge detection in the discrete wavelet domain in order to balance between the invisibility and robustness and improve the ability of resisting to geometric attacks of the digital image watermark. The second method is a robust watermarking method based on Hadamard Transform. The simplicity of Hadamard transform offers a significant advantage in shorter processing time and ease of hardware implementation than most orthogonal transform techniques such as DWT and DCT. The two techniques are compared for better image quality and more robustness under various attacks such as JPEG compression, cropping, sharpening, and filtering and so on. Peak Signal to Noise Ratio (PSNR) and Normalized Correlation Coefficient (NCC) are computed to measure image quality and robustness.

**Keywords**: Discrete wavelet transform (DWT), Hadamard transform, Arnold Transform, Peak signal-to-noise ratio (PSNR).

## I. INTRODUCTION

Digital watermarking provides a solution for protecting ownership of multimedia data, avoiding duplicity, illegal copying and copyright protection in the age of growing internet and digital technologies. Digital watermarking [1] is the process of embedding the watermark in the host signal in an imperceptible manner. Imperceptibility, security, robustness and payload are the main requirements of any watermarking scheme [2]. Based on the domain analysis, digital watermarking is divided into two categories: spatial domain and frequency domain watermarking [3]. In spatial domain, the watermark is embedded directly by modifying the intensity values of pixels. Spatial domain watermarking technique is easier and its computing speed is high than transform domain watermarking but this show less resistance against many of the image processing operations [4] and hence called fragile watermarking. While frequency domain techniques like discrete Fourier transform (DFT), discrete cosine transform (DCT), discrete wavelet transform (DWT) are more robust against image processing operations as well as geometric attacks. Based on watermark extraction process, [5] watermark techniques can be classified as blind and non blind. In non-blind method, watermark extraction requires both original and watermarked cover image whereas blind method does not require original cover image. Bors and Pitas developed a method based on DCT transform [6], in which input image will be divided into blocks of size 8x8 and dct will be performed and from which few blocks are selected based on a gaussian network classifier decision and accordingly dct coefficients are modified in those blocks according to watermark. Cox [7] developed the DCT based watermarking algorithm in which he embedded watermark in dct domain that uses human visual system properties. In above methods either all the coefficients or few coefficients of the image are used in watermarking. The amount of embedded information is an important parameter because it influences the watermark transparency. If more the embedded information then lower the watermark transparency.

In order to increase the transparency F Huang [8] proposed a hybrid DCT and SVD based watermarking, in which SVD transform and DCT are performed on the watermark and the original image, respectively. Only the singular values of the watermark are embedded into the DCT coefficients of original image. There also a few watermarking methods based on combination of DCT and DWT, one such technique was developed by [9, 10], in which they embedded the watermark in middle frequency coefficients DCT of three level DWT of LL band of original image. This combination shows little improvement on DCT based methods. Some of researchers developed the watermarking techniques using combination of DWT and human visual system, one such method was mentioned in [11].
Wang and Bai in [11] developed a new digital image watermarking algorithm based on texture block and edge

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

detection in the discrete wavelet domain in order to balance between the invisibility and the robustness and improve the ability of resisting to geometric attacks of the digital image watermark. For this purpose, digital watermark is embedded into the high-frequency and low frequency sub-bands in the discrete wavelet domain of texture blocks adaptively by using the masking property of human visual system.

Sarker and Khan [12] proposed a robust watermarking method based on Hadamard Transform. The simplicity of Hadamard transform offers a significant advantage in shorter processing time and ease of hardware implementation than most orthogonal transform techniques such as DWT and DCT.

In this paper we made analysis over the methods proposed by Wang and Bai [11] and Sarker and Khan [12]. The performance of the two methods is checked through various geometric attacks such as such as jpeg compression, Gaussian noise, clipping, rotation, and median filter.

