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A Variance based Approach (VBA) Digital Watermarking in Frequency Domain and Comparative Analysis using Walsh and Hadamard transform

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ABSTRACT
The paper introduces a Digital Image Watermarking technique based on Transform domain. The purpose of doing the watermarking in transform domain is to give more robustness in the watermarking process looking into its fast real time implementation and also the computational complexity which comes often in the implementation process. In the proposed algorithm, a binary watermark is embedded in a grayscale image(cover image). The cover image is segregated into blocks of high and low variances. The cover image is transformed into frequency domain and comparative higher variance blocks are considered for embedding the binary watermark. Integer portion of the transformed DC co-efficients of the considered blocks undergoes binary conversion and binary bits of watermark are embedded in those co-efficients. Both Walsh Transform and Walsh Hadamard transform are used for frequency domain conversion of the image and to make a comparative study as well. Software simulation of the algorithm is done using MATLAB

Keywords
VARIANCE, WALSH, HADAMARD, VERILOG

1. INTRODUCTION
In the field of digital media, the safety and security of the digital information is always a matter of concern since the digital information can easily be manipulated with the help of computers and other digital devices. So, gradually the needs of some techniques were felt to protect the identity and ownership of digital information and to authenticate those digital content. One such technique is Digital Watermarking. In digital Image watermarking, any digital information (message data) which is generally termed as 'Watermark' is embedded into a carrier image without causing permanent damage to the carrier image and the watermark as well , so that the information remains protected in its original form. For hiding the message, the encryption or watermark insertion algorithm should be robust and also it should be immune against various noises and attacks during the transmission or sharing process. In this proposed work, watermarking is performed in transform domain and then the watermark is inserted and embedded with the transformed values according to the algorithm in a robust manner. In the proposed work, Walsh transform & Hadamard transform is used to establish the transform domain.

2. RELATED WORKS
Many researchers have been working in this domain of digital watermarking. I. J. Cox at el presented a secure (tamper-resistant) algorithm for watermarking images, in the proposed methodology a watermark should be constructed as an independent and identically distributed Gaussian random vector that is imperceptibly inserted in a spread-spectrum-like fashion into the perceptually most significant spectral components of the data[1]. Hesham A. El Zouka proposed a new approach where a key based on a seed number is used to communicate and generate a sequence of numbers that identifies bits in the host digital media file that contains the secret message [2]. Gogoi et al proposed an algorithm which can embed double watermarks in a single cover image, it was further extended to video as well [3]. A low power, real time, reliable and secure data hiding system that can be achieved all the way through hardware implementation was proposed by Abhishek Basu at el[4]. A real time implementation of an algorithm for Watermarking and the results obtained using a Frequency approach by modifying the middle frequency coefficients was put forward by Ravi Shah [6]. Kishan Chand Gupta and Palash Sarkar studied the relationship between the Walsh transform and the algebraic normal form (ANF) of a Boolean function. They proposed an algorithm which can be applied in situations where it is practically impossible to use the fast Walsh transform algorithm [7]. A transform domain watermarking implementation was carried out by S. Yan at el they proposed a novel combined multi-polarity arithmetic–Walsh transform, in which recursive relationships between higher and lower matrix orders of hybrid multi-polarity arithmetic–Walsh transform are developed [8]. Fu Jun and Wang Shou-huai presented a Walsh code orthogonal spread spectrum watermarking algorithm in which the watermark is embedded into the medium frequency and low frequency of the carrier block, according to the visual masking effect of the human visual system[9]. D.Sasikala et al proposed a registration method on medical images using Fast Walsh Hadamard Transform, each basis function of Walsh Transform is a notion for determining various aspects of local structure. The co-efficients are normalized and used in forming a unique number for each type of local structure [10]. Patrick Gaydecki et al proposed a technique which inserts the binary bits of the handwritten signatures in the DCT blocks of Y channel of the digital colour image as well as uses 1-D walsh coding to embed mobile phone digits in images captured by the mobile[11]. Koushik Mahanta et al proposed a hardware watermarking technique where watermark embedding is done using a MSI number in walsh domain[12].

3. MODELLING OF WATERMARKING SCHEME

The transmitter and receiver block contains several components which are used at various stages of the flow of computing and are shown in the Fig1 and Fig 2.

Transmitter Block:

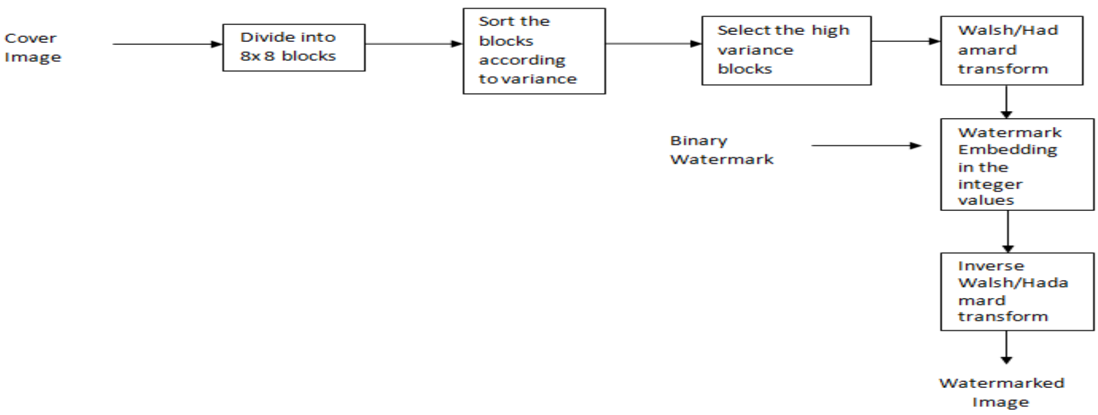


Fig1. Block Diagram of Transmitter

Receiver Block:

