A Hybrid Digital Watermarking Approach Using Wavelets and LSB

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ABSTRACT

The present paper proposed a novel approach called Wavelet based Least Significant Bit Watermarking (WLSBWM) for high authentication, security and copyright protection. Alphabet Pattern (AP) approach is used to generate shuffled image in the first stage and Pell’s Cat Map (PCM) is used for providing more security and strong protection from attacks. PCM applied on each 5×5 sub images. A wavelet concept is used to reduce the dimensionality of the image until it equals to the size of the watermark image. Discrete Cosine Transform is applied in the first stage; later N level Discrete Wavelet Transform (DWT) is applied for reducing up to the size of the watermark image. The water mark image is inserted in LH Sub band of the wavelet image using LSB concept. Simulation results show that the proposed technique produces better PSNR and similarity measure. The experimental results indicate that the present approach is more reliable and secure efficient. The robustness of the proposed scheme is evaluated against various image-processing attacks.

Keywords: Alphabet pattern, DCT, DWT, Pell’s cat map, Water mark

1. INTRODUCTION

In recent years, increase in use of the widespread internet has allowed the authors to distribute their content in digital form. Digital watermarking is the one of main richest research topic in the field of image processing and it has great attention for research community. Compare to audio and video, image watermarking is more dedicated and popular because of many practical applications such as Authentication of content and objects, Content identification and management, copy right protection and so on. The content includes audio, video, digital repositories, libraries or web publishing.

Watermarking is a process that inserts image/text called a watermark into another image and resultant image called watermarked image [1]. In order to be successful, the watermark should be unnoticeable and strong to deliberate or impulsive changes of the image. It should be robust against common image processing operations such as filtering, cropping, blurring, resizing etc; and common image compression techniques [2].

2. RELATED WORK

Basically, the watermarking can be classified into two major categories such as blind and non-blind watermarking approaches. In blind approach, original image is not required for extraction of watermark.
image where as in non-blind approach, original image is required. The present approach uses the blind technique. So many approaches are available in this category such as Wavelet technology, block based approach, LSB based approach, and edge based techniques [3, 4, 5, 6]. In a preferred watermarking system, the watermark should be robust to content preserving attacks including geometric deformations and image processing operations [7, 8, 9, 10, 11]. Typically, the following features are considered for deriving an optimal image watermarking system: Perceptual Transparency, Robustness, Data Rate, Security, Verification and reliability. The present paper considers all these features in designing digital watermarking technique in efficiency and effective manner.

The authors [12, 13] embedded the watermark in those regions that are invariant to geometric attacks to avoid synchronization errors. The well-known patch work watermarking methods [14, 15] inserted a message by supposing that two sets randomly selected pixels are Gaussian distributed with zero mean. The patch method is sensitive to de-synchronization operations because the watermark is highly related to the position of those marked patches. Histogram based watermarking schemes are also exploited as due to reference for reversible watermarking and also for audio watermarking in the literature [16, 17, 18, 19]. In the literature watermarking methods based on Gaussian kernel filter and the histogram shape invariance are reported to enhance the robustness [20, 21].

Watermarking is applied in frequency domain by applying transforms like Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT) [21, 22]. Recently, the researches for more secure watermarking techniques have revealed the fact that the content of the images could be used to improve the invisibility and the robustness of a watermarking scheme [24]. Sumalatha and Vijayakumar proposed content authentication schemes called Block based Content Checksum Watermarking method (BCCW) [25] and Local Edge Based Content Hash method [26] for efficient tamper detection. The novelty of these methods is hierarchical in nature and they show very high perceptual quality of embedded image. The BCCW method overcomes the drawbacks of Walton’s [27] and Chang et.al. [28] Schemes, by embedding the checksum computed on the block $B_i$ into the 2×2 sub block which has the maximum average compared to other sub blocks of the block.

FethiBelkhouche and UvaisQidwai [29] used one dimensional chaotic map. It has been shown that the method is used for binary image encryption with the possibility of using several keys such as the initial state, the external parameters and the number of iterations. It is also shown that the sensitivity of initial state plays an important role in chaotic encryption. Huang-PeiXiao, Guo-jizhang [30] proposed scheme using two chaotic systems based on the thought of higher secrecy of multistem. One of the chaotic systems is used to generate a chaotic sequence. Podesser, Schmidt and Uhl [31] proposed a selective encryption algorithm for the uncompressed (raster) images, which is quite opposite from the first method proposed by Droogenbroeck and Benedett [32]. More recently, a refined hierarchical scheme of digital watermarking was obtained by Tassa [33] from subtler properties of Birkhoff polynomial interpolation. In [34], a method using Lagrange interpolation formula is proposed to estimate and recover the lost data. Shereen.et.al [35] proposed a model called A New Profile Learning Model for system based learning technique which is used for authentication of the ownership.