## II. WAVELET TRANSFORM, HADAMARD TRANSFORM, ARNOLD TRANSFORM, HUMAN VISUAL SYSTEM AND BEST FIRST SEARCH ALGORITHM

### A. Wavelet Transform

The basic idea of wavelet theory was given by Gabor in 1945 [5]. The idea behind wavelet theory was to analyze the signal according to scale and time. Wavelet gives the time-frequency representation of the given signal. Wavelets are a set of non-linear bases. These bases are selected based on the function being approximated. Wavelets employ the dynamic set of bases functions in order to represent the given signal in most efficient way unlike static bases families [10]. Wavelet transform in two dimensional function can be expressed as a two dimensional scaling function $\phi(x,y)$ and three two dimensional wavelets $\psi^H(x,y), \psi^V(x,y), \psi^D(x,y)$ function. The discrete wavelet transform of an image f(x,y) of size M×N is defined by:

$$W_\phi(j_0,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\phi_{j0,m,n}(x,y) \quad (1)$$

$$W_\psi^i(j,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\psi_{j,m,n}^i(,m,n) \quad (2)$$

Where i={H, V, D} and $j_0$ is an arbitrary scale, $W_\phi(j_0,m,n)$ define low frequency coefficients of f(x,y) at scale $j_0$and $W_\psi^i(j,m,n)$define the horizontal, vertical and diagonal details for scale $j \geq j_0$ [14].

### B. Hadamard Transform

The Hadamard transform (also known as the Walsh-Hadamard transform, Walsh transform or Walsh–Fourier transform) is an example of a generalized class of Fourier transforms. [13]. The Hadamard matrix Hm represents a M ×M Hadamard matrix, where$M = 2^m$ , m = 1, 2, 3… with element values either +1 or -1, the rows and columns of $H_m$ are orthogonal. Now a Hadamard matrix is given by [13]:

$$H_m \quad \begin{bmatrix} H_{m-1} & H_{m-1} \\ H_{m-1} & -H_{m-1} \end{bmatrix}$$

Where, m > 0. Now for m=1, M=2. Hence 2×2 Hadamard matrix is given by:

$$H = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

Let [O]represents the original image and [T]the transformed image, the 2D-Hadamard transform is given by [13]:

$$[T] = \frac{H_m[O]H_m}{M} \quad (3)$$

The inverse 2-D Hadamard transformation (IHT) is given as:

$$[O] = H_m^{-1}[T]H_m^* = \frac{H_m[T]H_m}{M} \quad (4)$$

### C. Arnold Transform

A digital image can be considered as a two unit function f(x,y) in the plane Z. It can be represented as Z = f(x,y) where x,y ∈={0,1,2,3....N-1} . Hence, N represents order of digital image. The matrix of image can be changed into a new matrix by using the Arnold transform which results in a scrambled version to offer better security. It is a mapping function which changes a point (x,y) to another point ( x′ , y′ ) by using the equation:

$$x' = (x + y) \bmod N \quad (5)$$

$$y' = (x + 2y) \bmod N \quad (6)$$

### D. Human Visual System

If the visual masking effects of human eyes are utilized fully in the process of embedding watermark, the invisibility and robustness will be improved greatly. A plenty of researches showed the following properties:

- Human eyes have different sensitivities to different gray scales which to be the strongest to the medium gray scale. Besides, the sensitivity declines both in the directions of the low and high gray scale non-linearly.

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

- Human eyes are far more sensitive to the noise on the smoothing zone of the image than the texture area.
- As the image edge information is important to human eyes and vulnerable to factors extraneous noise or other conventional image processing, the edge quality should be ensured to avoid the large damage.

We can lean from HVS that the digital watermark should be embedded into the texture or edge part of image instead of the smooth part in order to ensure the invisibility.

**E.** Best First Search Algorithm

Now the best-first search algorithm is applied in [12] to find the increasing sequence of each block to embed watermark. In figure 1, C is the main point from which we start searching and 8, 5, 6 are the order of searching the coefficients and we get some increasing sequences. From these sequences efficient point is selected by using a priority queue.

