Entropy based Robust Watermarking Scheme using Hadamard Transformation Technique

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ABSTRACT
As a novel watermarking algorithm is required to protect copy rights of digital data entropy based robust watermarking scheme using Hadamard transformation technique is proposed in this paper. The proposed technique can hide an entire image or pattern as a watermark directly into the original image. As the quality of the image is to be preserved the entire image is not altered for embedding, instead few blocks are used based on the size of the watermark and information content of an image block. To reduce the computational complexity of the proposed algorithm Hadamard transformation is used for converting cover image from spatial domain to transform domain. The proposed algorithm is tested with Lena grey scale image of size 256x256 and watermark of size 64x64 using mat lab software. The experimental results show that the proposed scheme is robust to random noise addition attack, resize attack and cropping attack.

General Terms
Image Processing, Multimedia Security, Digital Watermarking

Keywords
Digital Watermarking, Hadamard transform based watermarking, Entropy based watermarking, transform domain watermarking.

1. INTRODUCTION
With the advent of the Internet in this digital era, there is a forcing need for copyright enhancement schemes that protect copyright ownership of digital media. Watermarking is one of the multimedia authentication techniques [1]. Watermarking is the process of embedding a piece of digital information into any multimedia data such as an image, audio or video file for the purpose of authentication. Watermarks can be embedded in the pixel/spatial domain or a transform domain [2]. In spatial domain, the watermark is embedded directly by modifying the intensity values of pixels. In frequency domain, the watermark is embedded by changing the frequency coefficients. To transform image into frequency domain, the transformation techniques such as discrete wavelet transformation (DWT), discrete cosine transformation (DCT), discrete Hadamard transformation and discrete Fourier transformation are used. Spatial domain watermarking technique is easier and its computing speed is high, than transform domain watermarking. But the disadvantage is that it is not robust against common image processing operations. Transform domain techniques are introduced to increase the robustness of the digital media.

An effective watermark should have the following characteristics:

a) It should be perceptually invisible or its presence should not interfere with the work being protected [3, 4].

b) It should be robust to common signal processing operations such as sharpening, dithering, resizing, compression, noise addition and so on [5, 6].

The most important uses of watermark include copyright protection, authentication and disabling unauthorized access to the contents [7].

In section 1 introduction about the necessity of watermarking is given. Section 2 discuss briefly about the review of related works. In section 3 and 4 discusses about preliminaries of transformation techniques and entropy. In Section 5 proposed algorithm is given in detail as step by step procedure discusses in detail. Section 6 tells about the performance evaluation of proposed technique. Proposed technique is concluded in section 7. Finally, in section 8 all the papers which are referred are mentioned.

2. REVIEW OF RELATED WORKS
B. J. Fnlkowski et al embedded a watermark using multiresolution Hadamard and complex Hadamard transforms in a grey scale image [8].They segmented the multiresolution Hadamard transformed image into numerous 8*8 blocks and then applied forward complex Hadamard transformation. This technique is robust to JPEG compression up to 10% quality factor, successive watermarking effects, and common signal processing operations such as dithering distortion (25%), image resizing, cropping and scaling (56.25%). Bogdan J. et al embedded a watermark using multiresolution and two dimensional complex Hadamard transformation techniques [9]. The process is similar to their previous work [8] and it classified ad non blind technique.

Anthony T.S. Ho et al from their work it is clear that that the simplicity of the fast Hadamard transformation not only offers a significant advantage in shorter processing time and ease of hardware implementation but also has more useful middle and high frequency bands available, for hiding the watermark [10]. This technique is robust to 60%of stir mark attacks. They described again how to embed a watermark in an image using fast Hadamard transformation [11]. To increase the invisibility of the watermark, a visual model based on original image characteristics, such as edges and textures are incorporated to determine the watermarking strength factor.

Roumen Kountchev et al discussed about how to embed a watermark based on decomposition with inverse difference pyramid and complex Hadamard transformation [12]. The features of this process are, it has no quantization values of transform coefficient, low computational complexity and different watermarking in every consecutive pyramid level. It deals about two types of watermarking. The technique proposed is robust against tampering, compression, affine transforms, filtration, dithering. In Tang Xianghong et al work watermark is embedded using singular value decomposition [13]. Cryptographic method can also be used to strengthen the secrecy of watermarking.

