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Significant Wavelet Hierarchical Approach Using Even Odd Method for Watermarking

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Abstract— Watermarking application requires flexibility to alter the cover image in order to embed the hidden information and makes the watermark more robust to attacks. These constraints are effectively achieved, in the present paper using SWH approach for digital watermark. In the proposed Significant Wavelet Hierarchical (SWH) approach, the selected subband of wavelet transform is divided in to non overlapped Hierarchical Regions (HR), each with sizes of B×B rows and columns. The HR is then divided into Significant Hierarchical Regions (SHR) of size (B-i) × (B-i) rows and columns. The SHR is used to represent the watermark. In the present approach watermark is inserted only in the SHR by a novel approach called REO Method. The unused row(s) and column(s) of HR are named as Unused Hierarchical Region (UHR). The UHR maintains the next level of hierarchy. This makes the present method as more efficient in terms of maintaining the hierarchy, security, authenticity, and in resisting various attacks. The experimental results with various attacks prove the efficacy of the proposed SWH approach.

Index Terms— Digital Watermarking, Discrete Wavelet Transformation, Significant Hierarchical Regions, Region based Even Odd

1 INTRODUCTION

Digital watermarking offers a means for protecting intellectual property of digital multimedia contents that have been explosively exchanged in the digital world. This technique is based on embedding information data (called watermark) into the digital contents. The main requirements of digital watermarking are invisibility, robustness and data capacity. These requirements are mutually conflicting, and thus, in the design of a watermarking system, the trade off has to be made [1].

Watermarking application requires flexibility to alter the cover image in order to embed the hidden information and makes the watermark more robust to attacks. These constraints are effectively achieved, in the present paper using SWH approach for digital watermark. In hierarchical digital watermarking methods the image is partitioned into non overlapping blocks, which constitute the lowest of the hierarchy, by combining distinct groups of blocks at a preceding level of the hierarchy [6]. In general, the number of blocks from a lower level of the hierarchy that are combined to form a block at the next level of the hierarchy may be arbitrarily chosen. Partitioning of the cover image into 'n' blocks is represented as given below in the figure 1.

Block based hierarchical watermarking system minimizes the changes in cover image when they are converted to corresponding watermark carrying regions in the watermarked image. Due to this nature, some regions in the cover object are experiencing less change in the statistics after embedding. This process makes very difficult to identify the watermark, for an intruder.

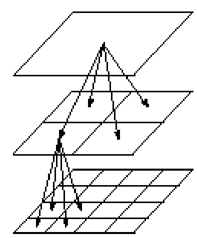

Fig.1 Hierarchical representation in the form of a quad-tree for a two dimensional image

The present paper is organized as follows. The section 2 describes the methodology, section 3 deals with the results and section 4 discusses regarding the conclusion of the paper.

2 SIGNIFICANT WAVELET HIERARCHICAL (SWH) APPROACH USING REGION BASED EVEN ODD (REO) METHOD

In the proposed Significant Wavelet Hierarchical (SWH) approach, the selected subband of wavelet transform is divided in to non overlapped Hierarchical Regions (HR), each with sizes of B×B rows and columns. The HR is then divided into Significant Hierarchical Regions (SHR) of size (B-i) × (B-i) rows and columns. The SHR is used to represent the watermark. In the present approach watermark is inserted only in the SHR by a novel approach called REO Method. By this (B–(B-i)) rows and columns are left unused for watermark insertion and they determine the address of the next hierarchical block where the watermark is inserted i.e., next level

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of hierarchy. The unused row(s) and column(s) are named as Unused Hierarchical Region (UHR). In the present paper, SHR are chosen from (B-2) × (B-2) rows and columns leaving top most and bottom most rows and left most and right most columns as unused for watermark. One bit from three pixels which constitute three bits are used to indicate the next level of hierarchy. The same address is preserved in the top most, bottom most, left most and right most column of the UHR. This phenomenon sustains any type of attack. The next level of hierarchy is taken at the time of extraction if and only if all four or three UHR show the same address. This makes the present method as more efficient in terms of maintaining the hierarchy, security, authenticity, and in resisting various attacks.