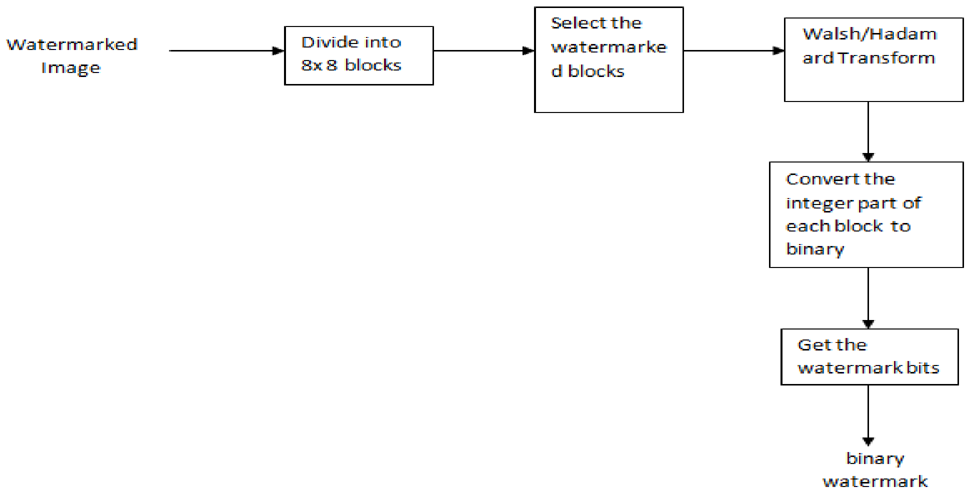


Fig2. Block Diagram of Receiver

4. THEORETICAL DETAILS OF THE TRANSFORM FUNCTIONS:

4.1 Theoretical details of Walsh Transform

The kernel of the Fast Walsh Transform can be given as:

$$f(x,u)=\pi_{i=0}^{k-1}\left((-1)^{b_i(x)b_{k-1-i}(u)}\right)*\frac{1}{N} \quad (1)$$

where N= No. of samples from an image

k= number of bits needed to represent x as well as u such that $N=2^k$.

$b_i(x)$ means i^{th} bit of the binary representation of x. Similar is the case with b_{k-1-i} (u).

$$W(u)=(\sum_{x=0}^{n-1} g(x)\ [\left(\pi_{i=0}^{n-1}\left((-1)^{b_i(x)b_{n-1-i}(u)}\right)\right)*\frac{1}{N}] \quad (2)$$

where g(x) is the input image pixel.

The inverse kernel of the Fast Walsh Transform is same as the forward kernel of Fast Walsh Transform i.e.

$$f'(x,u)=\pi_{i=0}^{n-1}\left((-1)^{b_i(x)b_{n-1-i}(u)}\right)*\frac{1}{N} \quad (3)$$

Inversed transform:

$$IW(u)=g'(x)\times N\times f'(x,u) \quad (4)$$

$$\text{i.e}\quad IW(u)=\sum_{x=0}^{n-1} g'(x)\ [\left(\pi_{i=0}^{n-1}\left((-1)^{b_i(x)b_{n-1-i}(u)}\right)\right) \quad (5)$$

Where g '(x)=W (u);

4.2. Theoretical details of the Hadamard Transform

Kernel of Walsh Hadamard Transform can be given as—

$$h(x,u)=\left((-1)^{\sum_{i=0}^{n-1} b_i(x)b_i(u)}\right)*\frac{1}{N} \quad (6)$$

where N= No. of samples from an image

k' = number of bits needed to represent x as well as u such that $N=2^{k'}$. $b_i(x)$ means i^{th} bit of the binary representation of x. Similar is the case with $b_i(u)$.

$$W_H(u)=\sum_{x=0}^{n-1} f(x)\,[((-1)^{\sum_{i=0}^{n-1} b_i(x)b_i(u)})*\frac{1}{N}] \quad (7)$$

f(x) = Original Image.

The inverse kernel of the Hadamard Transform is same as the forward kernel of Hadamard Transform i.e.

$$h'(x,u)=((-1)^{\sum_{i=0}^{n-1} b_i(x)b_i(u)})*\frac{1}{N} \quad (8)$$

Inverse transform is given by:

$$IW_H(u)=\sum_{x=0}^{n-1} m'(x)\,[((-1)^{\sum_{i=0}^{n-1} b_i(x)b_i(u)})] \quad (9)$$

Where $m'(u) = W_H(u)$

5. PROPOSED WATERMARKING ALGORITHM

There are two parts in the algorithm. One part is for the watermark encoding process and the other part is for the watermark decoding process.