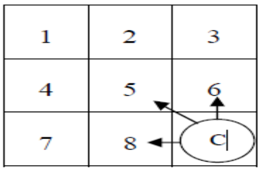


Fig 1. Order of Searching

## III. DIGITAL WATERMARKING SCHEMES

### A. Wang and Bai Method

**a) Digital Watermark Embedding**

In this algorithm, regard the number of edge points as the parameter for classification because the edge points are the characterization of the image gray mutation and the more edge points in the block are, the stronger the textures are. Let the original image $I = \{x(i,j), 1 \le i \le M, 1 \le j \le N\}$, the binary watermark image $W = \{w(i,j), 1 \le i \le P, 1 \le j \le Q\}$ , where i and j represent the pixel values of the i -th row and the j -th column of the original image and the watermark image respectively.

The steps of embedding the watermark are as follows:

1. Watermark Arnold Scrambling:

Make the original watermark Arnold scrambling with the scrambling time $K_l$ and then the first key $K_l$ generates. The water image after scrambling is W*.

2. Edge Detection:

Detect edge for the original image I with the canny operator. The obtained binary image is B.

3. Partition Blocks:

Partition the binary image B and the original image I into R blocks $B_k$ and $I_k$ (k= I,2, ...., R), and both of the size are Lx L. $B_k$ and $I_k$ are corresponding. Calculate the number of edge points in $B_k$ . Let the threshold be T. The texture blocks are extracted whose number of the edge points is more than T. Extract the original image blocks $I_k$ corresponding to the texture blocks as the carrier of embedded watermark. The number of extracted blocks is U.

4. Second Generation Discrete Wavelet Transform

Second generation discrete wavelet transform for the texture blocks $I_c$ ( c = 1,2,··,U). Embed the watermark of different strength into the low-frequency sub-band LLI and high-frequency sub-brands LHl, HLI and HHI. The formula of embedding the watermark is (7).

$$I_c^*(i,j) = I_c(i,j) \times [1 + \alpha \times W^*(h)]$$
$$c = 1,2,\cdots,U; U = P \times Q / 4$$
$$i = 1,2 \cdots, \frac{L}{4}; j = 1,2 \cdots, \frac{L}{4}; h = 1,2 \cdots P \times Q \qquad (7)$$

Where Ic(i,j) are the coefficients of each sub-band after wavelet transform for the original texture blocks. α is the strength coefficient and W*(h) is the watermark component after scrambling. Ic*(i,j) is the wavelet coefficients of the modified texture blocks. The second key $K_2$ generates which can be used in extracting the watermark information, namely the position of the extracted texture block Ic.

5. Determination of the Intensity Factor

α is divided into two kinds $\alpha_1$, and $\alpha_2$ because the low frequency sub-band and the high-frequency sub-band have different visual masking properties and the robustness after embedding the watermark is also different. Choose $\alpha_1$, in the low-frequency and choose $\alpha_2$ in the high-frequency sub-band. Define $\alpha_1$, and $\alpha_2$ as (8) according to the literature [14]:

$$\alpha_1 = 0.009134 \times \alpha_{0\times} lg(|C - 128| + 10) \qquad (8)$$
$$\alpha_2 = \alpha_1 \times lg(D + 10) \qquad \alpha_0 = \frac{\alpha}{2} = \frac{0.01 \times A}{127}$$

where A is the pixel average of the original image, C is the average of the low-frequency blocks of the texture block Ic* and Ic is the average coefficient of the corresponding each high-frequency sub-images. Embed the watermark into different frequency bands adaptively with $\alpha_1$and $\alpha_2$. The third key $K_3$ generates, namely the intensity factor of embedding the watermark.

6. Second Generation Inverse Discrete Wavelet Transform

The image J which has the scrambling watermark generates after second generation inverse discrete wavelet transform. The watermark embedding algorithm flowchart is showed in Fig.2.

