A New Wavelet Based Digital Watermarking Method for Authenticated Mobile Signals

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Abstract

The mobile network security is becoming more important as the number of data being exchanged on the internet increases. The growing possibilities of modern mobile computing environment are potentially more vulnerable to attacks. As a result, confidentiality and data integrity becomes one of the most important problems facing Mobile IP (MIP). To address these issues, the present paper proposes a new Wavelet based watermarking scheme that hides the mobile signals and messages in the transmission. The proposed method uses the successive even and odd values of a neighborhood to insert the authenticated signals or digital watermark (DW). That is the digital watermark information is not inserted in the adjacent column and row position of a neighborhood. The proposed method resolves the ambiguity between successive even odd gray values using LSB method. This makes the present method as more simple but difficult to break, which is an essential parameter for any mobile signals and messages. To test the efficacy of the proposed DW method, various statistical measures are evaluated, which indicates high robustness, imperceptibility, un-ambiguity, confidentiality and integrity of the present method.

Keywords: Mobile Network, Wavelet Transform, Even-Odd Method, Statistical Measures.

1. INTRODUCTION

The rapid growth of the Internet increased the access to multimedia data tremendously [1]. The development of digital multimedia is demanding as an urgent need for protect multimedia data in internet. Digital watermarking technique provides copyright protection for digital data [23,2,3]. The digital watermarking technique is proposed as a method to embed perceptible or imperceptible signal into multimedia data for claiming the ownership. A digital watermark is a piece of information which is embedded in the digital media and hidden in the digital content in such a way that it is inseparable from its data. This piece of information known as watermark, a tag, or label into multimedia object such that the watermark can be detected or extracted later to make an assertion about the object. The object may be an image, audio, video, or text [4].

Each watermarking application has its own requirements that determine the required attributes of the watermarking system and drive the choice of techniques used for embedding the watermark [5]. This demand has been lately addressed by the emergence of a variety of watermarking methods. Such methods target towards hiding an imperceptible and undetectable signal in the original data, which conveys copyright information about the owner or authorized user. Data hiding usually involves the use of secret keys possessed only by owners or authorized users. In order to verify the multimedia content owner and thus protect his copyrights, detection is performed to test whether the material in question is watermarked with his own secret key [19, 20]. Recent research trend in watermarking technique is focusing more on image data [6, 7, 8, 24, 25]. But watermarking is not limited to only images; but there are also watermarking techniques for audio [9, 10], video [26, 27, 11], and text [12, 13, 14, 15, 16, 17] data. Watermarking for black and white text data; e.g., electronic documents and manuscripts, is so-called binary watermarks [18]. Watermarks and Watermarking techniques can be divided into various categories. The watermarks can be applied either in spatial domain or frequency domain. The spatial domain watermarking schemes have less computational overhead compared with frequency domain schemes.

Authentication is an important security requirement, which conventionally requires the identity of a user or some other identifying information in terms of signals of a node [22]. On the other hand, users and consumers are becoming increasingly concerned about their privacy, and the risks (such as identity theft) of leaving any form of digital trail, when making electronic transactions. Hence, given a choice, users may well prefer to interact with service providers anonymously (or pseudonymously). Under these circumstances, it may in fact be undesirable to authenticate the identity of a user. Hence, to preserve the privacy of a user, or the routing signals or any other signals of a mobile IP are needed to be authenticated. Achieving security and privacy concurrently, whilst protecting the interests of both users and service providers remains an open problem. So, privacy preserving authentication schemes may be needed to be devised. Many Content Distribution Protection (CDP) schemes (e.g. Buyer– Seller watermarking and asymmetric fingerprinting) have since been proposed to address the problem of illegal distribution of copyrighted content. All of the existing CDP schemes heavily rely on (online) Trusted Third Party in one way or another to achieve the desired security objectives. This requirement for (online) Trusted Third Party in existing Buyer Seller Watermarking (BSW) and Asymmetric Fingerprinting (AF) schemes, either, to generate the buyer watermarks, or to provide pseudonyms for buyers, represents a major constraint. To provide a better security for a mobile environment, the present paper has carried out an in depth study on the existing Digital Watermarking algorithms and outlined a new spatial domain watermarking method. The present paper is organized as follows. Section 2 deals with the introduction of wavelet transform, section 3 introduces the proposed new mechanism, section 4 deals with results and discussions and section 5 deals with conclusions.