To maintain high security in the proposed hierarchical system the next hierarchical block address is given in the sixth bit position of 2^{nd}, 3^{rd} and 4^{th} pixels of the top row of UHR. The same is also represented in the same positions of the bottom most left and right most columns of UHR.

2.1 Embedding Algorithm for SWH approach using REO method

The entire algorithm of the proposed Significant Wavelet Hierarchical (SWH) based approach using the REO Method is given below.

Algorithm: SWH approach using REO method of digital watermarking

Begin

Step 1: Apply n level DWT on the cover image and obtain the nth level LL subband image.

Step 2: Divide the nth level LL subband image into non overlapped hierarchical blocks of size B × B rows and columns.

Step 3: Divide the Hierarchical block into the SHR with a window or sub block of size (B-2) × (B-2) rows and columns.

Step 4: Arrange the gray level values of SHR in ascending order along with their coordinate positions, P_i (x_i,y_j), $P_{i+1}(x_{i+l}, y_{j+l})$ …….; here P_i (x_i, y_j) denotes the gray level value of the location (x_i, y_j).

Step 5: Consider successive even (e_i) and odd gray values (e_{i+1}) as same after sorting. Where $((e_{i+1})-e_i)$ is always one and $e_i < e_{i+1}$. If two or more pixels of the SHR have the same gray level value or if they are successive even and odd values of the SHR then the least coordinated value of row and column is treated as least value. The watermark bit is embedded in the ascending order of gray level values of the considered SHR on the least x coordinate and y coordinate position.

Step 6: Convert each character of the watermark in to a 12 bit character by appending the MOD 9 value of each character.

Step 7: Insert the bits of watermark in to the identified pairs in ascending order of step 4.

Step 8: Place the next hierarchical block address from the nth bit position of three successive pixels of the UHR.

Step 9: If the watermark insertion process is over place the next level of hierarchical address as zero (000) and go to the step 10. Otherwise repeat the process in the next hierarchical block from step 3.

Step 10: Stop.

End of the algorithm

In the proposed SWH using REO method, successive even and odd values are treated as same but not successive odd and even values. Because an even number will have always a zero in the LSB, even by embedding a '1' in the LSB, its value is incremented by one at most. In the same way an odd number is always having a one in the LSB, even by embedding a '0' in the LSB its value is at most decremented by one. i.e., the odd values will never increment by 1 after embedding the digital watermark bit. And the even values will never decrement by 1 after embedding the digital watermark bit.

Therefore the maximum difference between successive even and odd values will be always one after embedding the digital watermark bit. Whereas the maximum difference between successive odd and even values is two after inserting the digital watermark bit. For this reason, the successive even and odd values of a neighborhood are treated as same in the proposed approach. This property removes the ambiguity in the extraction process of the watermark bits, based on ascending order of the window. The entire algorithm of the proposed SWH based approach using the REO method is explained with an example given below.

Consider that the DWT subband is divided into 7×7 bit non overlapping hierarchical blocks. Then on each hierarchical block, a SHR is formed with 5×5 bits leaving the top and bottom most rows and left and right most columns as shown in figure 2. The figure 2 shows a 7×7 non overlapped HR with gray level values. In figure 2 the UHR are shown with red border and the three pixels position of UHR which are used for storing the next level of hierarchy is shown in green. In the present experiment, the next level of hierarchy is considered from the sixth bit position of 2^{nd}, 3^{rd} and 4^{th} pixel locations of UHR, and this is shown in green color.

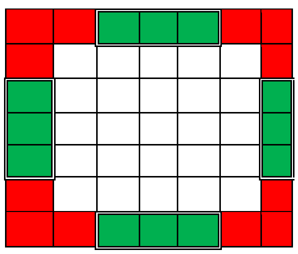

Fig. 2 Non overlapped HR with 7×7 bits

In the proposed method the first block has chosen as the first HR and the next level of hierarchy is determined by the 3 bit address of the UHR.

