A Hybrid Blind Watermarking With Redundant Discrete Wavelet and Hadamard Transform

T. Yasasvy, K. Venkat Sushil, K. Meenakshi, K. Swaraja, Padmavathi Kora

Abstract: The rapid growth in usage of digital technologies brings tremendous interest to the field of digital authentication. Digital watermarking is one of the most powerful authentication techniques used to restrict unauthorized usage of copyrighted images. Unique logo can be inserted into different copies of the same digital image for different clients. This will curtail the illegal usage. Most of the earlier works used Redundant Discrete Wavelet (RDWT) transform in combination with SVD. These watermarking schemes suffered with false positive problem. Hence, in this work, a hybrid blind watermarking is developed by using a combination of Redundant Discrete Wavelet (RDWT) and Hadamard transform to get rid of false positive problem and to produce imperceptible, robust and secure watermarking scheme.

Keywords: Redundant Discrete wavelet transform, slant transform, PSNR, NCC.

I. INTRODUCTION

The proliferation and exchange of multimedia data with increased usage of cellular mobile communications and Internet has brought with it new challenges for secured communication [1]. Steganography [2] and watermarking [3-16] techniques are two main data hiding techniques commonly used for covert communication. Both techniques are aimed at hiding secret information. Steganography is mainly used for embedding secret information in point-to-point communication whereas watermarking is used for concealing secret data in single to multi point communication. If underlying secret information is known then steganography fails. On the other hand, watermarking scheme fails if watermark is erased or removed. In this paper, digital watermarking is used to identify the proprietorship ownership and track the misuse of digital data works. Primarily, to authenticate the source or proprietorship of a information a digital watermark is inserted in the digital data permanently. The important properties of watermarking are transparency, robustness and payload [4].

In literature, several watermarking schemes are proposed. Ref.[17] developed a robust watermarking using RDWT and SVD using SADE. The main drawback of the algorithm is the optimization algorithm which takes more computational time. Further SVD based watermarking schemes suffered with false positive problem. To remove this, the authors incorporated hash-based authentication which further increases the complexity of watermarking scheme. The algorithm is non blind and it requires the cover image for watermark extraction. In the proposed watermarking scheme, more than one transform is used for watermark concealing. In it, the advantage of both of the transforms that is RDWT and Hadamard is explored. It was found that the features extracted from hybrid domain are more resistant to tampering than a single transform alone. In this work redundancy in RDWT and simple computational aspects of Hadamard transform are combined to obtain imperceptible, robust and high capacity watermarking scheme. The main contribution of the work is that for the first time a still image watermarking based on RDWT and Hadamard transform is proposed. It is blind and cover image for watermark extraction is also not required. Further it is free from false positive problem and low computational transform because Hadamard kernel requires only ±1 coefficients.

II. PRELIMINARIES

The proposed transform utilizes RDWT and slant to embed the watermark in blind manner.

A. Redundant Discrete Wavelet transform

The main drawback of the Discrete wavelet transform is that it is not shift variant. The features of RDWT is shift invariance and over complete frame expansion which has attracted researches to use in watermarking. The decimation steps of DWT [20] are removed in RDWT. If the size of cover image is 512×512, the size of RDWT is increased by 1024×1024 thereby increasing the capacity of the watermarking scheme in Figure 2 by four times as compared to Figure 1.

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Hadamard transform is a fast transform which has image like basis function. It has good energy compaction among non-sinusoidal transforms.

B. Hadamard Transform

Hadamard transform is the lowest computational transform among the non-sinusoidal transforms. The 8 × 8 kernel is

$$H_8 = \frac{1}{\sqrt{8}}\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & -1 & 1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix} \quad (1)$$

Hadamard transformed coefficients are obtained by using Eq 2 as given in [19].

$$A_N = H_8 B_N H_8^T \quad (2)$$

A_N represents the block of Hadamard transform coefficient and B_N represent the 8 × 8 block of host image. Similarly, image can be reconstructed using Eq. 3

$$B_{recN} = H_N A_N H_N^T \quad (3)$$

block of host image. Similarly, image can be reconstructed using Eq.3.