2. INTRODUCTION TO WAVELET

The wavelet transformation is a mathematical tool for decomposition. The wavelet transform is identical to a hierarchical sub band system [18, 19], where the sub bands are logarithmically spaced in frequency. The basic idea of the DWT for a two-dimensional image is described as follows. An image is first decomposed into four parts based on frequency sub bands, by critically sub sampling horizontal and vertical channels using sub band filters and named as Low-Low (LL), Low-High (LH), High-Low (HL), and High- High (HH) sub bands as shown in Figure 1. To obtain the next coarser scaled wavelet coefficients, the sub band LL is further decomposed and critically sub sampled. This process is repeated several times, which is determined by the application at hand. The block diagram of this process is shown in Figure 1. Each level has various bands information such as low–low, low–high, high–low, and high–high frequency bands. Furthermore, from these DWT coefficients, the original image can be reconstructed. This reconstruction process is called the inverse DWT (IDWT). If C[m,n] represents an image, the DWT and IDWT for

C[m,n] can similarly be defined by implementing the DWT and IDWT on each dimension and separately.

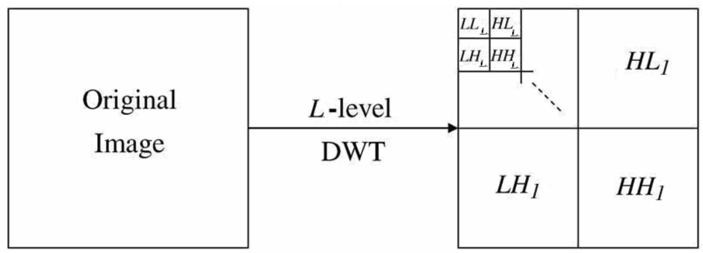


FIGURE 1: Representation of n-Levels of Wavelet Transform

The Haar wavelet [21] is the first known wavelet and was proposed in 1909 by Alfred Haar. Haar used these functions to give an example of a countable orthonormal system for the space of square-integrable functions on the real line. The Haar wavelet's scaling function coefficients are h{k}={0.5, 0.5}and wavelet function coefficients are g{k}={0.5, -0.5}.In the wavelet transform [28],[29],[30],[31],[32],[33],[34],[35],[36],[37] an image signal can be analyzed by passing it through an analysis filter bank followed by a decimation operation. This analysis filter bank consists of a low pass and a high pass filter at each decomposition stage. When the signal passes through these filters it splits into two bands. The low pass filter, which corresponds to an averaging operation, extracts the coarse information of a signal. The high pass filter, which corresponds to a differencing operation, extracts the detail information of the signal. The output of the filtering operations is then decimated by two [28], [34], [36].Because of decimation the total size of the transformed image is same as the original image, which is shown in the figure 2 as horizontal wavelet transform. Then, it is followed by filtering the sub image along the y-dimension and decimated by two. Finally, the image splits into four bands denoted by low-low (LL1), high-low (HL1),low-high (LH1) and high-high (HH1) after one-level decomposition as depicted in figure 3. The sub bands labeled, LL1 HL1, LH1, and HH1 represent the finest scale wavelet coefficients. To obtain the next coarser scaled wavelet coefficients, the sub band LL1 is further decomposed and critically sub sampled. This process is repeated several times, which is determined by the application at hand. Furthermore, from these DWT coefficients, the original image can be reconstructed. This reconstruction process is called the inverse DWT (IDWT). If I[m,n]represents an image, the DWT and IDWT for I[m,n] can be similarly defined by implementing the DWT and IDWT on each dimension and separately. Figure 4 shows second level of filtering. This process of filtering the image is called 'Pyramidal decomposition' of image. Figure 5 shows the results of different levels of Haar wavelet decomposition of Lena image.

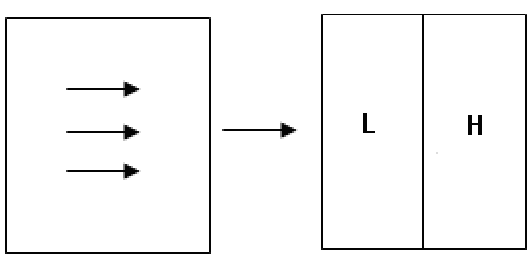


FIGURE 2: Horizontal Wavelet Transform.