Emad E. Abdallah et al describes how to make a transparent and high rate embedding of watermarks into digital images using fast Hadamard transform and singular value decomposition [14]. The three main attractive features of their work are: high rate of watermark embedding into the cover image, robustness to the most common attacks, and possible implementation in real time. Elijah Mwangi describes a technique that embeds a grey level binary image as a watermark at selected DWT coefficients by the use of a private key [15]. This is achieved by spreading the binary image bits into the elements of a Hadamard matrix row by using CDMA techniques. The depth of watermarking is adjusted to give an image of acceptable quality. A correlation process is used to detect and recover the watermark. Their algorithm is effective against common signal processing attacks such as additive Gaussian noise, cropping, low pass filtering, and JPEG compression.

Bogdan J. Falkowski reveals about how to embed a watermark on the grey scale image using multi-resolution modified multi-polarity Walsh-Hadamard transform and complex Hadamard transform [16]. The process is, the raw pixels are extracted from the bit map image and it is stored in two dimensional arrays. Then multi polarity Walsh-Hadamard transformation is applied to decompose the image into pyramid structure with various sub bands. The lowest frequency sub band is selected and segmented into 8*8 blocks and then apply one dimensional complex Hadamard transformation on the rows followed by columns. Then complex Hadamard transform coefficients are altered and watermark is embedded. Then inverse complex Hadamard transformation and modified multi resolution Walsh-Hadamard transformation is applied and low frequency sub band is kept in the original position to get the watermarked image. This technique is robust to jpeg encoding, image resizing, dithering noise distortions, sharpening, cropping and successive watermarking**.**

Gaurav Bhatnagarl and Balasubramanian Raman describes about how to decompose an image using MR-WHT (Multiresolution Walsh-Hadamard Transform) and then middle singular values of High frequency sub-band at the finest and the coarsest level are modified with singular values of watermark [17]. The process of watermark embedding involves, Performing L-level MR-WHT on the host image and Selecting HH sub-band from the coarsest and the finest level and then Apply SVD on both HH sub-band and watermark image. Modify the middle singular values of the HH sub-band Perform inverse SVD to construct the watermarked Map modified sub-band to its original position and L-level inverse MR-WHT is performed to get the watermarked image.

Yasunori Ishikawa, Kazutake Uehira and Kazuhisa Yanaka tells about how to embed a illumination (invisibly contains watermark) using discrete cosine transformation and fast Hadamard transformation [18]. This technique is robust to illegal use of images of objects which has not watermarked. The data is embedded by two methods. First is, block method in which 1 bit data is embedded on one block and next is, majority method where same 1 bit is embedded in first three blocks sufficiently form one another. Thus improves the accuracy of reading the data.

Aris Marjuni, Rajasvaran Logeswaran, and M. F. Ahmad Fauzi proposed a watermarking scheme in which fast Walsh Hadamard transformation (FWHT) is applied on the original watermark before it is embedded on the DC coefficients of the host image [19]. The digital cosine transformation is applied to each 8*8 block of original image to get the DC coefficient then embed the PN sequence and then apply the inverse discrete cosine transformation on DC component to reconstruct the watermarked image. It provides good visual perception and robust against common attacks.Yasunori Ishikawa, Kazutake Uehira, and Kazuhisa Yanaka proposed an “Illumination Watermarking” technology with which the images of objects without copyright protection can contain invisible digital watermarking [20]. The main attribute of this technology is watermarking can be added by light. The watermark is embedded by using fast Hadamard transformation and discrete cosine transformation. It has two methods to get a watermarked image. First is, by using two dimensional discrete cosine transformation and the next is, using two dimensional Hadamard transformation. It provides 100% accuracy and it is robust to jpeg compression.

From the survey of Hadamard transformation based watermarking techniques it is observed that the complexity of the transformation based watermarking work is greatly reduced as the transformation matrix have only +1 and -1. In addition to that watermark embedded in Hadamard transform domain is more robust to many attacks. In this literature survey Hadamard transformation technique is combined with singular value decomposition (SVD) for embedding watermark. Multiresolution concept is used based on out HVS model. As a result in the proposed algorithm Hadamard transformation technique is combined with entropy model. This entropy model measure the information content of each block which is used as criterion for selection of blocks.