Content authentication applications [36] where any tiny changes to the content are not satisfactory, the embedding distortion has to be rewarded perfectly. Many digital watermarking schemes proposed in the literature for still images and videos are mainly used in applications. In all these applications, apart from copyright protection, illegal copy protection, proof of ownership problems, identification of manipulations, there is a growing need for the authentication of the digital content.

3. MOTIVATION

The most essential properties of any digital watermarking techniques are robustness, security, imperceptibility, complexity, and verification. Robustness is the property where the watermark can be identified even after standard operations such as filtering, adding noise, scaling, lossy compression, color correction, or geometric modifications. Security is defined as the embedded watermark that cannot be removed away from trustworthy detection by embattled attacks. Imperceptibility means the watermark cannot be seen by the Human Visual System (HVS). Complexity is defined as the effort and time essential for watermark embedding and recovery. Finally, verification is a process in which there is a confidential key or public key function. The present paper considers all these properties in designing digital watermarking techniques.

According to the different properties of watermarking, it is applied in various fields like Ownership Assertion, Broadcast Monitoring, Copyright Protection, Fingerprinting, ID Card Security, Content labeling, Copy Control Fraud and Tamper Detection, Content Authentication, Integrity Verification, Usage control, Medical Safety and Content protection. Sometimes, several applications are combined in one watermarking
scheme. However, it is impossible to put all the applications in one scheme because different applications demand different properties of watermarking system to different extent. Depending on the watermarking applications and purpose, different properties or requirements of watermarking also arise and result in various design issues.

To overcome the disadvantages, the present paper proposes a method called Wavelet based Least Significant Bit Watermarking (WLSBWM) integrates the alphabet pattern approach for generating the shuffled image, wavelet concept to reduce the dimensionality, Pell’s cap map for protection from attacks and LSB approach is used to insert the watermark image. The present approach is simple technique to insert the image and provides high protection from attacks. The novelty of the proposed approach is that double protection is provided for watermarked image so that it protect from attacks. The rest of the paper is organized as follows. Proposed WLSBWM described in section 4 and results are discussed in section 5. Attacks on the proposed method are discussed in section 6 and finally conclusions are given in section 7.

4. PROPOSED METHOD

In order to provide copyright protection for the identification of ownership, the present paper provides a hybrid technique to insert and extract the watermark in effective and efficient manner. The proposed WLSBWM method consists of 8 simple steps for inserting the watermark image and 8 steps for extracting the watermark image. The block diagram of the inserting water mark image is shown in Figure 1. The watermark insertion algorithm is described below.

![Figure 1. block diagram of the WLSBWM method](image)

**A. Watermark insertion algorithm**

**Step 1: Identify the Alphabet pattern:** In insertion algorithm step one, for providing the security to protect from attacks the present approach converts the original image into shuffled image. The present paper uses the Alphabet patterns to generate the shuffled image. The generation of shuffled image has two sub tasks i.e. identify the Alphabet patterns on each 3×3 and change the direction of the pixel values in reverse direction. The present paper uses ‘T’ pattern, ‘E’ pattern, and ‘U’ patterns. The 3×3 window consists of 9 pixels. The pixel values are indicated by $P_1, P_2, P_3, P_5, P_7$. The 3×3 window is shown in Figure 2.

![Figure 2. 3×3 window](image)

In a given window, if the pixels values of $P_1, P_2, P_3, P_5$, and $P_7$ are same then treats the 3×3 window forms the ‘T’ pattern. If ‘T’ pattern existed in 3×3 window then change the direction of the pixel position to form inverted T pattern. The figure 3 depicts the inverted ‘T’ pattern. If the pixel positions shown in figure 4 which are highlighted has same values then 3×3 window forms the E pattern and change the pixel position according to figure 4(b). In the same way if the 3×3 window form U pattern, change the positions of the pixels according to figure 5b. The same procedure is applied for remaining 3×3 windows in the entire image the resultant image is treated as shuffled image.

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Step 2: Pell’s Cat Map (PCM):

For providing further security and authentication, Pell’s Cat Map (PCM) [37] is employed on the 5×5 non-overlapped blocks of shuffled image.

A discrete mapping using the matrix $P = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$ with determinant $-1$ is still area preserving but also orientation reversing. As it turns out the matrix $P$ will generate numbers in the Pell’s and half-companion Pell sequences, so $P$ together with the modulo $N$ operation will henceforth be denoted Pell’s cat map as shown in equation (1)

$$T_p : Z_n \times Z_n \rightarrow Z_n \times Z_n$$

Step 3: Apply DCT on mixed image before inserting the watermark image.

