International Journal of Computer Engineering Science (IJCES)
Volume 2 Issue 8 (August 2012) ISSN : 2250:3439
https://sites.google.com/site/ijcesjournal http://www.ijces.com/

Region Based Even Odd Watermarking Method With Fuzzy Wavelet

S.Maruthuperumal [1], G.Rosline Nesakumari[1] , Dr.V.Vijayakumar[2]

[1] Research Scholar, Dr.MGR University Chennai.
Associate Professor, GIET Rajahmundry, India.
[2] Dean Computer Sciences, Head Srinivasa Ramanujan Research Forum, GIET Rajahmundry

maruthumail@gmail.com
rosemaruthu@gmail.com
vakulabharanam@hotmail.com

Abstract. To overcome the weak robustness problem of embedding the watermark in the spatial domain and to provide high authentication, the present paper presents a novel watermarking scheme with two steps. In the step one, the proposed method modifies the original image in transform domain and identifies the pixel location to insert the watermark bits in the difference values between the original image and its reference image based on a novel fuzzy logic method. To provide high authentication and security in the step two, the watermark bits are embedded in the pixel location selected by step one using Region based Even Odd (REO) Method. The Fuzzy Wavelet (FW) scheme of step one eliminates the requirement of original image for the watermark extraction. The experimental result indicates the efficacy of the proposed method when compared with the various other methods.

Keywords: Fuzzy logic, Wavelet Transformation, Robustness, Authentication, Security.

1 Introduction

In recent years, the necessity to protect multimedia content from illegal copying and image authentication has been made more critical by the advent of digital technology [1]. To protect the content, digital image watermarking techniques are applied. The digital watermark represents the copyright information of the protected image. In general, a digital watermark can be a logo, label, or a random sequence. With the use of the watermark embedding process in the watermarking technique, a digital watermark can be embedded into the protected image and produce a watermarked image. Afterwards, the owner can broadcast the watermarked image over the Internet. When a dispute over the copyright of the digital image occurs, the legal owner can be verified using the watermark verifying process.

The majority of watermarking techniques can be categorized as algorithms operating either in the spatial domain or in the transform domain. The spatial domain techniques are to embed the watermarking data by directly modifying the pixel values of the original images. The main advantage of watermarking in the spatial domain is simplicity [5]. Watermarking schemes operating in the transform domain represent the original image in a transformed domain where the embedding is performed. They are generally more robust than those in the spatial domain, since most of the attacks can be characterized and modeled in the transform domain [2]. DWT [3] has been used in digital image watermarking more frequently due to its excellent spatial localization and multi-resolution characteristics, which are similar to the theoretical models of Human Visual System (HVS) [4].

The proposed watermarking system is designed to be transparent from human visual perception as well as be robust against noise, lossy compression, and filtering. In this paper, we propose a new method of digital image watermarking that embeds the watermark in an image by means of DWT compression technique using FW and REO method.

The rest of this paper is organized as follows: The section 2 describes the proposed method for embedding and extraction watermark. The section 3 describes the experimental results. The conclusion will be discussed in the final section.

2 The proposed FWREO approach

2.1 Watermark embedding procedure

The proposed watermark embedding scheme contains two basic steps.

The proposed FW method modifies the original image in transform domain and selects the pixel locations to insert a watermark in the difference values between the original image and its reference image based on a novel fuzzy logic in step one.

Step1: In the first step the pixel locations where watermark is embedded is determined using Fuzzy Wavelet (FW) scheme. The FW scheme is explained below. The discrete wavelet transform decomposes an image in subbands having a bandwidth approximately equal on a logarithmic scale. To achieve imperceptibility, the lowest band of the image is left unmodified. The gray level image is transformed into a DWT in both vertical and horizontal directions, resulting in one low frequency subband (LL) and three higher frequency subbands(LH,HL and HH). The same is repeated on the LL subband to generate the next level of decomposition. This process can be repeated to n-level decomposition by considering the length of watermark, robustness, fidelity and so on. The determined LL_n can be seen as a reduced version of the original image. Based on this a reference LLn′ is prepared by inverse wavelet transforming the original LL_n by initializing the three high frequency subbands(LH_{n+1},HL_{n+1} and HH_{n+1}) excluding LL_{n+1} as zeros. The Self-reference watermarking scheme selects all those pixels that have the difference in $LL_n{}'$ and LL_n. This makes the scheme easy to break. To overcome this, the present paper adopts the FW scheme; which selects the pixel location based on Fuzzy logic, which is dynamic. The difference between LL_n and $LL_n{}'$ mainly ranges from -1 to +1, because the error content in the wavelet transform is minimum, that is the reason one always obtain the original image by inverse transformation. The proposed FW scheme evaluates the difference between (LL_2-$LL_2{}'$) for selecting the pixel locations. The proposed FW divides the range -1 to +1 in to four regions as R0, R1, R2 and R3 as shown in the Figure 1. The FW pixel locations are selected based on the following fuzzy algorithm.