3. OVERVIEW OF HADAMARD TRANSFORMATION

The Hadamard transform is a non-sinusoidal, orthogonal transformation that decomposes a signal into a set of orthogonal, rectangular waveforms called Walsh functions. The transformation has no multipliers and is real because the amplitude of Walsh (or Hadamard) functions has only two values +1 or -1

The Hadamard matrix is a square array of plus and minus ones whose rows (and columns) are orthogonal to one another. If H is an N x N Hadamard matrix then the product of H and its transpose is the identity matrix

Let *[U]* represents the original image and *[V]* the transformed image, the 2D-Hadamard transform is given by

$$[V]=(H_n\,[U]\,H_n)/N \qquad (1)$$

Where H, represents an NXN Hadamard matrix, $N=2^n$, n=1,2,3 ... with element values are either +1 or -1. The advantage of Hadamard transform is that the elements of the transform matrix H_n, are binary real numbers. The inverse 2D-Hadamard transform (IHT) is given as

$$[U]=H_n^{-1}[V]H_n^{*}=(H_n\,[V]\,H_n)/N \qquad (2)$$

In the proposed algorithm, the transformation process is carried out on 8×8 blocks using the third order Hadamard transform matrix H_3 which is given below.

$$H_3 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{pmatrix}$$

4. PRELIMINARIES OF ENTROPY

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image.

Let P contains the histogram counts. The entropy is represented as

$$E = -\sum P\ log2(P) \qquad (3)$$

5. PROPOSED ALGORITHM

In the proposed algorithm, the Hadamard transformation technique and entropy concepts are used. The input image is divided into many blocks and entropy is calculated for each block. If the information content is very high then those blocks are marked as primer blocks for embedding watermark. The embedding and extraction process of watermark is given in Fig.1 and Fig.2. The Lena image of size 512x512 and watermark of size 64x64 is used to test the proposed system. The embedding and extraction algorithm is given below in detail.

5.1 Watermark Embedding Algorithm

1. Convert the cover image A into gray scale image if it is a color image.
2. Divide the cover image into blocks B_{ij} of size 8 x 8
3. Find entropy E_{ij} for each 8 x 8 blocks and find the threshold value T_{ij}.
4. Select the 8 x 8 blocks B_{ij}^{*} whose entropy value is greater than threshold value
5. Apply Hadamard Transformation to the selected 8 x 8 blocks $B_{ij}^{*}=(H_n[B_{ij}^{*}]H_n)/N$..
6. Divide the watermark W into blocks W_{ij} of size 8 x 8.Embed the watermarked block W_{ij} with the selected block B_{ij}^{*} using constant factor.
8. Apply IHT to the embedded 8 x 8 blocks $B_{ij}^{*}=H_n^{-1}[B_{ij}^{*}]H_n^{*}= B_{ij}^{*}=(H_n[B_{ij}^{*}]H_n)/N$.
9. Rearrange the modified 8 x 8 blocks B_{ij}^{*} with the unmodified 8 x 8 blocks B_{ij}.
10. Integrate the 8 x 8 blocks B_{ij} to display the watermark image A^{*}.

5.2 Watermark Extraction Algorithm

1. Convert the watermark image A* into gray scale image if it is a color image.
2. Divide the watermark image into blocks of size 8 x 8 C_{ij}.
3. Find entropy for each 8 x 8 blocks E_{ij}^{*} and find the threshold value T_{ij}^{*}.
4. Select the 8 x 8 blocks C_{ij}^{*} whose entropy value is greater than threshold value.
5. Apply HT to the selected 8 x 8 blocks $C_{ij}^{*}=.^{*}=(H_n[C_{ij}^{*}]H_n)/N$.
6. Extract the watermark blocks W_{ij} from the respective blocks C_{ij}^{*} using constant factor.
7. Apply IHT to the respective 8 x 8 blocks $C_{ij}^{*}=H_n^{-1}[C_{ij}^{*}]H_n^{*}= C_{ij}^{*}=(H_n[C_{ij}^{*}]H_n)/N$.
8. Rearrange the watermark blocks W_{ij} and original 8 x 8 blocks C_{ij}.
9. Integrate the 8 x 8 blocks to display the original image A and watermark blocks to display the watermark image W.
10. Convert to color image if needed and display the cover image.

6. PERFORMANCE EVALUATION

The performance of the algorithm is tested by simulating it using matlab software. Lena image of size 256x256 and watermark of size 64x64 is used to test its performance. The quality of the watermarked image is objectively measured using PSNR and it is observed that quality of the watermarked image is good. The measured psnr value is 42.7454db. The original image, watermark and the watermarked image is shown in Fig.3. Similarly extracted watermark from undistorted watermarked image is shown in Fig.4. The similarity measure or the normalized correlation coefficient of original and extracted watermark from undistorted watermarked image is 1. The psnr value is calculated using the eq. 4.