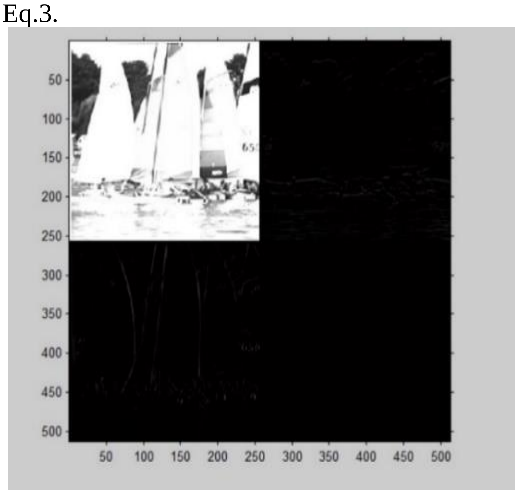

Fig. 1.First Level Decomposition of DWT

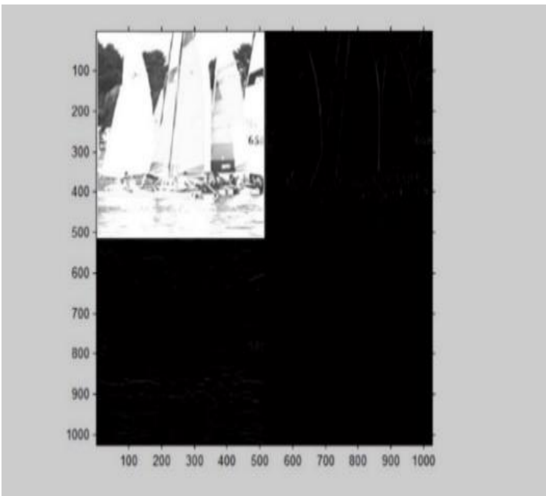

Fig. 2.First Level Decomposition of RDWT

B. Proposed Methodology

In this scheme, after applying RDWT to the whole host image is divided into four quadrants LL_{cover}, LH_{cover}, HL_{cover}, and HH_{cover}. The four quadrants are further divided into non-concurrence 8×8 sections and the sections having lowest summation are taken for watermark concealing which may ensure to improve the imperceptibility. Later Quantization index modulation is applied on Hadamard transform coefficients to embed the binary watermark. To improve the security of binary watermark toral automorphism is employed.

C. Watermark Concealing

The inputs to the watermark embedding are the cover image and the watermark. The output is the watermarked image. Embedding steps of proposed algorithm is given Figure.3.

1. Apply RDWT to cover image A and obtain 4 quadrants: LL_{cover}, LH_{cover}, HL_{cover}.and HH_{cover}.
2. Divide all four blocks into non overlapping blocks of 8 × 8 and apply Hadamard 8 × 8 kernel to obtain Hadamard transformed image.
3. In order to differentiate the features of host and watermarked image, Low summation blocks are used as much as possible and these are selected before and after fixing the watermark [18]. The size of the ciphered watermark bit sequence is less than the RDWT frequency component blocks of size 8 × 8 each.The strategy is to insert watermark in lower summation blocks as it improves the imperceptibility of the scheme.
4. Watermark robustness in Hadamard transform, is achieved when watermark is embedded in middle frequency bands. These locations provide better compromise between imperceptibility and robustness.
5. Watermark is encrypted by Toral automorphism [12].
6. The middle frequency coefficients in Hadamard are selected based on HVS Quantization matrix, The embedding location of the watermark bits is inserted based on the imperceptibility of marked image and withstand capability to attacks. The two AC coefficients AC_p and AC_q are modified as per the watermark bits as follows: to embed bit '0' to embed bit'1'. Block element (0, 0) contains DC and the remaining coefficients are AC components. where, 'P' and 'Q' indicate position of the coefficient in the block and T is a threshold

$$AC_Q = \begin{cases} AC_P + T, if\ watermark\ bit = 1 \\ AC_P - T \quad\quad otherwise \end{cases} \quad (4)$$

7. Apply inverse Hadamard and RDWT to obtain watermarked image.

D. Watermark extraction

The inputs to the watermark extraction are the watermarked images. The output is the extracted watermarks from four bands.