Fuzzy Algorithm:

begin

if $[(LL_2(X_i,Y_i)-LL_2{}'(X_i,Y_i)]==0$ Then the $F_i(X_i,Y_i)$ is not considered

if $(LL_n(X_i,Y_i)-LL_n{}'(X_i,Y_i))<0.5$ and $(LL_n(X_i,Y_i)-LL_n{}'(X_i,Y_i)>-0.5$ Then the F_i(Xi,Yi) is considered for finding new pixel location

end

International Journal of Computer Engineering Science (IJCES)
Volume 2 Issue 8 (August 2012) ISSN : 2250:3439
https://sites.google.com/site/ijcesjournal http://www.ijces.com/

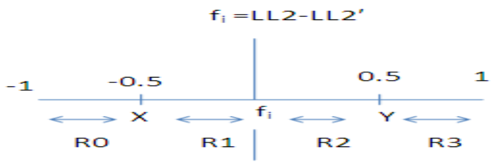


Fig. 1. Representation based on Fuzzy Approaches

The pixel locations are selected for the embedding of watermark if they fall in the fuzzy region R1 and R2. Finally, the watermark information is embedded into the sub-band LL_2.

Step 2. To embed the watermark in the second step Region wise Even Odd (REO) Method is applied on the FW approach of the first step. The detailed process of the proposed REO Method is explained below.

Step2a: To achieve high security and authentication the proposed method embeds the watermark bits in the selected pixel locations of FW scheme of step one by using a Block wise or Region wise Even Odd (REO) Method as explained below. The 2-level LL subband image is divided into 5×5 non overlapped blocks ′Wi′. All windows are assumed logically to start with window coordinates of (0, 0), (i, j) represents the coordinate position and CP represents Central Pixel. The entire window is not chosen for embedding watermark .

W_i =

(i ,j)		✔	✔	(i ,j+4)
✔	✔			✔
		CP(i+2,j+2)		✔
	✔	✔		
(i+4 ,j)	✔		✔	

Fig. 2. Representation of coordinate position
✔ - represents the pixel locations selected by FW pixel locations

As stated in step one only those pixel locations that satisfies the if condition of FW are selected for embedding the water mark ,which are shown as ✔ mark in the Figure2.

Step2b: Arrange the gray level values of FW pixel locations in the ascending order form along with their coordinate value, P_i (x_i, y_j), P_{i+1} (x_{i+l}, y_{j+l}) ………… here P_i (x_i,

y_i) denotes the gray level value of the pixel location (x_i, y_j). Consider the 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 selected FW pixel location values are having the same gray level values or if they are successive even and odd values, then the least coordinated value of row and column will be treated as least value. The watermark bit will be embedded in the ascending order of gray level values of the least x-coordinate and y-coordinate position. Figure 3 shows the proposed Scheme. The successive even and odd process is explained with an example.

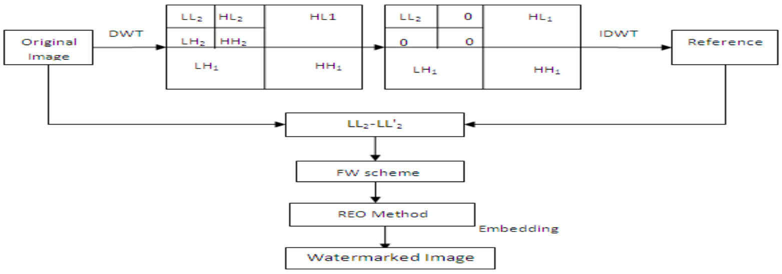


Fig. 3. The block diagram of FWREO watermarking Scheme

Figure 4 shows the gray level positions and their values selected by FW scheme of a 5×5 window. The Table1 gives the sorted list of gray level values with the co-ordinate position of Figure4 as specified in step 2.