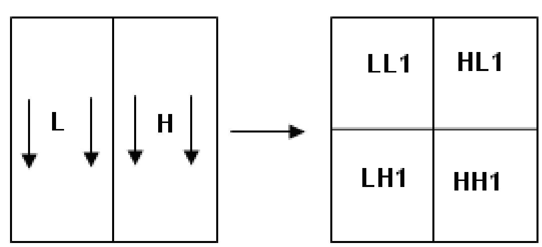


FIGURE 3: Vertical Wavelet Transform

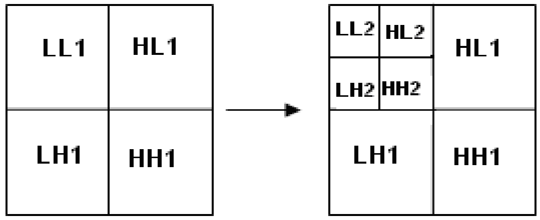


FIGURE 4: Second Level Wavelet Transform.

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

FIGURE 5: (a) Original Lena Image (b) Level-1 Haar Wavelet Transformed Lena Image (c) Level-2 Haar Wavelet Transformed Lena Image (d) Level-3 Haar Wavelet Transformed Lena Image.

3. METHODOLOGY

The proposed method embeds the given mobile signals (watermark) in the n level decomposed LL subband of the original image. The proposed algorithm is given in the following steps.

Step 1: Apply the n- level Haar wavelet transform on the input image and obtain the n-level LL subband image.

Step 2: Let the n-level LL subband image is represented by C(x,y). The n-level LL subband image is divided into non overlapped windows of size 5×5. Let the window be Wi i=1, 2 …….. n. The Wi will be having a central pixel and 24 neighboring pixels as shown in Figure 6. All windows are assumed logically to start with window coordinates of (0, 0). (i,j) represents the coordinate position and CP represents Central Pixel.

Wi=

(i,j)	(i,j+1)	(i,j+2)	(i,j+3)	(i,j+4)
(i+1,j)				
(i+2,j)		CP(i+2,j+2)		
(i+3,j)				
(i+4,j)				(i+4,j+4)

FIGURE 6: A 5×5 window with coordinate position

Step 3: Arrange the gray level values in the ascending order form along with their coordinate value, Pi (xi, yj), Pi+1 (xi+l, yj+l) …….; here Pi(xi,yi) denotes the gray level value of the location (xi, yj).

Step 4: Consider the successive even (ei) and odd gray values (ei+1) as same after sorting. Where ((ei+1)-ei) is always one and ei<ei+1. If two or more pixels of the window have the same gray level values or if they are successive even and odd values of the window 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 considered window 5x5 on the least x-coordinate and y-coordinate position. This process is explained with an example.

Step 5: Convert each character of the watermark in to a 12 bit character by appending the MOD 9 value of each character.

Step 6: Insert the bits of watermark in to the identified pairs in ascending order of step-4.

Step 7: Repeat the process for each 5×5 non-overlapped n- level wavelet based window.

Step 8: Apply n-level inverse wavelet transformation to obtain the watermarked image.

The detailed explanation of digital watermarking embedding process is given below with an example. Any image is represented by a two dimensional array of values $f(x_i,y_j)$ where 0 ≤(i, j)≤ N. The present paper divides the image into non overlapped window of a predefined size. Any window of size m x m will be having m^2 pixels. Figure 7 shows the gray level values of an 5x5 window. The Table1 gives the sorted list of gray level values with the co-ordinate position of figure7 as specified in step 3. The present method considers the pair of values (80,81), (78,79),(76,77), and (74,75) as same because they are successive even and odd gray values(ei, (ei+1)) as specified in step 4. By this method the successive even and odd values of the figure 7 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 7 is shown in table 2.

78	75	79	80	81
81	80	81	81	80
76	75	76	75	80
78	77	79	78	75
80	81	75	74	73

FIGURE 7: Gray level Values of the image 5x5

Coordinate Positions		Pi(xi,yi)
xi	yi	
4	4	73
4	3	74
0	1	75
2	1	75
2	3	75
3	4	75
4	2	75
2	0	76
2	2	76
3	1	77
0	0	78
3	0	78
3	3	78
0	2	79
3	2	79
0	3	80
1	1	80
1	4	80
2	4	80
4	0	80
0	4	81
1	0	81
1	2	81
1	3	81
4	1	81

TABLE 1: Sorted gray level values with the coordinate position of figure 7

Coordinate Positions		Pi(xi,yi)
xi	yi	
4	4	73
0	1	75
2	1	75
2	3	75
3	4	75
4	2	75
4	3	74
2	0	76
2	2	76
3	1	77
0	0	78
0	2	79
3	0	78
3	2	79
3	3	78
0	3	80
0	4	81
1	0	81
1	1	80
1	2	81
1	3	81
1	4	80
2	4	80
4	0	80
4	1	81

