Enhanced Security and Reinstatement Computing of Images Using Fragile Invisible Integer Wavelet Watermarking Scheme

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***Abstract*—This paper introduces an enhanced technique for image authentication/ restoration using self-embedded watermarks based on IWT (Integer Wavelet Transform). The lower bit plane was selected and JPEG compression applied to each 8x 8 block with a quality factor of fifty to reduce the watermark size. The reduction in the watermark size comforts in self-embedding the watermark four times in the cover image. The bit transformation was carried out by using the block classification method and 8x 8 quantized blocks were then encoded to pre-define variable bit lengths. The verification watermark was generated by computing a 24 bits hash function value for every 8x 8 block and concatenated it further to watermark bits of lower bit plane. The proposed wavelet based self-embedding scheme has the ability to restore the tampered image successfully up-to altered region ≤ 74% as compared to existing schemes having restoration capability up- to 60%. The fragility of the watermarking scheme employed also helps in identifying even trivial changes in the image with resolution capability. In this regard the Mean Square Error (MSE), image fidelity and Correlation Coefficients (CC) were determined. The experimental verification confirms an enhanced image authentication/ restoration capability.**

***Index Terms*— Data hiding; tampered areas; robustness; wavelet transform.**

I. Introduction

THE digital image processing techniques continue to play a substantial role in ongoing advancements related to image/ video processing and emerging multimedia applications [1]. The recent progression in image and video based media services has posed serious security challenges to keep the information intact from malicious attacks and deliberated changes [2]. The watermarking schemes help in protecting data from such unwanted squalors by making use of fragile, semi fragile, and robust watermarks [1, 3]. The attacks on multimedia data can broadly involve geometrical attacks, protocol attacks and cryptographic attacks [4].

In this regard, the self-embedding techniques have received much attention over past few years to intelligently conceal and retrieve data that has been maligned illegally [5]. The fixed length encoding algorithm proposed by Fridrich [6] to retrieve tampered regions from secluded connected blocks ignored the assortment of very small patches or individual pixels [7]. The content based watermarks generally have limitations in terms of preserving image fidelity due to contrast variations [8, 9]. The self- embedding schemes for missing block reconstruction described in [10] suffers from convergence issues. The self-embedding algorithm proposed in [11] has used cover image to embed the watermark provides a restoration capability of 60%. But as three least significant bits were for the watermarking, the image quality was compromised. The limitations of preceding algorithms were to recover efficiently the tampered plane if the impact of change encompasses a larger image area [12].

In this paper, self- embedded wavelet watermarking scheme is proposed that agrees localization in spatial domain. The proposed scheme has the ability to track even slight changes with good resolution results. The presented self- embedded watermarking scheme can regenerate tampered area up-to 74% that has previously been limited to 60% [11]. The multiple self-embedding in the cover image is imperative from security view point and enhanced quality was ensured by engaging only two bits to embed the watermark. The first level approximation and JPEG quantization followed by toral automorphism routine to identify the destination block position with a private key imparts a resilient feature to the proposed scheme.

II. Watermark Embedding Algorihm

The embedding algorithms responsible for authentication and reconstruction of the tampered region are outlined in Fig. 1. The Wavelet transform is applied and the LOW-LOW image part is selected. The image size reduction was done by applying Discrete Cosine Transform (DCT) and then JPEG compression with the quality factor of 50% is applied on each block.

The quantization matrix with quality factor of 50 is illustrated in Table 1. The quantized DCT coefficients were computed by using the expression in Eq. (1).

$$\boldsymbol{B}_{j,k} = \text{round}\,(G_{j,k}/Q_{j,k}) \qquad (1)$$

where j=0, 1, 2…7 and k=0, 1, 2… 7. The $G_{j,k}$ represent the un-quantized DCT coefficients, $Q_{j,k}$ is the quantization

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matrix with quality factor 50.