Extraction steps of proposed algorithm is given Figure.4.

1. Apply RDWT to signed image A and and map them into 4 quadrants: LL_{wa}, LH_{wa}, HL_{war} and HL_{war}.
2. Divide all four blocks into nonoverlapping blocks of 8 × 8 and apply Hadamard 8 × 8 kernel to obtain Hadamard transformed image.

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3. Select the same low summation blocks from where watermark is extracted.

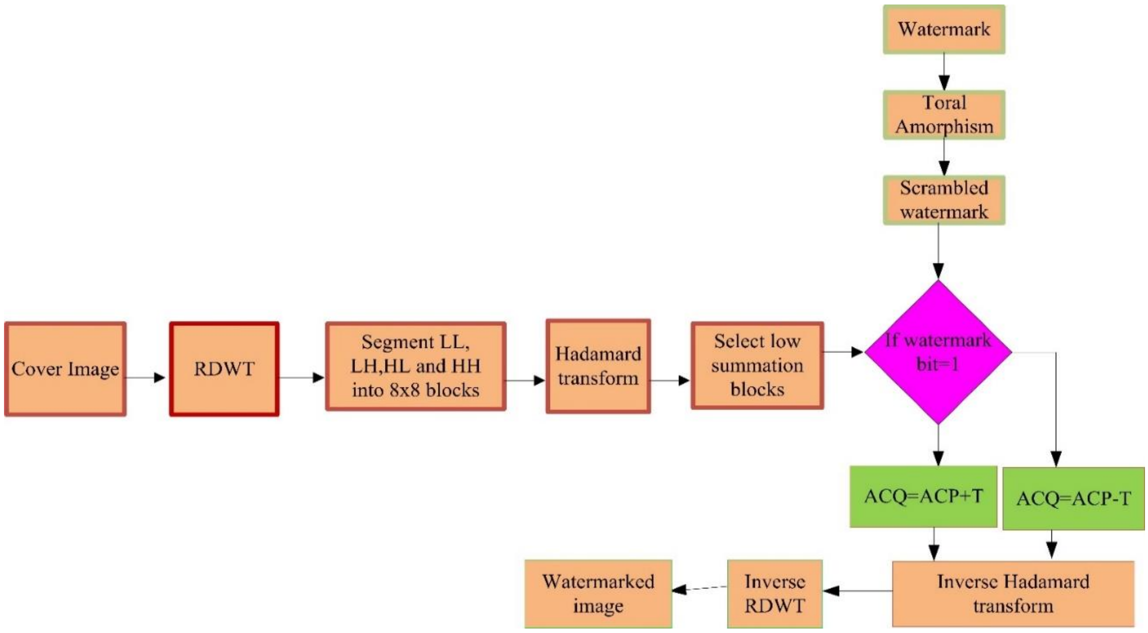

Fig. 3 Watermark embedding using RDWT and Hadamard

4. Watermark bits are extracted based on the following rule:

$$Watermark\ bit = \begin{cases} 1 & AC_Q > AC_P \\ 0 & AC_Q < AC_P \end{cases} \quad (5)$$

5. Concatenate all the watermark bits and transform 1d to 2d array.

Decrypt the watermark using inverse toral automorphism.