		79	80	
81	80			80
				80
	75	79		
	81		74	

Fig. 4. P(i ,j) selected by FW scheme on a 5×5 window

The present method considers the pair of values (80, 81) and (74, 75) as same because they are successive even and odd gray values (e_i, (e_{i+1})) as specified in step 2. By this method the successive even and odd values of the Figure 4 are treated as same and the watermark bit is inserted based on the least x-coordinate and y-coordinate position. The order of embedding bits of the Figure 4 is shown in Table 2.

In the proposed 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, it's value will be incremented by one at most. In the same way an odd number will have always a one in the LSB; even by embedding a '0' in the LSB its value will be at most decremented by one. That is the odd values will never increment by 1 after embedding the digital watermark bit either 0 or 1. And the even values will never decrement by 1 after embedding the digital watermark bit either 0 or 1.

Table 1. Sorted gray level values with the coordinate position of Figure 4 by REO method

Coordinate Positions		**P (x_i , y_i)**
x_i	y_i	
4	3	74
3	1	75
0	2	79
3	2	79
0	3	80
1	1	80
1	4	80
2	4	80
1	0	81
4	1	81

Table 2. Embedding order of watermark bits by REO method

Coordinate Positions		**P (x_i , y_i)**
x_i	y_i	
3	1	75
4	3	74
0	2	79
3	2	79
0	3	80
1	0	81
1	1	80
1	4	80
2	4	80
4	1	81

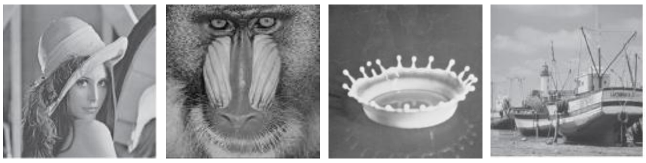
Therefore always the maximum difference between successive even and odd values will be one after embedding the digital watermark bit. That is the values 74 and 75 of pixel locations (4, 3) and (3,1) are treated as same as shown in Table 1. For this reason, the successive even and odd values of a neighborhood 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. Whereas the maximum difference between successive odd and even values will have difference of two after inserting the digital watermark bit.

2.2 Watermark extraction procedure

The original image is not necessary at the watermark extraction stage. This refers to a "blind" watermarking process. We utilize the sequence of embedding Location to extract the watermark. Transform the watermarked image into wavelet coefficients by two-level Wavelets transform. Perform the inverse FWREO approach to obtain the pixel locations and watermark contents.

3 Experimental Results and Discussion

Eight 256 × 256 sized cover image are used by the proposed FWREO approach in the following experiments, as shown in Figure 5, those are Lena, Baboon, Pepper, Milk drop and Boat. Two binary images of size 32×32 is considered as the watermark image (Logo GIET) and Logo MGR as shown in Figure 6. The present paper used two quality measures for the watermarked images which are PSNR and NCC. PSNR is often a useful tool to measure perceptibly level; it is always accurate to human eyes judgment. It takes into consideration the importance of the human visual system and its characteristics and therefore is more suitable for digital watermarking. Four 256×256 sized watermarked images as shown in Figure 7, those are Lena, Baboon, Milk drop and Boat.



(a) (b) (c) (d)

Fig. 5. Original Images: (a) Lena; (b) Baboon; (c) Milk drop; (d) Boat

(a) (b)

Fig. 6. Watermark Image (a) Logo GIET (b) Logo MGR

(a) (b) (c) (d)

Fig. 7. Watermarked images (a) Lena; (b) Baboon; (c) Milk drop; (d) Boat

Table 3. Presentation of the correlation and PSNR values of Lena after different attacks between extracted watermarks and the original watermarks.

Type of Attack	PSNR	NCC
JPEG Compression (20%)	58.95	0.9231
JPEG Compression (30%)	56.49	0.8940
JPEG Compression (40%)	56.01	0.8241
Additive noise	59.98	0.9265
Gaussian noise	59.65	0.9458
Salt and pepper	59.36	0.9862
Median Filter(3×3)	59.99	0.9559
Median Filter(4×4)	58.69	0.9429
Median Filter(5×5)	57.45	0.8507

The proposed method is also tested with various attacks such as JPEG compression with different ratios (20%, 30% and 40%), Additive Noise, Gaussian Noise, salt and pepper noise, Median Filter with different size (3×3,4×4, 5×5). The Table 3 shows the

NCC values and PSNR values with various attacks on the Lena image. The NCC value of Table 3 clearly indicates the quality of the watermark image is not degraded for all the attacks. From the Table 4, it is clearly evident that the proposed method is having high PSNR for all the images.