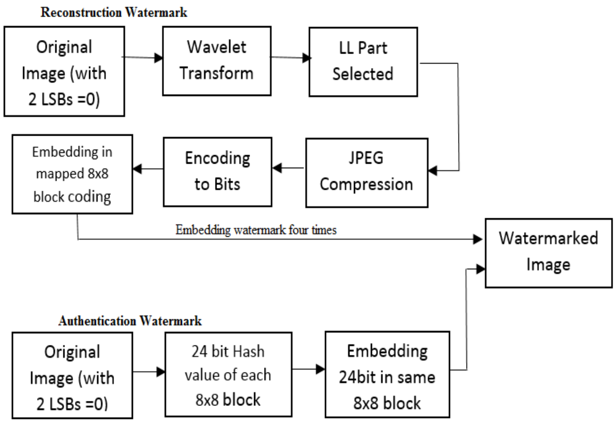

Fig. 1 The block representation of embedding scheme.

TABLE I
THE 8X8 BLOCK QUANTIZATION VALUE (QUALITY FACTOR= 50)

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

Some of the high frequency coefficients in each quantized 8x 8 block results in a zero value due to round operation involved resulting in reduced block size. An example of such quantized 8x8 block is given in Eq. (2).

$$\begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ 0 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -3 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (2)$$

The zig- zag scanning method is employed on each 8x8 block, obtained to all coefficients until the zero coefficients start. The resulting zig- zag becomes;
-26, -3, 0, -3, -2, -6, 2, -4, 1, -3, 1, 1, 5, 1, 2, -1, 1, -1, 2, 0, 0, 0, 0, 0, -1, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0. The desired sequence after disregarding the high frequency coefficients with zero values yields; -26, -3, 0, -3, -2, -6, 2, -4, 1, -3, 1, 1, 5, 1, 2, -1, 1, -1, 2, 0, 0, 0, 0, 0, -1, -1. It is pertinent to note that only 26 coefficients are required instead of 64 to represent an 8x 8 block. This routine is applied to entire image to achieve compaction.
The next stage involves encoding each 8x8 block to binary bits. The predefined variable encoding scheme was applied keeping in view the number of non-zero coefficients in each block. For this purpose, four sets namely have been defined. This concept is presented in Table 2. The coefficients with negative values were encoded with signed binary number and positive values with an unsigned binary number.

TABLE II
THE VARIABLE LENGTH ENCODING FOR SETS CLASSIFICATION

Sets	**Header bits**	**Number of non-zero coefficients in an 8x 8 block**	**Total number of coefficients to encode in an 8x 8 block**	**The encoded bit length for each 8x 8 block**
SET1	00	0-9	9	57
SET2	01	10-12	12	69
SET3	10	13-16	16	84
SET4	11	17-64	21	100

The two bits header string was appended to keep track of block identification. To determine the coefficients to be encoded from each 8x8 block, the four tables are illustrated in Fig. 2 [11].

For SET1

8	7	6	5	0	0	0	0
7	6	5	0	0	0	0	0
6	5	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

For SET3

8	7	6	5	4	2	0	0
7	6	5	4	0	0	0	0
6	5	4	0	0	0	0	0
5	4	0	0	0	0	0	0
4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

For SET2

8	7	6	5	0	0	0	0
7	6	5	0	0	0	0	0
6	5	0	0	0	0	0	0
5	3	0	0	0	0	0	0
4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

For SET4

8	7	6	5	4	3	0	0
7	6	5	4	3	0	0	0
6	5	4	3	0	0	0	0
5	4	3	0	0	0	0	0
4	3	0	0	0	0	0	0
3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Fig. 2 The coefficients to be encoded based on the tabular entries of sets.

III. WATERMARK DETECTION ALGORIHM

The watermark detection scheme involves the authentication of image to check for any tampered area and retrieves the image if it has been tempered with help of self-embedded watermark.

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A. *Image Authentication*

The watermark embedding has been done by computing a 24 bit hash value for every 8x8 block. This value was used by the reconstruction watermark. The authentication watermark was placed in the same block for which the hash value was calculated.
The flow scheme for image recognition and retrieval is presented in Fig. 3.