DCT has been extensively used in image watermarking because of high energy compaction competence and respectable robustness. Generally, from spatial domain to frequency domain conversion Discrete Cosine Transform (DCT) is used [38, 39]. It also delivers suitable trade-off between Human Visual System (HVS) model and the image misrepresentation degree [40, 41]. DCT watermarking can be classified into two categories: Global DCT watermarking and Block-based DCT watermarking [42, 43]. The DCT computation is performed on the entire image in Global DCT [41], whereas the DCT computation is performed separately on each non-overlapping blocks [44, 45] to get low-frequency, mid-frequency and high-frequency sub-bands [43]. Generally, the watermark is inserted into a mid-frequency sub-band, which provides protection from watermarking attacks and it is well-matched with HVS model [46, 47]. Given an image $f$ of size $M \times N$, the forward and inverse DCTs are shown in equations (2) and (3) [48]. The present paper utilizes and applies DCT on mixed image.

$$F(u, v) = c(u)c(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x, y) \cos \left[ \frac{\Pi(2x+1)u}{2M} \right] \cos \left[ \frac{\Pi(2y+1)v}{2N} \right]$$

$$f(x, y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} c(u)c(v) F(u, v) \cos \left[ \frac{\Pi(2x+1)u}{2M} \right] \cos \left[ \frac{\Pi(2y+1)v}{2N} \right]$$
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Where \( u = 0 \ldots M - 1, v = 0 \ldots N - 1 \) and

\[
\begin{align*}
    c(u) &= \begin{cases} 
        \frac{1}{M}, & u = 0 \ldots M - 1 \\
        \frac{2}{M}, & u = 1 \ldots M - 1 
    \end{cases} \\
    c(v) &= \begin{cases} 
        \frac{1}{N}, & v = 0 \ldots N - 1 \\
        \frac{2}{N}, & v = 1 \ldots N - 1 
    \end{cases}
\end{align*}
\]

**Step 4: Apply N level DWT on DCT image:**

In frequency domain, another reliable transformation technique is Discrete Wavelet Transform (DWT). DWT is a mathematical tool for disintegrating an image hierarchic [39]. It divides the image into four sub-bands which are lower resolution approximation image (LL), horizontal (HL), vertical (LH) and diagonal (HH) detail sub-bands [37]. This process of division can be repeated several times to compute multi-level wavelet decomposition. Based on HVS model, the LL sub-band is not suitable for the watermark embedding, because it contains important data about the image and causes image distortion. HH sub-band is not suitable because of less hearty against image processing operations such as lossy compression [45]. Thus, the suitable sub-bands for watermark embedding are the mid-frequency sub-bands LH and HL[46, 48]. Figure.6 illustrates decomposition of an image using 2D wavelet transform after 3 levels of decomposition.

![Figure 6. Third level wavelet transform](image)

Apply N\textsuperscript{th} level DWT on DCT image to insert the watermark, N level depends on the Size of the original image and watermark image. Suppose the size of the image 256×256 and the watermark image size is 64×64 the 2 level DWT is applied. If the size of the original image is 512×512 then 3 levels of the DWT applied on original image.

**Step 5: Embedding the watermark:**

Find the Size of the Watermark image and Converts the watermark into a vector of zeros and ones. The condition for inserting the watermark is the size of the LH\textsuperscript{n} is equal to size of the watermark image. Where \( n \) is the \( n \)th level DWT. The LSB of the each value in LH\textsuperscript{n} sub-band is replaced with the corresponding watermark image bit value. The new LH\textsuperscript{n} sub-band is called the watermark sub-band image

**Step 6 Apply N\textsuperscript{th} inverse DWT:** Apply nth level Inverse DWT on watermark sub-band image and IDCT is also applied.

**Step 7:** The reverse of step 3, inverse PCM is applied on the shuffled watermarked image.

**Step 8:** The reverse of step one, Identify the Alphabet patterns on each 3×3 of shuffled watermarked image and change the direction of the pixel values in reverse direction to obtain a shuffled image. The resultant image is called watermarked image.

**B. Watermark extraction algorithm**

The block diagram of the watermark extraction is shown in Figure 7. The proposed method Wavelet based LSB Watermark Extraction (WLSBWME) consists of 8 steps as illustrated below.

**Step 1:** In step one, Identify the Alphabet patterns on each 3×3 sub-window of the watermarked and change the direction of the pixel values in reverse direction to obtain a shuffled watermarked image.