6. Extract the watermark from four bands.

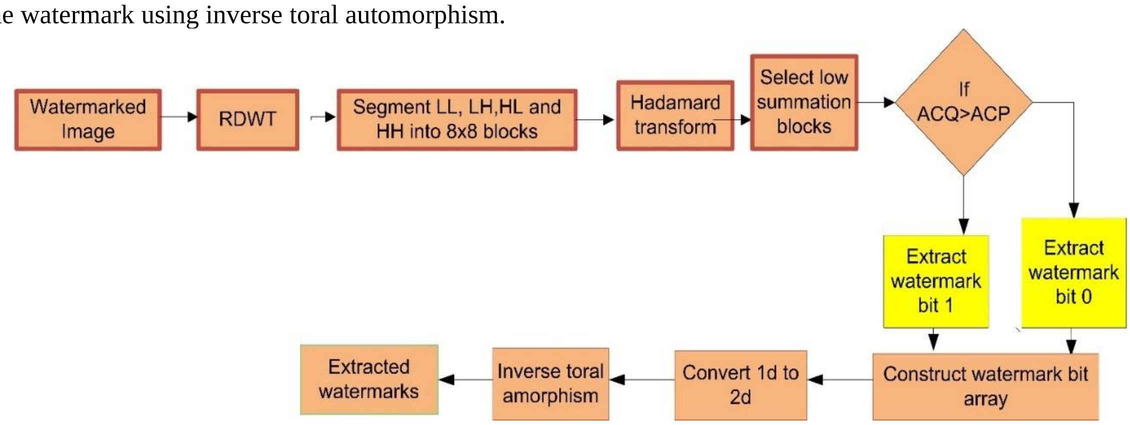

Fig. 4 Watermark embedding using RDWT and Hadamard

III. RESULTS AND DISCUSSION

In this work, the test images used are Boat, Zelda, Lena, medical images human skull, MRI brain images and airplane of size 512×512. After RDWT transformation, the size of individual bands LL, LH, HL and HH are 512×512. Each band later is split into 8×8 blocks of size 64×64. Out of each 8 × 8 block two middle frequency band AC coefficients are selected for watermark concealing. Therefore, in each band, 64 × 64 bits watermark can be used.

However, as imperceptibility, robustness and capacity are mutually conflicting; increasing one parameter may decrease the other two. Hence, out of them only the low summation blocks of size 32 × 32 are used for watermark insertion. The watermark used is 32 × 32 of java cup.

A. Imperceptibility

It is one of the vital parameters for the evaluation of watermarking scheme. It is measured by PSNR. It means that the perceived quality of the cover image should not be destroyed by the presence of watermark. The PSNR andMean square error(MSE) are given by Equations 6 and 7.

$$PSNR = 10\log_{10}\frac{255^2}{MSE} \quad (6)$$

$$MSE = \frac{\sum_{j=1}^{N}\sum_{i=1}^{M}\left(I_{i,j}-I_W(i,j)\right)^2}{MN} \quad (7)$$

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The host images boat, Zelda, Lena, two medical images and airplane are downloaded from the website www. image processing place. com. The average PSNR of the proposed algorithm is 52.4 dB. So, the proposed method is highly imperceptible.Fig.5(a)(b)(c)(d)(e)(f)),Fig. 6(a)(b)(c)(d)(e)(f). emphasize that there is no perceptible difference between the watermarked and host image and the watermark is completely invisible.

The Comparison of proposed watermarking algorithm with RDWT+SVD [12], DCT+DWT+SVD [13] in terms of PSNR is carried to prove that the proposed algorithm is highly imperceptible. The watermark size in individual bands are 256 × 256. Therefore, the average PSNR of RDWT+SVD is around 32.34dB. In DCT+DWT+SVD, the average PSNR is 36.66 dB. The average PSNR of proposed scheme is 53.4 dB.

B.Robustness

The performance of proposed watermarking scheme in terms of robustness is checked by conducting numerous experiments. The thresholds selected for different bands must be distinct and a threshold value of 0.05, 0.0005, 0.0005 and 0.0005 are used for four frequency bands.