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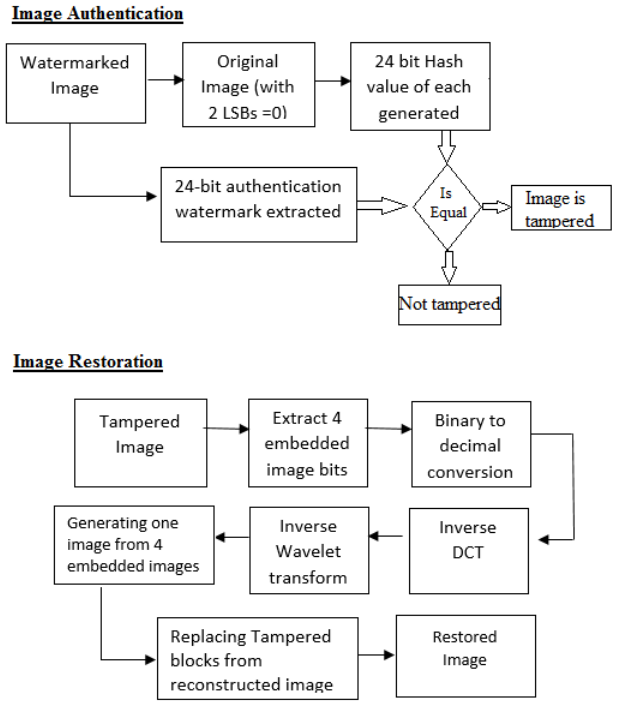


Fig. 3 The flow scheme for image recognition and its retreival.

By setting the two least significant bits of the watermarked image to zero, the 24 bits hash value is regenerated and compared to check for tampering. If the generated and extracted watermarks are found equal then the image is not tampered, otherwise reconstruction watermark will used to restore the image.

B. Image Restoration

The image restoration procedure is outlined in Fig. 3. As we have embedded the reconstruction watermark in the image four times and the mapping location of each block was already known, therefore the watermark from each 8x8 block is extracted. The header bits allow us to determine the sets classification. The extracted binary bits from each 8x8 blocks were then converted to decimal value and taking inverse DCT followed by a Wavelet transform yields actual quantized coefficients values. By performing the inverse zig- zag scanning 8x8 blocks were reconstructed. The procedure was repeated for all four of the embedded images. The tampered areas have not the same position as each of four images was embedded at different positions. These four images were used to generate a unique reconstruction image. The restored blocks were then replaced with the tampered ones in the generated reconstruction image.

IV. Experimental Results

The experimental validation was done in MATLAB and the results are presented in Figs. 4- 9. The test images were taken in gray-scale format with an image size of 512x512. The watermarked images namely 'lena. bmp' and 'car. bmp' in Fig. 5 have PNSR values of 44.89dB and 46.92dB and results are illustrated in Table 3. An analysis of the MSE, CC and image fidelity is illustrated in Table 4. The reconstructed image presented in Fig. 9 has PSNR of 35.58dB and 36.25dB. The tampering in Fig. 6 was achieved using Adobe Photoshop CS 6. The histogram analysis of the processed images is illustrated in Fig. 10.

The presented results in Fig. 9 are almost similar to [11] but with a much reduction in the size of watermark and enhanced restoration ability from 60% to 74%. The proposed technique has the ability to process square images. The other existing techniques embed the watermark only once in the image but the proposed technique done it four times to recreate up to 74 % of the damaged area.

(a) Lena (b) Car

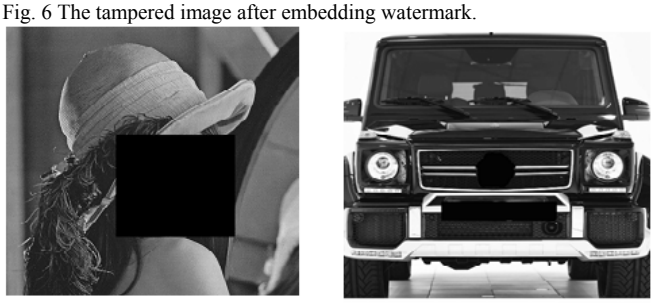
Fig. 4 The original image used for experimental verification.

(a) Lena (b) Car

Fig. 5 The image after embedding watermark.

(a) Lena (b) Car

Fig. 6 The tampered image after embedding watermark.



(a) Lena (b) Car

Fig. 7 The authentication process used for tampered image.

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(a) Lena (b) Car

Fig. 8 The reconstructed image obtained by using four embedded images.

(a) Lena (b) Car

Fig. 9 The final retrieved image after restoration stage.