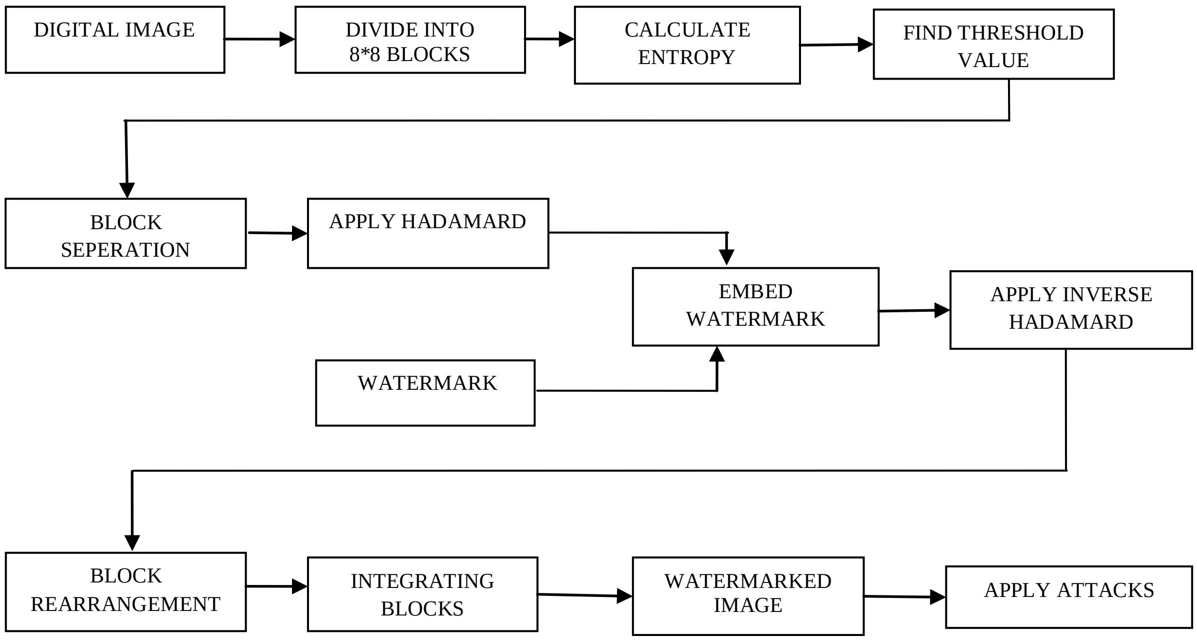


Figure.1 Embedding Process

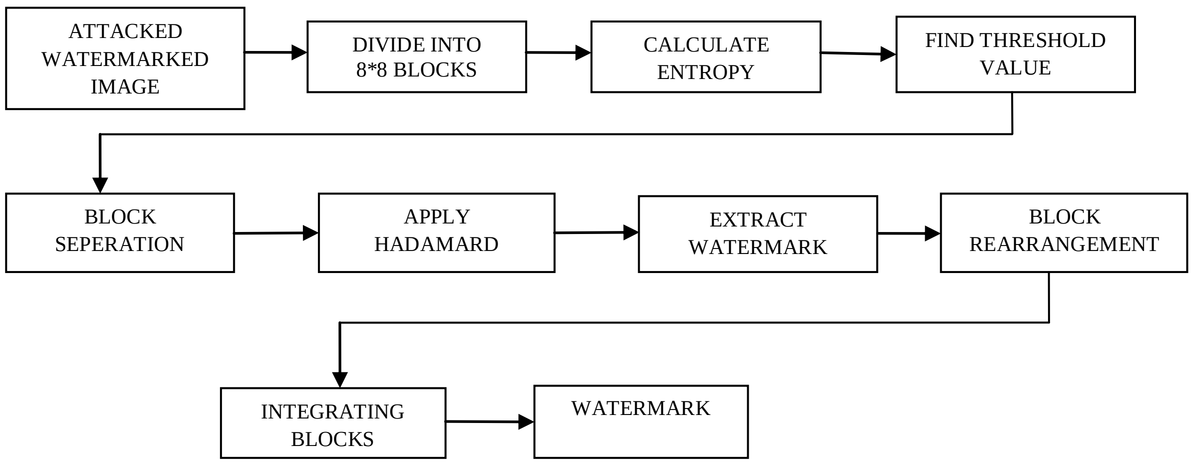


Figure.2 Extraction Process

TABLE.1 EXTRACTED WATERMARK FROM WATERMARKED IMAGE

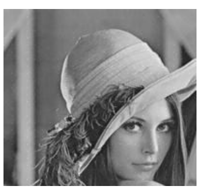
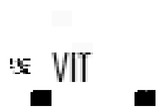
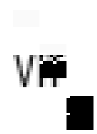
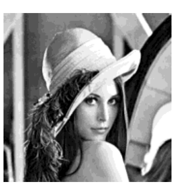
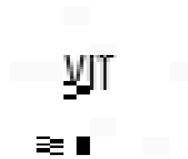
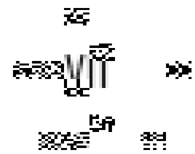
Attacked Image	Size of [128 128]	Size of [64 64]	Size of [32 32]
			
Resizing attack	Psnr =12.8143	Psnr = 12.6612	Psnr = 12.4743
	Size of [175 175]	Size of [183 183]	Size of [199 199]
			
Cropping attack	Psnr =42.6460	Psnr = 42.5540	Psnr = 42.4692
	Size of [128x128]	Size of [256x256]	Size of [512x512]
			
Histogram Equalization	Psnr =19.1149	Psnr =19.2590	Psnr =19.2590

TABLE.2. EXTRACTED WATERMARK FROM WATERMARKED IMAGE

Attacked Image	0.001	0.01	0.1
			
Salt and pepper noise addition attack	Psnr =35.8950	Psnr =25.2913	Psnr =15.4439
	.0001	.001	.01
			
Gaussian noise addition attack	Psnr =41.9159	Psnr =38.1170	Psnr =29.7199
	0.00001	0.0001	0.001
			
Speckle noise addition attack	Psnr =41.8537	Psnr =37.8466	Psnr =29.4612
	90	180	270
			
Rotation attack	Psnr =11.2366	Psnr =10.8898	Psnr =11.2370

$$MSE = \frac{1}{MN} \sum_{i=1}^{m} \sum_{j=1}^{n} (f(i,j) - f(i,j))2 \quad (4)$$

$$PSNR = 10\ log_{10} \left(\frac{255^2}{MSE}\right) \quad (5)$$

$f(i,j)$ and $f'(i,j)$ represent the pixel values of original host image and the watermarked image respectively and parameters *m*,*n* specify row and column size of images respectively.