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
IJARCCE
International Journal of Advanced Research in Computer and Communication Engineering
SITES
Smart And Innovative Technologies In Engineering And Sciences
Gyan Ganga College of Technology
Vol. 5, Special Issue 3, November 2016

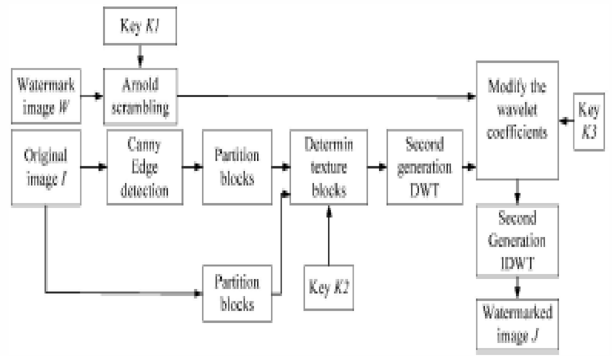

Fig 2. Digital watermark embedding algorithm flowchart

**b) Extraction of The Digital Watermark**

The extraction and the embedding of the digital watermark are reciprocal process. The watermark extraction algorithm flowchart is showed in Fig.3. The specific process for the digital watermark extraction is as following according to the watermark embedding algorithm

1. Partition Blocks:
Partition the image to be detected J and the original image I into R blocks $J_k$ and $I_k$ (k= 1,2, . ., R ), and both of the size are 32 x 32 . $J_k$ and $I_k$ are corresponding in position.

2. Determination of Texture Blocks
Determine texture block set U = { $U_k$, k = 1,2,⋅⋅, P x Q / 4} from the R blocks of the original image I according to the key $K_2$ generated in the process of embedding watermark. Extract the corresponding blocks from J as the texture block set to be measured U' = {$U'_k$, k = 1,2,⋅⋅, P x Q / 4} according to the position of the texture blocks set.

3. Second Generation Discrete Wavelet Transform
Second generation discrete wavelet transform for the extracted $U'_k$ and the corresponding $U_k$. Calculate the intensity factor $\alpha_1$ and $\alpha_2$ according to the method of embedding the watermark. Extract the watermark component according to (9) and (10).

$$W^*(h) = [U'_k(i,j)/U_k(i,j) - 1] / \alpha \quad (9)$$
$$h = 1,2,\cdots,P \times Q; i = 1,2,\cdots,L/4; j = 1,2,\cdots,L/4 \quad (10)$$

where $U'_k$ (i,j) is the coefficients of each frequency band of the texture blocks to be measured after second generation discrete wavelet decomposition. $U_k$ (i,j) is the coefficients of each frequency band of the texture blocks of the original image after second generation discrete wavelet decomposition and is corresponding to $U'_k$ (i, j) . Judge the value of W* ( h ) . If it is more than 0, the watermark component exists and let the value be 1. If not, let the value be 0.

4. Arnold Anti-scrambling
Make the extracted water component W*(h) Arnold anti-scrambling according to the key $K_l$. And then the extracted watermark image W' {w' (i,j), 1 ≤ i ≤ P, 1 ≤ j ≤ Q} can be obtained.

5. Evaluation of the Watermark
Determine the degree of similarity between the extracted watermark image and the original watermark image. It is the most effective to use the subjective approach for meaningful watermark. At the same time, the normalized correlation coefficient NCC as (13) and the peak signal to noise ratio PSNR (11) are used to evaluate the degree of similarity between W' and W and the quality of the image embedded watermark.