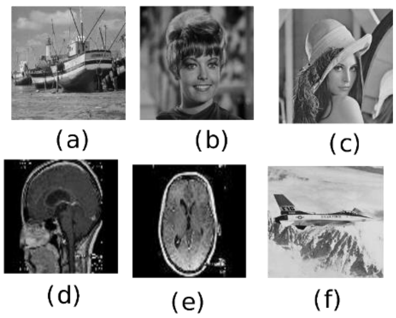

Fig.5 Host images used in proposed watermarking

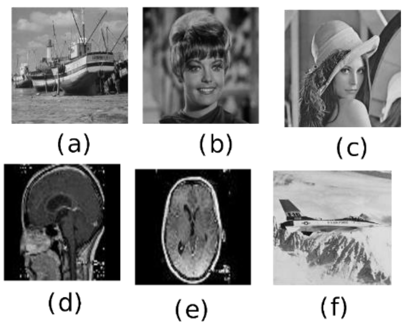

Fig.6 Watermarked images used in proposed watermarking

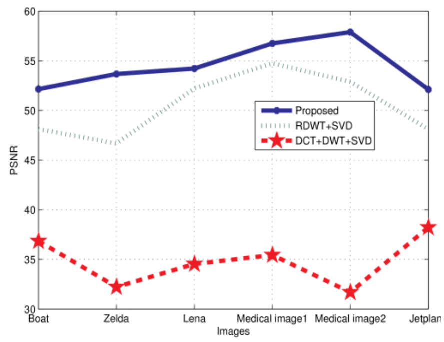

Fig.7 Comparison of proposed watermarking with RDWT+SVD+SADE [12] and DCT+DWT+SVD [13]

Attack	Watermarked image	Extracted watermarks
Scaling by 0.5 using bilinear interpolation		

Fig 8. Rescaling and its extracted watermarks from four bands

. The following attacks are applied on watermarked image namely average filtering, rotation, scaling by 0.5, high pass filtering and median filtering. All the attacks are carried in MATLAB platform on a PC with 4 GB RAM and Core i5 Duo processor.

Watermarked attack	Watermarked image	Extracted watermarks
Low pass filtering		

Fig.9. Low pass filtering and its extracted watermark from four bands

Watermarked attack	Watermarked image	Extracted watermarks
Scaling		

Fig. 10. Rotation attack and extracted watermark from four bands

1. Scaling: In this attack, the watermarked image is reduced to half and later its size is increased to normal by doubling it. The NCC values obtained for this attack in LL, LH, HL and HH band are 1, 0.988, 0.866, 0.744.
2. Low pass filtering: In this attack, the watermarked image is subjected with averaging filter of size 3 × 3 window. TheNCC values obtained for this attack in LL, LH, HL and HH band are 1, 1, 0.322, 0.756. In this watermark in HL band is not withstand to this attack.
3. Rotation: In this attack, the watermarked image is subjected to quarter of complete rotations once in clockwise followed by anticlockwise rotations The NCC values obtained for this attack in four bands are 1, 1, 0.222, 0.843. In this attack watermark is not survived in HL band.
4. Salt and Pepper noise. In this attack, the watermarked image is subjected to salt and pepper noise with density 0.01. The NCC values obtained for LL, LH, HL and HH band are 1,1, 0.32, 0.546,0.786.

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C. Payload

The payload of the proposed algorithm is very high and is equal to $32 \times 32 \times 4 = 4096\ bits$. So the payload of the algorithm is very high due to usage of RDWT.

IV CONCLUSION

The proposed watermarking explores the redundancy of RDWT and competency simplicity of Hadamard transform to provide copyright protection of still images. The algorithm is made more imperceptible by concealing watermarking LABS. The hybrid combination of RDWT and Hadamard produces a robust and high capacity watermarking.

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