TABLE III
THE COMPARISON OF PSNR AND RESTORATION METRICS WITH [11]

Images	Techniques	PSNR of watermarked image	PSNR of reconstructed image	Restoration capability if the image is tampered (%)
Lena	Method described in [11]	37.9 dB	35 dB	60%
	Proposed scheme	44.89 dB	35.58 dB	Upto 74%
Baboon	Method described in [11]	-	25.1 dB	60%
	Proposed scheme	45.06 dB	30 dB	Upto 74%

TABLE IV
AN ESTIMATE OF MSE, CC AND IMAGE FIDELITY.

Images	PSNR (dB)	MSE	CC	Image Fidelity
Lena	44.89	1.42002	0.9995	0.9945
Baboon	45.06	1.1095	0.9995	0.9956

V. CONCLUSIONS

The paper presents a novel self-embedding method for image authentication and its restoration up- to an affected region of 74%. The proposed scheme deploy fragile lower bit plane watermarking to track trivial changes. The unprecedented watermark size reduction was made possible due to IWT watermarking. The presented scheme has an enhanced authentication and restoration capability.

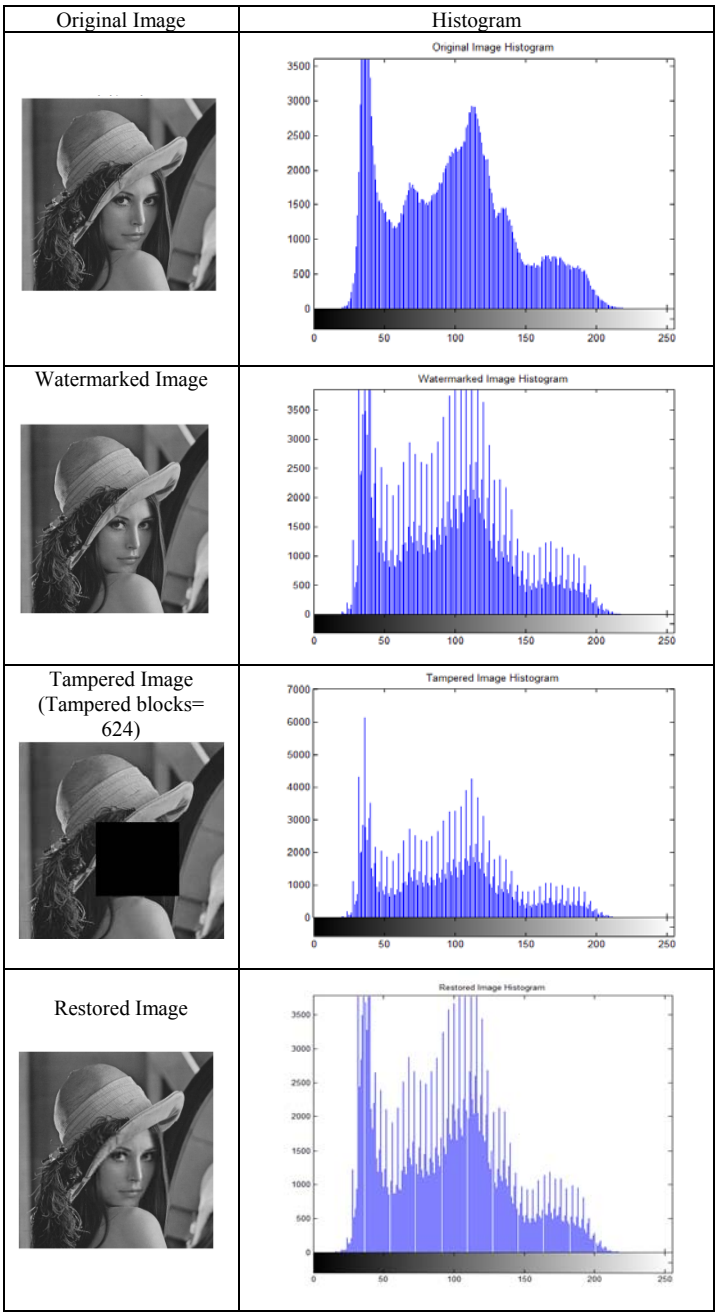

Fig. 10 The histogram representation of different stages involved in the proposed scheme.

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