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An Efficient Robust Reversible Blind Watermarking For Colour Images Using Maximum Wavelet Coefficient in the Selected Blocks of Fixed Size

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Abstract:-- **An efficient robust reversible blind watermarking for colour images is proposed which enables the recovery of the original host image upon extraction of the embedded watermark. Blind watermarking technique is applied for watermark extraction which does not require host image for extraction. For embedding, two level DWT is performed. Watermark is embedded in the maximum wavelet coefficients of the selected blocks of LH and HL sub-bands of both levels. Blue component is chosen for watermark embedding. This watermark scheme is robust against various geometric and non-geometric attacks. It is proved experimentally that the PSNR of the watermarked image versus the original image is guaranteed to be above 40dB. Also it is proved that the reversibility is also high. The proposed method achieves imperceptibility, robustness and reversibility. Experimental results and performance comparison with other schemes are presented to demonstrate the validity of the proposed algorithm.**

Keywords:-- **Watermarking, Reversibility, Wavelet, Blind Watermarking, Colour Images, Robustness.**

1. INTRODUCTION

Digital image watermarking is a process that embeds a watermark into a digital image to form a watermarked image. Digital watermarking methods for images are usually categorized into two types: invisible and visible. Invisible type aims to embed copyright information imperceptibly into host media such that in cases of copyright infringements, the hidden information can be retrieved to identify the ownership of the protected host. Methods of visible watermarking type on the other hand, yield visible watermarks which are generally clearly visible after common operations are applied. In addition, visible watermarks convey ownership information directly on the media and can deter attempts of copyright violations [2-3].

Another way of classification is blind and non-blind watermarking systems. In non-blind watermarking systems, the detector requires either the original image or some information about the original image. However, in blind watermarking systems, there is no need of original or any information about the original image [4], [5], [8].

Reversible Watermarking (RW) methods [1], [4] are used to embed watermarks, e.g., secret information, into digital media while preserving high intactness and good fidelity of host media. It plays an important role in protecting copyright and content of digital media for sensitive applications, e.g., medical and military images. RRW recovers original image as well as resist intentional and unintentional attacks and extract watermark successfully. DWT approach is the most effective and easy to implement techniques for reversible image watermarking[8],[7].

In this paper, we present a new robust and blind reversible watermarking method for colour images using Maximum Wavelet Coefficient in the Selected Blocks of Fixed Size. Here, blue component is used for watermark embedding. We use the local maximum wavelet coefficient of the selected blocks for watermark embedding. Compared with the known reversible watermarking techniques in the literature, the advantages of our scheme are as follows: first, our scheme has strong robustness; second, the imperceptibility of our scheme is perfect; third, our scheme has better reversibility.

This paper is organized as follows. In Section 2, we give some preliminary descriptions about two-level Discrete

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Wavelet Transform technique (DWT). In Section 3, we propose our watermarking scheme. In Section 4, we give some experimental results for the proposed scheme. Finally, we give a short conclusion in Section 5.

2. TWO LEVEL DWT

DWT offers multi-resolution representation of image and gives perfect reconstruction of decomposed image. When an image is passed through a series of low pass and high pass filters, DWT decomposes the image into several sub-bands in three different directions: horizontal, vertical and diagonal. With L-level decomposition, we have 2 x L+1 sub-bands. The LL_L frequency band is found to be unsuitable to be modified since it is a low frequency band which contains important information about an image and easily causes image distortions. Embedding a watermark in the HH_L,HH_{L-1},…,HH_1 sub-bands is also not suitable, since the sub-bands can be easily eliminated, for example by lossy compression. The significant sub-bands must be transmitted in the order of LL_L, LH_L, HL_L, HH_L, LH_{L-1}, HL_{L-1}, HH_{L-1},….., LH_1, HL_1, and HH_1 as shown in Fig.1. According to the characteristics of this scan order, we embed the watermark bits into the LH_L and HL_L sub-bands. Here Haar filter is used.