2.2 Extraction algorithm

The DWT is applied on the watermarked image. The watermarked image in the DWT is divided into non overlapped hierarchical blocks of size B×B rows and columns. The SHR is obtained by dividing the HR in to (B-2) × (B-2) rows and columns by leaving the top and bottom most rows and left most and right most columns. The watermark is obtained from LSB positions of SWH approach using REO method. For the next level of hierarchical address, the 3 bit address of top most and bottom most row and left and right most columns of the UHR are compared. If three or all four UHR show the same address then next HR address is chosen and

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the process is repeated. Otherwise the process is stopped saying that an attack has occurred and changed the hierarchical block address, which is a rare phenomenon.

3 RESULTS AND DISCUSSION

The proposed SWH method using REO method is experimented on 24 images of size 512×512 with the text "srinivasaramanujan". In the present paper Haar wavelet is used in the SWH method. The few watermarked images and the extracted images are given in figure 3 and figure 4 respectively. Table 1 shows the PSNR and NCC values for all the considered 24 images. From the table 1 it is clearly evident that all the images shows high PSNR value above 60 dB and NCC value above 0.92. The average PSNR value for the considered images is 64.23 dB and NCC is 0.94 without attacks. This indicates high robustness and high quality of the images after watermark insertion.

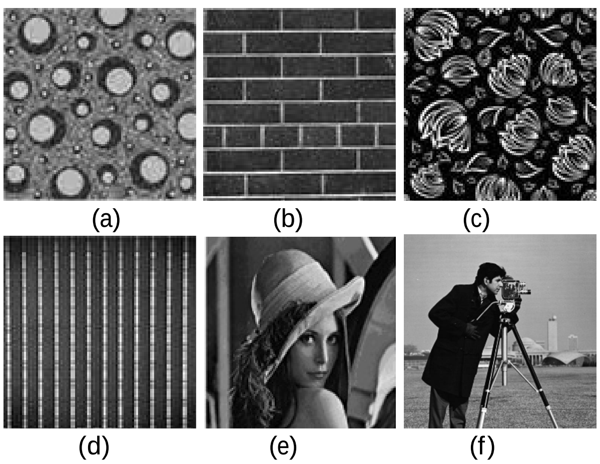

Fig.3 Watermarked images (a) Circle (b) Brick (c) Flower (d) Line (e) Lena (f) Cameraman

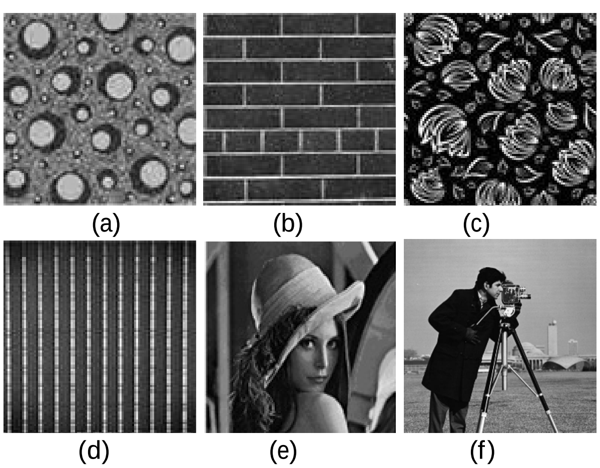

Fig.4 Extracted cover images (a) Circle (b) Brick (c) Flower (d) Line (e) Lena (f) Cameraman

TABLE 1 QUALITY MEASURES OF THE WATERMARKED IMAGES FOR THE PROPOSED SWH APPROACH USING REO METHOD

S.No	Original images	PSNR	NCC
1	Lena	64.76	0.94
2	House	65.25	0.92
3	F16	64.47	0.94
4	Joker	65.38	0.94
5	Living room	64.23	0.93
6	Child	66.37	0.94
7	Monalisa	64.25	0.93
8	Milkdrop	64.09	0.94
9	Baboon	63.54	0.94
10	Bear	63.23	0.94
11	Fruit	65.12	0.93
12	Line	64.48	0.93
13	Circle	64.49	0.99
14	Brain	60.37	0.94
15	Barbara	65.32	0.93
16	Brick	63.46	0.99
17	Pepper	65.64	0.93
18	Flight	63.39	0.94
19	Lake	64.78	0.93
20	Flower	64.29	0.97
21	MRI Scan	63.57	0.96
22	Cameraman	63.34	0.99
23	Boat	63.45	0.95
24	Lungs	64.37	0.96
	Average	64.23	0.94

Table 2 clearly indicates that the robustness and quality of the image is not degraded for all attacks.