To test the robustness of the algorithm various attacks are introduced to the watermarked image. Initially the noise addition attack is introduced and it is observed that algorithm is robust if the variance is 0.001and 0.01. Various noises such as salt and pepper, Gaussian noise and speckle noise are added and robustness is tested. It is found that the algorithm is withstanding noise addition attacks. To check the quality of the extracted watermark from the distorted image the similarity measure is used. To check the similarity normalized correlation (NC) between original and extracted watermark is calculated using Eq. 7. If normalized correlation value is high then the quality of the extracted watermark is considered as good. If the vale of NC goes below 50% , it is assumed that the algorithm is not robust to that particular attack.

$$NC = \frac{\sum_{I=1}^{N} \sum_{J=1}^{M} W(I,J) * W_Z(I,J)}{\sqrt{\sum_{I=1}^{N} \sum_{J=1}^{M} W^2\ (I,J)} \sqrt{\sum_{I=1}^{N} \sum_{J=1}^{M} W^2{}_Z(I,J)}} \quad (7)$$

Algorithm is also tested with attacks like image resizing, cropping, rotation, image sharpening and histogram equalization. The tampered image and extracted watermark is shown in table1 and table 2.

Fig.3 (a) CoverImage (b)Watermark (c)Watermarkedimage

7. CONCLUSION

In this proposed algorithm Hadamard Transformation and entropy concept is used. As the Hadamard transformation matrix consists of +1 and -1 only the computational complexity is reduced. Embedding is carried out in most of the blocks which have more information content which is measured through entropy equation. The proposed algorithm is found to be robust to most of the image related attacks as per the results. So it is classified as non-blind watermarking algorithm which can be used for copyright protection where robustness is very important. Finally, we note that our experimental results suggest that our proposed algorithm is not robust to rotation attack. Thus our future work is to make algorithm robust to rotation attack.

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