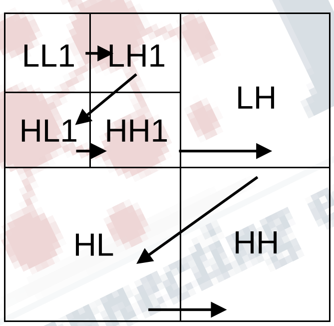

Fig.1 Wavelet sub-bands by scan order

3. PROPOSED TECHNIQUE

The proposed scheme is 'An Efficient Robust Reversible Blind Watermarking for Colour Images using Maximum Wavelet Coefficient in the Selected Blocks of Fixed Size'. Here, a new reversible watermarking for color images is introduced. RGB color space is used for watermark embedding. Watermark is embedded in the Blue component as it is less sensitive to Human Visual System. Our proposed scheme is divided into two phases namely embedding phase and extraction and host image recovery phase. Blind watermark extraction process is employed in which there is no need for host image to extract the watermark.

Algorithm 1: Watermark Embedding.

Input: Colour Host Image I of size 512 x 512 and Binary Watermark W of size 32 x 32.

Output: Watermarked Image I^w

The steps are given below:

1. Separate colour host image I into Red R, Green G and Blue B components.
2. Perform 2 level DWT on B and obtain LH, HL,HHsub-bands at level1 and LL1, LH1, HL1 and HH1 sub-bands at level 2.
3. Select 1024 blocks of fixed size from LH1, HL1, LH and HL sub-bands.
4. Find out maximum value from each block where watermark is to be embedded ie. Maxi where i=1, 2, ……, 1024.
5. Find out second maximum value also from each block as SecMaxi where i=1, 2, …. , 1024.
6. Compute Mean = $\frac{1}{1024}\sum_{i=1}^{1024} Max_i$ (1)

where Mean is the average value of the local maximum wavelet coefficients in all 1024 blocks.

7. Compute average of each block excluding Maxiie. avgi where i=1, 2, ….. , 1024.

8. Now compute α_i=Maximum $\{|avg_i|, |\text{Mean x } T_s|\}$ (2)

whereT_s is a scale parameter with value 1.2.

9. Perform watermark embedding as

a) If watermark bit w=1, Max_i^{new}= $Max_i + \alpha_{i(3)}$

where Max_i^{new} is the new value of Max_i.

b) If w=0, Max_i^{new}= Max_i xT1 $_{(4)}$

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where T_1 is a threshold value with value T_1=0.2

c) If Max_i^{new}<$SecMax_i$, then $SecMax_i$= $SecMax_i$ x T_2 (5)

where T_2 is a threshold value with value T_2=0.5

10. Perform 2 level Inverse DWT to obtain watermarked blue component Bw.

11. Combine R,G,Bw components to get watermarked colour image Iw.

Algorithm 2: Watermark Extraction and Host Image Recovery

Input: Watermarked Image I^w.

Output: Extracted Watermark W^e.

The steps are given below.

1. Separate I^w into RGB^w components.
2. Perform two level DWT of B^w and obtain LH', HL', HH' sub-bands at level 1 and LL_1', LH_1', HL_1' and HH_1' sub-bands at level 2.
3. Select 1024 blocks of fixed size from LH_1', HL_1', LH' and HL' sub-bands.
4. Find out maximum value from each block where the watermark was embedded.ie Max_i' where i = 1, 2, ….., 1024
5. Find out second maximum value from each block as $SecMax_i$' where i = 1, 2, …, 1024.
6. ComputeMean' $= \frac{1}{1024}\sum_{i=1}^{1024} Max_i{}'$ (6)
7. $\text{ComputeMean}_{block} = \frac{1}{1024}\sum_{1=1}^{1024} |avgi'|$ (7)

where avg_i' is the average coefficient value of the i^{th} block excluding Max_i'.

8. Compute α_i' = | $Mean_{block}$| + σ1 + σ2 (8)

where σ1 = Max_i'/Mean' σ2 = avg_i'/$Mean_{block}$

9. Rearrange α_i' as α_i'=Maximum $\{|avgi'|, |Mean_{block}| + \sigma 1 + \sigma 2\}$ (9)
10. Obtain extracted watermark bit w^e as

Watermarkbit (w^e) = $\begin{cases} 1, if\ (Max_i' - \alpha_i') \geq SecMax_i' \\ 0, \quad\quad\quad\quad Otherwise \end{cases}$ (10)

The extracted watermark is W^e.