3.1 Comparisons with Other Wavelet-Based Algorithms

The Table 4 compares the PSNR values after inserting the watermark without attacks by the proposed FWREO approach with various other methods i.e. Saeed K. Amirgholipour, Ahmad R. Naghsh-Nilchi (2009), Sameh Oueslati, Adnane Cherif , and Bassel Solaiman (2011) , Gaurav Bhatnagar, Balasubramanian Raman, K. Swaminathan(2008) and Wei-Che Chen, Ming-Shi Wang(2009). All the images have shown a PSNR value of 60 for the FWREO approach.

Table 4. Comparison of the proposed method with Various Other methods

Test Images	Saeed K. et.al (2009)	Sameh Oueslati et.al. (2011)	Gaurav Bhatnagar et.al (2008)	Wei-Che Chen et.al (2009)	Proposed Method	
	PSNR(dB)				PSNR(dB)	NCC
Lena	37.87	41.97	41.91	44.88	60.81	0.99
Baboon	37.45	41.26	41.75	44.91	59.26	1
Milk drop	36.98	40.99	41.26	44.32	60.78	1
Boat	37.04	42.02	41.94	44.98	60.32	0.99

The high PSNR values indicate the high robustness of the proposed FWREO approach. The Table 4 clearly indicates high PSNR values for the proposed FWREO approach, for all images, when compared to other methods [6], [7], [8],[9]. The Table 4 also shows the NCC value of above 0.9 for all images using the proposed FWREO approach.

4 Conclusion

The proposed two steps watermarking approach overcomes the weak robustness problem of embedding watermark in spatial domain. Even in the case of compression attack the proposed method show a high robustness. The proposed approach does not require the original image for watermark extraction. The proposed FWREO approach overcomes the repeating factor of embedding watermark as in the case of reference image scheme. The proposed Method provides high security and authentication by applying fuzzy logic and REO on wavelet domain. The experimental results on various images with various attacks shows the proposed technique provides good image quality, high robustness, high authentication and security when compared to other methods as shown in Tables 4.

References

1. Cox I. J., Miller, M. L. and Bloom J. A., "Digital Watermarking", Morgan Kaufmann Publishers, USA, 2002.
2. Podilchuk, C.; Zeng, W. Image-adaptive watermarking using visual models. IEEE J. Sel. Are. Comm. 1998, 16, pp. 525–539.
3. Vetterli M, Kovacevic J (1995) Wavelet and Subband Coding. Prentice-Hall, Engle-wood Cliffs.
4. Wolfgang R B, Podichuk C I, Delp E J (1999) Perceptual watermarks for digital images and video. Proceedings of the IEEE, 87(7):1108– 1126.
5. Cox, I.; Kilian, J.; Leighton, F. T.; Shamoon, T. Secure spread spectrum watermarking for multimedia, In IEEE Transaction on Image Processing, Piscataway, New Jersey, USA, December 1997; 6, pp. 1673–1687.
6. Saeed K. Amirgholipour, Ahmad R. Naghsh-Nilchi, "Robust Digital Image Watermarking Based on Joint DWT-DCT", International Journal of Digital Content Technology and its Applications, pp.no. 42- 54,Volume 3, Number 2, June 2009.
7.Sameh Oueslati, Adnane Cherif , and Bassel Solaiman, "A Fuzzy Watermarking System Using the Wavelet Technique for Medical Images", International Journal of Research and Reviews in Computing Engineering Vol. 1, No. 1, March 2011.
8. Wei-Che Chen, Ming-Shi Wang," A fuzzy c-means clustering-based fragile watermarking scheme for image authentication", Expert Systems with Applications 36 (2009) 1300– Elsevier Ltd.
9.Gaurav Bhatnagar, Balasubramanian Raman, K. Swaminathan,"DWT-SVD based Dual Watermarking Scheme", IEEE Trans. Pp.526-531,2008.