5.1. Watermark encoding

Step 1: Take the cover image and divide it into (8x8) no of blocks.

Step 2: Sort the blocks according to the variance in descending order.

Step 3: Select the higher variance blocks.

Step 4: Perform walsh/ Hadamard transform to all the blocks.

Step 5: Take the watermark image which is of 256 bits (16 x 16 binary image).

Step 6: Watermark Embedding

(i)Two watermark bits are added to each 8x8 block

(ii) Each 8x8 block contribute 8 DC components.

(iii) The integer part of each DC component is converted to binary with 8 bits.

(iv)The LSB 0^{th} and 1^{st} positions / LSB 1^{st} and 2^{nd} positions of each DC component are replaced by the same two bits.

Step 7: Perform Inverse Walsh Transform

5.2. Watermark decoding

Step 1: Take the watermarked Image and divide it into (8x8) number of blocks.

Step 2: Perform walsh/hadamard transform to all the blocks.

Step3:Select the watermark embedded blocks.

Step 4 : For each block

(i) Select the eight DC components and convert to binary form.

(ii) Get the LSB 0^{th} and 1^{st} positions / LSB 1^{st} and 2^{nd} positions of each component and count no. of 1's for both. In each position consider the following

If (no. of 1's>no. of 0's)

extracted bit=1

else

extracted bit=0

end

6. MATLAB SIMULATION

By following the Watermarking algorithm a detailed comparison of the watermarked image has been performed for the two domains (i.e-Walsh Transform and Hadamard Transform). The original image, watermarked image and the watermark locations have been shown in Fig3, Fig4 and Fig5.

Fig3-Cover Image

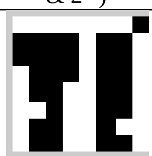
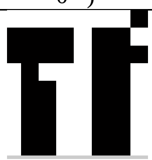
Fig 4-Watermark

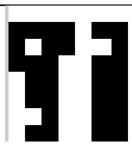
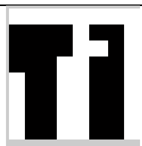
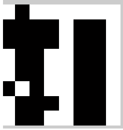
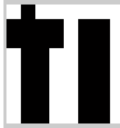
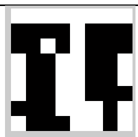
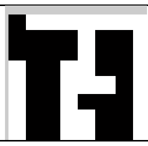
The PSNR value of the watermarked image with watermarked embedded at different positions for Walsh Transform and Walsh hadamard Transform shown in TABLE I & II

Walsh Transform:

For bit positions (1^{st} & 2^{nd}), PSNR=48.34 and for bits positions (1^{st} & 0^{th}), PSNR=54.28

Table I: Extracted watermarks and PSNR values.

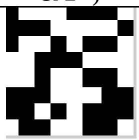
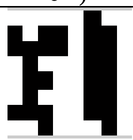
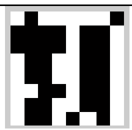
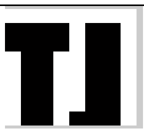
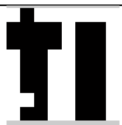
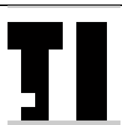
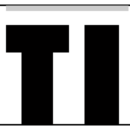
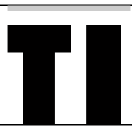
Watermarking Attacks	Watermark image		PSNR values (Walsh Transform)	
	bits positions(1^{st} & 2^{nd})	bits positions(1^{st} & 0^{th})	Watermarks	
Gaussian Filter			bits positions(1^{st} & 2^{nd})	bits positions(1^{st} & 0^{th})
			60.17	61.42

Salt&Pepper noise			60.17	63.18
Median Filter			60.17	66.19
Histogram Equalization			57.16	61.42

Walsh Hadamard Transform:

For bit positions (1st & 2nd), PSNR=56.19 and for bits positions (1st & 0th), PSNR=50.2

Table II: Extracted watermarks and PSNR values

Watermarkin g Attacks	Watermark image		PSNR values (Walsh Hadamard Transform)	
	bits positions(1st & 2nd)	bits positions(1st & 0th)	Watermarks	
Gaussian Filter			bits positions(1st & 2nd) 52.21	bits positions(1st & 0th) 57.74
Salt&Pepper noise			58.41	66.12
Median Filter			63.18	66.19
Histogram Equalization			--------	---------

The experimental result shows that the PSNR values of the extracted watermarks are very much acceptable for both the transform. The algorithm was implemented in 50 gray scales images all showed satisfactory results.

7. CONCLUSION

The design of Digital Image Watermarking in transform domain is done using Walsh and Hadamard Transform mainly for their robustness against different image processing attacks. The designing process will reduce the complexity of the circuit when extended to hardware design as the transform domain does not involve any imaginary co-efficient. The algorithm can also be implemented for video watermarking. Apart from the attacks mentioned above there is also a future scope of extending the watermarking algorithm to increase its robustness for more attacks like rotating etc.

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