11. Compute maximum value for the recovered image.

If w_i^e = 1, Max_i^r=Max_i' - α_i' (11)

else Max_i^r = Max_i' / T_1

where i = 1, 2, ….., 1024. (12)

12. Perform 2 level inverse DWT and obtain recovered Blue component B^r.
13. Combine R, G, and B^r components to obtain recovered image I^r.

In the Extraction Algorithm, the extraction of the watermark does not require the original cover image, that is, it satisfies the blindness property. The robustness of the proposed scheme will be demonstrated in Section 4 by simulations against various attacks.

4. EXPERIMENTAL RESULTS

We have conducted a series of experiments implementing the proposed method using MATLAB. Colour images with dimensions 512 x 512 were used in the experiments. Binary watermark with size 32 x 32 is used. Watermark is embedded in the blue component of the host image. Two level wavelet transform is performed with watermark inserted in the maximum values of the 1024 chosen blocks of LH_1, HL_1,LH and HL sub-bands. Also we predetermine the scale parameter T_s 1.1 and threshold values T_1 and T_2 as 0.2 and 0.5 respectively. Watermarking is a blind watermarking which doesn't require host image for watermark extraction.

TABLE I

Image	PSNR of Watermarked Image (dB)	PSNR of Recovered Image (dB)	Similarity Measure (SM) of Extracted Watermark
Lena	50.2552	46.2092	0.9941
Sneha	47.0947	44.0470	0.9805
Birds	50.3039	44.7907	0.9893
Pink Flower	44.9578	41.5044	0.9326

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National Image (Lotus)	52.7544	46.3738	0.9902
Texture Image	48.6207	45.9910	0.9746

The peak signal-to-noise ratio is used to evaluate the quality of the watermarked image as well as the quality of the recovered image. The accuracy of the extracted watermark is evaluated by the Similarity Measure (SM). Similarity Measure is nothing but the evaluation of similarity of the extracted watermark with the owner's watermark. These three measures are shown in Table I. From the table, we came to the conclusion that the quality of watermarked image is very high as the average PSNR values obtained are 48dB. It is apparent that the recovered image is identical to the original image and satisfies reversibility. From the table, also it is seen that SM>0.97 and proved that the accuracy is high.

To test the robustness of the proposed approach, the watermarked image is JPEG compressed by varying the quality factor from 50 to 80 and similarity of extracted watermark with owner's watermark is measured. Even after JPEG compression, Similarity Measure (SM) is very high which is shown in Table II. It proves that the proposed method is highly robust against JPEG compression. We simulate nine simple attacks on the watermarked images. Similarity Measures of extracted watermarks from the attacked images with the owner's watermark are also tabulated in Table II. According to Table II, the proposed approach has strong robustness against various attacks.

TABLE II

JPEG Attack (Various Quality Factors)	Similarity Measure after JPEG Compression (Lossless Attack)	Other Attacks	Similarity Measure after other Attacks
QF=50	0.9902	Median Filter (3 x 3)	0.8223
QF=60	0.9902	Median Filter (5 x 5)	0.7705
QF=70	0.9902	Gaussian Filter	0.9736
QF=80	0.9902	Rotation (0.10^{o})	0.8281
QF=90	0.9902	Rotation (-0.10^{o})	0.7910
QF=100	0.9902	Scaling 256 x 256	0.8535

From the above tables, we draw a conclusion that the proposed method achieves better quality in terms of watermarking and reversibility.

5. CONCLUSION

In this paper, we proposed a new watermarking technique for Robust Reversible Blind Watermarking for colour images. The process includes i) 2 level DWT ii) Watermark embedding iii) Watermark extraction and host image recovery. Embedding factor determination is based on the local coefficients of HL and LH sub-bands of first level as well as second level DWT. Watermark embedding is done in the maximum wavelet coefficient of the selected blocks of LH and HL sub-bands of both levels. The reversibility achieved is very high. The experimental results show that the proposed scheme provides good performance in terms of imperceptibility, reversibility and robustness.

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