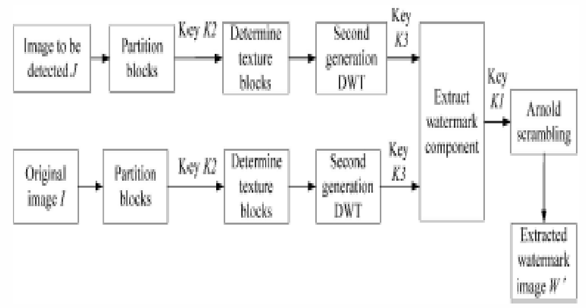

Fig 3. Digital watermark extracting algorithm flowchart

**B. Sarker and Khan Method**

This watermarking method consists of two process:

**1. Embedding Process**

The proposed watermark embedding process is shown in Figure 1. To embed the watermark into the host image following steps are required.

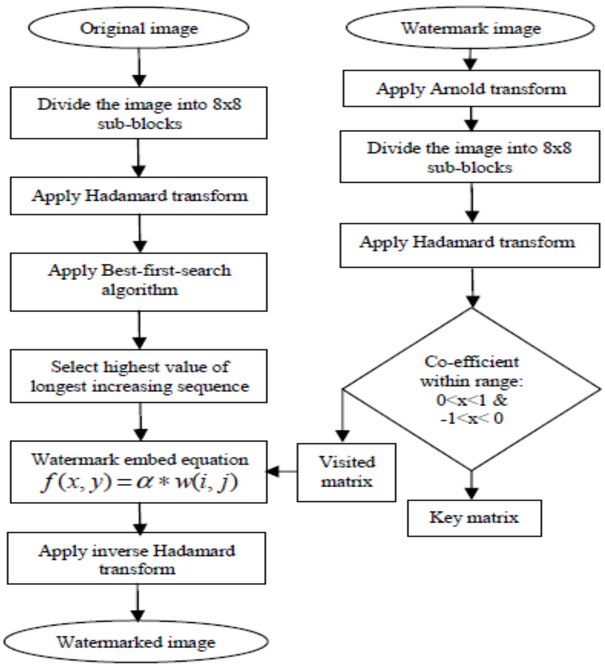

Fig.4 Flow Diagram for Watermark Embedding Process

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
IJARCCE
International Journal of Advanced Research in Computer and Communication Engineering
SITES
Smart And Innovative Technologies In Engineering And Sciences
Gyan Ganga College of Technology
Vol. 5, Special Issue 3, November 2016

Watermark Embedding Equation: Then we have to use the following equation for embedding process.

$$f(x,y) = \alpha \times w(i,j) \quad (11)$$

Where w(i,j) denotes watermark Hadamard co-efficient, f(x,y) denotes watermarked Hadamard co-efficient and α denotes the scaling factor, which defines the strength of the watermark.

**1. Extraction Process**

The proposed watermark extraction process is shown in figure 5.
Apply Extraction Equation: The watermark image is extracted using the visited matrix. Here we use the inverse equation of (12) for extraction of watermark image.

$$w'(i,j) = \frac{f'(x,y)}{\alpha} \quad (12)$$

where,f′(x,y ) denotes the watermarked co-efficient and w′(i,j) denotes the extracted watermark co-efficient.

To extract the watermark image from watermarked image following steps are required.

