Digital Watermarking as a distributed noise by Discrete Wavelet Transformation, Fast Fourier Transformation and Fast Walsh-Hadamard Transform to study the sensitivity between Robustness and Fidelity

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ABSTRACT

Information security and copyright protection are at the highest attention in digital communication community. Digital Image Watermarking provides one of the ways to claim copyright for the information owner. The main emphasis is given on Fidelity, Capacity and Robustness while devising digital watermarking schemes and techniques. In this paper DWT, Fast Fourier Transformation and Fast Walsh-Hadamard Transforms used for digital image watermarking to study the sensitivity between robustness and fidelity. DWT is used for locating the suitable area in the cover image for watermark embedding. Fast Fourier Transformation used to convert the input signal from a spatial domain representation to a frequency domain representation. Fast discrete Walsh–Hadamard transformation returns the coefficients of the input x. Then watermark is embedded depending on pseudo random sequence multiplied with a constant gain factor into predefined mid-band components of the block of cover image. The sensitivity is studied by varying the gain factor.

Key words: Gain factor, Fidelity, Robustness, mid-band component, FWHT, DWT, FFT.

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1. INTRODUCTION

Since many years several watermarking methodology and techniques are devised for variety of applications. (Dayanand G.Savakar and Anand Ghuli, 2014) Proposed a watermarking and watermark retrieval methodology using DWT,Chirp-Z and Walsh-Hadamard transformations to demonstrate the relation between fidelity and robustness with limited capacity. (S.Manikanda prabu, Dr.S.Ayyasamy 2014) have proposed a watermarking algorithm based on DWT and FFT Approach. (Apoorv Tiwari et.al., 2014) have developed digital image watermarking using fractional Fourier Transform with Different Attacks. (M. Kim et.al., 2014) proposed an algorithm that has improved the extraction performance by accurately extracting the hidden information in the 2D barcode from the detected watermark. Also, combining the dual transform method, DWT and DFRNT, has improved the imperceptility and robustness of the watermark against basic image signal processing attacks. ( Hongqin Shi et.al.,2014) presented a new color watermark embedding technique with circulation, based on non-overlapping Singular Value Decomposition (SVD) for hiding important information in images. ( Kaushal R. Patel and Nabila Shaikh 2014) proposed a Robust color image watermarking based on DWT-HT. (Piyush .V. Gattani and Dr. C. S. Warnekar 2014) suggested a new invisible digital watermarking scheme for color images based on the amalgamation of wavelet transform (SWT2) with singular value decomposition (SVD), and advanced encryption scheme (AES). (Anu Bajaj 2014) surveyed that still there is a necessity in order to significantly improve performance of digital watermarking. New secure techniques can be proposed for copyright protection so that the performance of algorithms can be enhanced by combining with security techniques. Most of the work had been done for increasing the robustness of the techniques, but there are some applications like tamper proofing which require fragile watermarks; new techniques can be proposed for fragility. New schemes for medical images can be proposed for medical database. (Shuchi Sirmour, Archana Tiwari 2014) developed a hybrid DWTSVD based algorithm for watermark embedding and extracting process. The suggested method is performed by modification on singular value decomposition of images in Discrete Wavelet Transform (DWT) domain. Modification of the appropriate sub-bands leads to a watermarking scheme which favorably preserves the quality. They shown good robustness by using hybrid DWT-SVD method in comparison with DWT based watermarking algorithm using Haar wavelet. (Ali Al-Haj, 2007) has proposed combined DWT-DCT digital image watermarking scheme.

2. THE METHODOLOGY FOR WATERMARK INSERTION

The Haar wavelet divides the input image into four non-overlapping multi-resolution sub-bands LL, LH, HL and HH. Then HH is divided into sub-bands LL1, LH1, HL1 and HH1. The high frequency sub-band HH1 includes the edges and textures of the image which the human eye is not generally sensitive to changes in such sub-bands. This allows the watermark to be embedded without being perceived by the human eye. Then Fast Fourier Transformation used to convert the input signal from a spatial domain representation to a frequency domain representation. The Fast Walsh Hadamard Transform is used as is a suboptimal, non-sinusoidal, orthogonal transformation that decomposes a signal into a set of orthogonal, rectangular waveforms called Walsh functions. Recursively, Hadamard transform $H_m$ defined for $m > 0$ by:

$$H_m = \frac{1}{\sqrt{2}} \begin{pmatrix} H_{m-1} & H_{m-1} \\ H_{m-1} & -H_{m-1} \end{pmatrix}$$

where the $1/\sqrt{2}$ is a normalization that is sometimes omitted. Thus, other than this normalization factor, the Hadamard matrices are made up entirely of 1 and $-1$. 


Algorithm 1: Watermark Embedding

Input:
  i. Cover image.
  ii. Watermark image.

Output: Watermarked image.