The proposed SWH method using Haar wavelets is tested with various attacks such as Cropping with different ratios (2%, 3% and 4%), Rotation with 2, 3 and 4 degrees, Gaussian noise with different ratios (3%, 5% and 7%) and Median filter with different size (3×3, 5×5 and 7×7), to test the robustness, and shown in table 2.

TABLE 2 RESULTS OF THE EXPERIMENTS ON SWH METHOD WITH VARIOUS ATTACKS ON THE WATERMARKED TEXT

S.No	Attacks	Circle		Brick		Flower	
		PSNR	NCC	PSNR	NCC	PSNR	NCC
1	Cropping (2%)	59.32	0.85	59.24	0.83	59.28	0.81
2	Cropping (3%)	58.01	0.71	58.68	0.79	58.82	0.70
3	Cropping (4%)	57.16	0.73	57.43	0.66	57.97	0.71
4	Rotation 2^0	61.14	0.80	60.61	0.84	60.86	0.79
5	Rotation 3^0	60.02	0.70	59.42	0.77	58.63	0.69
6	Rotation 4^0	57.41	0.68	57.53	0.69	56.01	0.67
7	Gaussian noise (3%)	62.36	0.87	62.86	0.81	61.11	0.86
8	Gaussian noise (5%)	61.12	0.81	60.51	0.75	59.74	0.80
9	Gaussian noise (7%)	59.16	0.78	58.41	0.71	57.69	0.77
10	Filtering (3×3)	61.39	0.86	62.36	0.82	62.32	0.85
11	Filtering (5×5)	59.28	0.81	60.41	0.77	59.56	0.80
12	Filtering (7×7)	58.23	0.78	59.33	0.71	57.67	0.77

3.1 Comparison of the proposed SWH using REO method with various other methods

Table 3 compares the PSNR values after inserting the watermark without attacks with various other existing methods [2, 3, 4 and 5]. Table 2 clearly indicates that SWH with REO method outperforms the other existing methods. The remaining three methods show a PSNR value between 29.42 dB and 51.48 dB, where as the proposed method shows a minimum of 63.34 dB and an average of 64.13 dB.

TABLE 3 COMPARISON OF SWH APPROACH USING REO METHOD WITH VARIOUS OTHER METHODS

Test Images	Wei-Hung Lin et.al method	Wei-Hung Lin et.al method	Mei Jian-sheng et.al method	V. Padmanabha Reddy et.al method	Proposed SWH using REO method
	PSNR(dB)				
Circle	42.14	42.45	50.12	29.42	64.49
Brick	41.89	42.48	49.34	29.79	63.46
Flower	42.02	41.98	50.04	29.67	64.29
Line	42.72	42.81	51.34	29.85	64.48
Lena	42.02	42.53	50.02	29.54	64.76
Cameraman	42.61	42.53	51.48	29.56	63.34

Table 3 clearly indicates that the proposed method shows very high PSNR value when compared with the other existing methods.

4 CONCLUSIONS

The present paper proposed an effective wavelet based hierarchical watermarking scheme with Haar wavelets for protecting copy rights of digital images. The proposed SWH approach created a new direction for the feature researchers in hierarchical watermarking methods, by dividing the each hierarchical block into SHR and UHR. The proposed SWH approach using REO watermarking system minimizes the changes in cover image when they are converted to corresponding watermark carrying regions in the watermarked image. Due to this nature, some regions in the cover object will experience less change after embedding. This process makes it very difficult to identify the watermark, for an intruder. That's why the present scheme can be used for both copyright protection and for encryption. The novelty of the proposed REO method is, it embeds the information in a non linear order based on the values and position of a window.
Table 2 clearly indicates the proposed two steps SWH with REO watermarking scheme outperforms the other existing methods [2, 3, 4 and 5]. The proposed SWH method exhibited a high PSNR and NCC value, with various attacks such as Cropping, Rotation with different degrees, Gaussian noise and Median filter with different size to test the robustness.

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