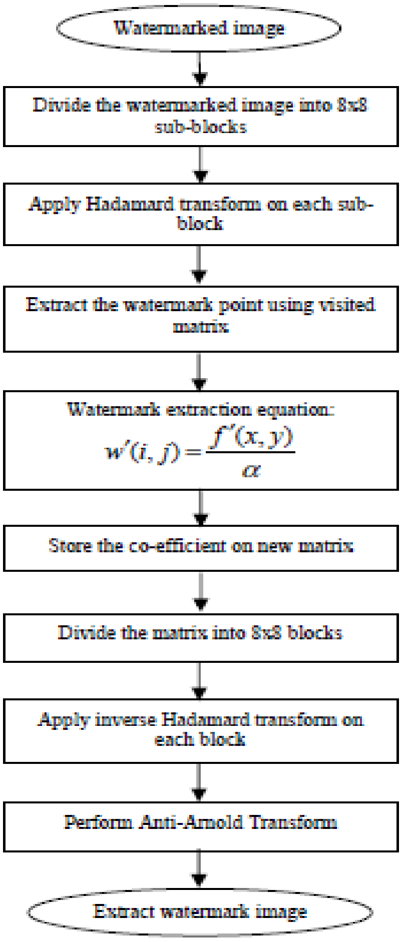


Fig.5 Flow Diagram of Watermark Extraction Process

## IV. EXPERIMENTAL RESULTS AND ANALYSIS

The peak signal to noise ratio (PSNR) is used to evaluate the quality of the watermarked image in comparison with host image. The PSNR formula is as follows:

$$PSNR = 10\log_{10}\frac{255\times255}{MSE}dB \quad (13)$$

$$MSE = \frac{1}{M\times N}\sum_{i=1}^{N-1}\sum_{j=1}^{M-1}[x(i,j) - y(i,j)]^2 \quad (14)$$

MSE defines mean square error. The M and N are the height and width of the image respectively. x (i, j) and y(i, j) are the values located at coordinates (i ,j) of the host image and the watermarked image. After extracting the watermark, the normalized correlation coefficient (NCC) is computed to measure the correctness of an extracted watermark. It is defined as:

$$NCC = \frac{1}{M\times N}\sum_{i=1}^{N-1}\sum_{j=1}^{M-1}[w(i,j) * w'(i,j)] \quad (15)$$

Where, m and n are the height and width of the watermark respectively. w(i, j) and w′(i, j)are the watermark bits located at coordinates (i, j) of the original watermark and the extracted watermark.

Among various test images employed in experiments, the "Lena" image which is shown in Fig. 6 is used to compare the effectiveness of the above two methods.

Fig. 6 Lena Image

Table 1 PSNR and NCC after JPEG Compression

| Attack | For compression | |
|---|---|---|
| JPEG Compression (quality factor=30) | PSNR | NCC |
| Wang and Bai Method | 29.2796 | 0.9533 |
| Sarker and Khan Method | 33.7029 | 0.9842 |

Table 2 PSNR and NCC after applying Filtering Attacks

| Attack | For Median Filtering 3×3 | |
|---|---|---|
| | PSNR | NCC |
| Wang and Bai Method | 29.7812 | 0.8935 |
| Sarker and Khan Method | 34.4961 | 0.9873 |

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

Table 3 PSNR and NCC after Different Rotation Attacks

| Attack | For Rotating | | | |
|---|---|---|---|---|
| | PSNR | | NCC | |
| | Rotate 5 degrees | Rotate 10 degrees | Rotate 5degrees | Rotate 10 degrees |
| **Wang and Bai Method** | 23.3373 | 20.8347 | 0.9331 | 0.9100 |
| **Sarker and Khan Method** | 24.1601 | 22.5655 | 0.8875 | 0.9915 |

Table 4. PSNR and NCC after noise

| Attack | For Gaussian noise (density=0.002) | |
|---|---|---|
| | PSNR | PSNR |
| Wang and Bai Method | 27.9748 | 27.9748 |
| Sarker and Khan Method | 26.8266 | 26.8266 |

Table 5. PSNR and NCC after cropping attacks

| Attack | For Cropping | | | |
|---|---|---|---|---|
| | PSNR | | NCC | |
| | Cropping [32×32] | Cropping [64×64] | Cropping [32×32] | Cropping [64×64] |
| **Wang and Bai Method** | 21.0356 | 11.9469 | 0.9282 | 0.8373 |
| **Sarker and Khan Method** | 30.1313 | 25.4391 | 0.9982 | 0.9894 |

## V. CONCLUSION

In order to balance the invisibility and robustness and improve the ability of resisting to geometric attacks of the digital image watermark, we have made comparative analysis of the two watermarking schemes. One scheme proposed by Wang and Bai designed a watermarking algorithm based on texture block and edge detection in the discrete wavelet domain. In this algorithm, watermark is embedded adaptively both in the low-frequency sub-band and the high-frequency sub-band in the discrete wavelet domain. Sarker and Khan proposed another watermarking scheme based on Hadamard transform which provides a complete procedure that embeds and extracts the watermark information effectively. The experimental results show that the method proposed by Sarker and Khan is efficient and more robust against malicious attacks such as JPEG compression, median filtering, rotatating, gaussian noise and cropping.