Start

Step.1: Decompose the cover host image into four non-overlapping multi-resolution sub-bands: LL, HL, LH, and HH using DWT.

Step.2: Apply DWT again to sub-band HH to get four smaller sub-bands and choose the HH1 sub-band.

Step.3: Divide the sub-band HH1 into 4 x 4 blocks.

Step.4: Apply FFT to each block in the chosen sub-band (HH1).

Step.6: Apply Fast Walsh-Hadamard transform which performs an orthogonal, symmetric, involutional, linear operation on $2^m$ numbers (real or complex)

Step.7: Re-formulate the grey-scale watermark image into a vector of zeros and ones.

Step.8: Generate two uncorrelated pseudorandom sequences. One sequence is used to embed the watermark bit 0 and the other sequence is used to embed the watermark bit 1.

Step.9: Embed the two pseudorandom sequences; sequence 0 and sequence 1, with a gain factor some k, in the FFT-FWH transformed 4x4 blocks of the selected DWT sub-bands of the host image.

  If the watermark bit is 0 then
  \[ X' = X + k \times \text{pseudorandom sequence for 0} \]
  otherwise,
  \[ X' = X + k \times \text{pseudorandom sequence for 1} \]
  [ Where $X'$ represents the pseudorandom sequence embedded block. $X$ denotes the matrix of the midband coefficients of the FFT-FWH transformed block. ]

Step.10: Apply inverse FFT to each block after its mid-band coefficients have been modified to embed the watermark bits as described in the previous step, then inverse FWH transform to it.

Step.11: Apply the inverse DWT on the DWT transformed image, including the modified sub-band, to produce the watermarked host image.

Stop.
3. METHODOLOGY FOR WATERMARK EXTRACTION

Locate middle frequency sub-bands using Haar wavelets in watermarked image. With gain factor \( k \) and block size 4 compute pseudorandom sequence and apply FWHT block wise then extract middle band coefficients. Calculate the correlation of the middle band sequence to pseudorandom sequence and move to next block to get watermark. The watermark extraction process discussed so far is depicted in Fig. 3 and procedure in Algorithm 2.

**Algorithm 2: Watermark Extraction**

Input : Watermarked image.
Output : Watermark.

**Start**

**Step.1:** Decompose the watermarked image into four non-overlapping multi-resolution subbands: LL, HL, LH, and HH using DWT.

**Step.2:** Apply DWT to HH to get four smaller sub-bands, and choose the sub-band HH1.

**Step.3:** Divide the sub-band HH1 into 4X4 blocks.

**Step.4:** Apply FFT to each block in the chosen sub-band (HH1) and then FWHT

**Step.5:** Regenerate the two pseudorandom sequences for 0 and 1 using the same seed used in the watermark embedding procedure.
Step 6: For each block in the sub-band HH1, calculate the correlation between the mid-band coefficients and the two generated pseudorandom sequences for 0 and 1. If the correlation with the pseudorandom sequence 0 was higher than the correlation with pseudorandom sequence 1, then the extracted watermark bit is considered 0. Otherwise the extracted watermark is considered 1.

Step 7: Reconstruct the watermark using the extracted watermark bits, and compute the similarity between the original and extracted watermarks.

Stop.

![Watermarked Image](image)

Watermarked Image (Without Noise)  | Retrieved Watermark
---|---
Input | Output

Fig.4- Input and Output of the Algorithm 2

4. RESULTS AND DISCUSSIONS

The evaluation of proposed scheme is done with respect to robustness and fidelity. Matlab 2009a programming tool and the bitmap cover image Lena of size 225 X 225, binary watermark bitmap image containing text ‘ANAND’ of size 50 X 20 are used for the purpose. The imperceptibility by the presence of watermark is measured as 57.0593 dB. Better robustness is achieved by increasing the gain factor k as it increases the value of transformed midband coefficient and by reducing gain factor k as it decreases the value of transformed midband coefficient and there is increase in fidelity as depicted in table 1.

<table>
<thead>
<tr>
<th>Gain Factor</th>
<th>Perceptual Similarity of Watermarked Image</th>
<th>Perceptual similarity of Watermark</th>
<th>Gain Factor</th>
<th>Gaussian Noise with Mean=0.1 and Variance=0.01</th>
<th>Gaussian Noise with Mean=0.5 and Variance=0.05</th>
<th>Poisson Noise</th>
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<td>PSNR</td>
<td>Correlation</td>
<td>k_value</td>
<td>Correlation</td>
<td>Correlation</td>
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Table 1- Effect of Gain factor
CONCLUSION
The DWT, FFT and Fast Walsh-Hadamard Transforms are used successfully for digital watermarking. The combination is feasible for the properties like robustness and fidelity. The experimental results reveal that the greater fidelity can be achieved by lower gain factor and the greater robustness by higher gain factor. Table.1 shows that in this schema fidelity and robustness are inversely relative.

5. REFERENCES