TABLE 2: Embedding order of watermark bits as specified in step 4

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. And the even values will never decrement by 1 after embedding the digital watermark bit. Therefore always the maximum difference between successive even and odd values will be one after embedding the digital watermark bit. Where as the maximum difference between successive odd and even values will be 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 method has used various quality measures for the watermarked image, like Mean Square Error (MSE), Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR), Signal to Noise Ratio (SNR), Root Signal to Noise Ratio (RSNR) and Normalized Correlation Coefficient

(NCC) given in Equations (1.1) to (1.6). The embedding distortion performance is usually measured by the Mean Square Error and Root Mean Square Error as given by the equation (1.1) and (1.2). MSE and RMSE for the image should be as low as possible. A better perceptual quality of the image is possible for lower values of MSE and RMSE. Signal to Noise Ratio (SNR) and Root SNR (RSNR) measures, estimates the quality of the reconstructed image compared with an original image. The fundamental idea is to compute the value which reflects the quality of the reconstructed image. Reconstructed image with higher metric are judged as having better quality. SNR and RSNR can be defined as in equation (1.3) and (1.4). A higher value of SNR and RSNR indicates the better quality of the reconstructed image. To study the quality of watermarked image, the peak signal to noise ratio PSNR is used. In general, a processed image is acceptable to the human eyes if its PSNR is greater than 30 dB. The larger the PSNR, the better is the image quality. The PSNR is defined as given by the equation (1.5). To verify the robustness of any digital watermarking method, Normalized Cross Correlation (NCC) is used. NCC is an important performance parameter in any extracting module. NCC is defined in the equation (1.6). Using NCC, the similarity value about 0.75 or above is considered as acceptable.

$$MSE = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (f(i,j) - g(i,j))^2 \quad (1.1)$$

$$RMSE = \sqrt{\frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (f(i,j) - g(i,j))^2} \quad (1.2)$$

$$SNR = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} g(i,j)^2}{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (g(i,j) - f(i,j))^2} \quad (1.3)$$

$$RSNR = \sqrt{\frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} g(i,j)^2}{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (g(i,j) - f(i,j))^2}} \quad (1.4)$$

$$PSNR = 10 * \log_{10}\left(\frac{255^2}{MSE}\right) \quad (1.5)$$

where f(i,j) and g(i,j) are the original image and watermarked image with coordinate position (i,j).

$$NCC = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} g(i,j) \times f(i,j)}{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} g(i,j)^2} \quad (1.6)$$

where f(i,j) and g(i,j) are the original watermark and extracted watermark.

4. RESULTS AND DISCUSSION

For the experimental analysis on the proposed method different images of size 256×256 are taken. The cover images considered in the proposed method are Circle, Brick, Curve, Line, Lena and Cameraman images which are shown from Figure 7(a) to 7(f) respectively. The proposed method is applied on 2-level Haar wavelet decomposed images. In the wavelet based watermarked image, a set of 16 characters “srinivasaramanuj” is embedded. The set of 16 characters is chosen because the present study founds that no mobile signal is more than 16 characters. The Figure 8(a) to 8(f) shows the 2- level proposed method based watermark (16 bit character) embedded images. The Figure 9(a) to 9(f) shows the reconstructed watermarked image. The values of above discussed quality parameters are calculated on the proposed watermarked images and are listed in the Table 3. The Table 3 clearly indicates the efficacy of the proposed scheme since the quality measures of watermarked images falls with in the good range i.e. the proposed method produces minimum values for MSE, RMSE, NCC and higher values for SNR, PSNR, RSNR.