## REFERENCES

[1] G. Langelaar, I. Setyan, and R. Lagendijk, "Watermarking digital image and video data: a state of art overview," IEEE Transactions on Signal Processing Magazine (2000) pp. 20-46.

[2] P. Moulin, M. Mincak, "A framework for evaluating the data hiding capacity of image sources," IEEE Trans. Image Processing, vol. 11 no. 9, pp. 1029-1042, 2002.

[3] I.J. Cox., J. Kilian, F.T. Leighton and T. Shamoon, "Secure spread spectrum watermarking for multimedia," IEEE Trans. On Image Processing vol. 12, no. 6, pp. 1673-1687, 1997.

[4] H.C. Andrews and C.L. Patterson, "Singular value decomposition and digital image processing, "IEEE Trans. On Acoustics, Speech and Signal

[5] .Musawir Ali, An introduction to wavelets and haar transform, Available: http://www.cs.ucf.edu/ mali/haar/.

[6] Bors and I. Pitas, Image wate rmarking using DCT domain constraints in Proc. IEEE. Int. Conf. Image Processing , Lausanne, Switzerland, Sept. 1996, pp. 231-234.

[7] Cox, IJ, Miller, ML Bloom, JA 2002, Digital Watermarking, Morgan Kaufmann Publisher, San Francisco, CA, USA.

[8] Fangjun Huang, Zhi-Hong Guan, A hybrid SVD-DCT watermarking method based on LPSNR, Pattern Recognition Letters 25 (2004) 17691775.

[9] W. H. Bin, Y. H. Liang, W. C. Dong, W. S. Ming: A New Watermarking Algorithm Based on DCT and DWT Fusion," International Conference on Electrical and Control Engineering, pp. 2614 - 2617, 2010.

[10] A. Al-Haj: Combined DWT-DCT digital image watermarking, Journal of Computer Science 3 (9): pp. 740- 746, 2007.

[11] Yingli Wang, Xue Bai, Shuang Van, "Digital Image Watermarking Based on Texture Block and Edge Detection in the discrete wavelet transform", International Conference on Sensor Network Security Technology and Privacy Communication System (SNS & PCS), pp, 170-174, 2013.

[12] Md. Iqbal H. Sarker, M.I. Khan, "An Improved Blind Watermarking Method in Frequency Domain for Image Authentication", 978-1-4799-0400-6/13, 2013.

[13] Anthony T.S.Ho, Jun Shen, Andrew K.K. Chow, J. Woon, "Robust Digital Image-in-Image Watermarking Algorithm Using the Fast Hadamard Transform", In proceedings of the international symposium on Circuit and system 2003, (ISCAS '03), IEEE, Vol.3, pp.826-829.

[14] Xiang De-sheng, Xiong Vue-shan, "Image adaptive gray-scale watermarking embedding based on discrete wavelet transform," Computer Applications and Software, 2005, 22(5), pp: 19-2.

## BIOGRAPHY

**Silky Pareyani** was born in Jabalpur, Madhya Pradesh, India on 7th march 1987. She received bachelor of engineering degree in Electronics & Communication from Gyan Ganga Institute of Technology & Science, Jabalpur, Madhya Pradesh, India in 2009 and Master of Engineering degree in Communication Systems from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India in 2012. Currently, she is Assistant Professor in Gyan Ganga College of Technology, Jabalpur and has a teaching experience of 4.5 years.