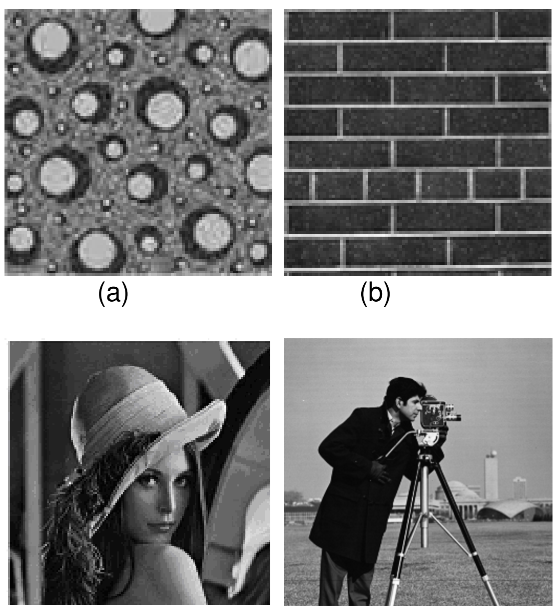
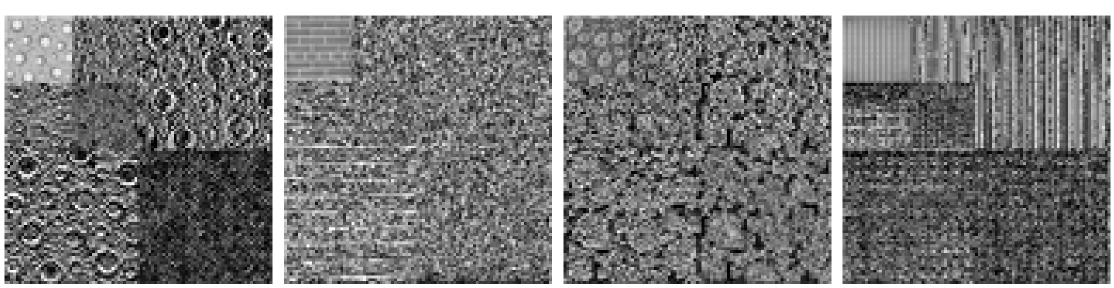
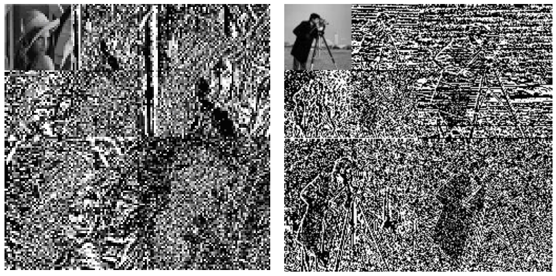


FIGURE 7: Original Images (a) Circle Image (b) Brick Image (c) Curve Image (d) Line Image (e) Lena Image (f)Cameraman Image

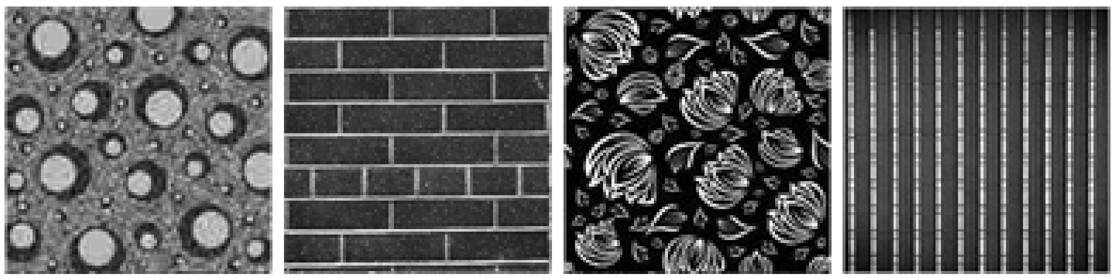


(a) (b) (c) (d)



(e) (f)

FIGURE 8: Two level wavelet transformed images (a) Circle Image (b) Brick Image (c) Curve Image (d) Line Image (e) Lena Image (f) Cameraman Image



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

(e) (f)

FIGURE 9: Reconstructed watermarked Images with the proposed method (a) Circle Image (b) Brick Image (c) Curve Image (d) Line Image (e) Lena Image (f) Cameraman Image

S.No	Image Name	MSE	RMSE	SNR	RSNR	PSNR	NCC
1	Circle	0.0237	0.1539	212880.0000	461.3800	64.3870	0.9997
2	Brick	0.0293	0.1712	265050.0000	514.8300	63.4630	0.9998
3	Curve	0.0242	0.1555	378250.0000	615.0200	64.2980	0.9999
4	Line	0.0222	0.1491	400070.0000	632.5100	64.6640	0.9999
4	Lena	0.0247	0.1629	396050.0000	589.2600	64.7623	0.9997
5	Cameraman	0.0241	0.1633	387904.0000	599.3200	63.3452	0.9996

TABLE 3: Quality Measures for the watermarked images

5. CONCLUSIONS

The proposed watermarking method is applied on 2- level decomposed images to hide the mobile signals or messages for high authentication and security. The experimental result with various statistical parameters indicates high robustness, imperceptibility, un-ambiguity, confidentiality and integrity of the proposed digital watermarking method which are the essential features for mobile transmissions. The novelty of the proposed method is it embeds the information in a non linear order based on the values and position of a window. Moreover each 8-bit character is represented as a 12 bit character in the proposed method. This makes the proposed method as more secured when compared to the other methods especially for transmission of mobile signals. To reduce the time limit, the present method can directly apply on a original image in which case the robustness, imperceptibility, confidentiality and integrity will be degraded little bit.

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