**Step 2:** Apply Pell’s Cat Map (PCM) on the each 5×5 sub-window of shuffled image.

**Step 3:** Convert the watermark image into a vector of zeros and ones and find the Size of the Watermark image

**Step 4 & 5:** Apply DCT on watermarked shuffled image and get watermarked shuffled DCT Image

**Step 6:** Apply N level DWT on DCT image to extract the watermark image.

**Step 7:** After N\textsuperscript{th} DWT is applied on image, stores the LH1 values into S.

**Step 8:** extract the LSB of the each values in S, store the values inTemp which is equal size of the S. The Temp is the watermark image.
5. RESULTS AND DISCUSSION

The proposed WLSBWM method is experimented over 30 images of size 256×256. The images used in this approach are shown in figure 8. The present method is tested with two different watermark images, i.e. ‘AITAM’ and ‘GITAM’ logos of size 64×64 and shown in figure 9(a) and 9(b) respectively. The proposed method tested with Matlab software on i3 processor and 4GB RAM. The resultant watermarked images after inserting the watermark image logos of ‘GITAM’ and ‘AITAM’ are shown in Figure 10 and 11 respectively.

Figure 8: Images used in this experiment (i) Lena, (ii) Barbara, (iii) Monalisa, (iv) Cameraman, (v) Terraux, (vi) House, (vii) Airplane, (viii) Jetplane, (ix) Eagle-1, (x) Eagle-2, (xi) MRI-1, (xii) MRI-2, (xiii) MRI-3, (xiv) Mandrill, (xv) CT-1, (xvi) Butterfly, (xvii) Cheetah, (xviii) Landscape, (xix) Chips, (xx) Paint, (xxi) Peppers, (xxii) Baby-1, (xxiii) Baby-2, (xxiv) circles, (xxv) Joker, (xxvi) Milkdrop, (xxvii) Character, (xxviii) Seed, (xxix) Tile, (xxx) Iris.

Figure 9: Watermark images (a) Logo of GITAM and (b) logo of AITAM

Figure 10. Watermarked images: a) Monalisa b) Eagle-1 c) Cameraman d) Baby-2 e) MRI-1 f) Landscape g) Jetplane h) House i) Joker k) Cheetah when insert the watermark logo of ‘GITAM’
To find the effectiveness of the proposed method, the present paper used two popular and effective criteria called Normalized Correlation Coefficient (NCC) and Peak Signal Noise Ratio (PSNR) for evaluating the performance of the proposed watermarking algorithm.

The quality of the watermark or the frangibility of the algorithm is assessed by the similarity measurement NCC between the referenced watermark W and the extracted watermark W* as given in Equation 4.

$$NCC = \frac{\sum_{i=0}^{N-1} W(i) W^*(i)}{\sum_{i=0}^{N-1} (W(i))^2}$$

Where, N is number of pixels, w(i) and w*(i) are the original watermark and the extracted watermark. In the above equation $\rho = 1$ indicates perfect correlation, while an extremely low value reveals that the watermarks are dissimilar. If NCC value ranges from 0.65 to 1.0 then one can say that the image preserves high quality after inserting the watermark.

The present method also calculates, the difference between the original image and the watermarked image by Peak Signal Noise Ratio (PSNR). The bigger PSNR is, the smaller is the difference, and PSNR is defined through given Equation (5).

$$PSNR = 10 \log \left( \frac{255^2}{MSE} \right)$$

Where mean squared error (MSE) is evaluated using Equation (6)

$$MSE = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (X_{ij} - X'_{ij})^2}{MN}$$

Where M and N are respectively the length and the width of the host image; $X_{ij}$ denotes the gray level of the original image pixel; $X'_{ij}$ denotes the gray level of the watermarked image pixel.

Table 1 and 2 shows the PSNR and NCC values for all the 30 images when two watermark images are used. From the Table 1 and 2, it is clearly evident that all the images shows high PSNR and NCC values which indicates high robustness and high quality of image after watermark insertion.
Table 1. PSNR and NCC values of the proposed method when insert the logo of ‘GITAM’

| S.No | Image   | PSNR | NCC |
|------|---------|------|-----|
| 1    | Lena    | 49.19| 0.985|
| 2    | Barbara | 51.66| 1   |
| 3    | Monalisa| 54.19| 0.995|
| 4    | Cameraman| 50.61| 0.997|
| 5    | Terraux | 49.36| 0.987|
| 6    | House   | 49.1 | 1   |
| 7    | Airplane| 49.85| 0.985|
| 8    | Jetplane| 52.02| 0.993|
| 9    | Eagle-1 | 51.17| 0.995|
| 10   | Eagle-2 | 50.63| 0.955|
| 11   | MRI-1   | 50.23| 0.965|
| 12   | MRI-2   | 51.21| 0.975|
| 13   | MRI-3   | 51.8 | 0.965|
| 14   | Mandrill| 49.62| 0.985|
| 15   | CT-1    | 49.08| 0.985|
| 16   | Butterfly| 49.02| 0.983|
| 17   | Cheetah | 49.83| 1   |
| 18   | Landscape| 50.57| 0.959|
| 19   | Chips   | 51.31| 0.975|
| 20   | Paint   | 48.55| 0.993|
| 21   | Peppers | 48.47| 1   |
| 22   | Baby-1  | 48.94| 1   |
| 23   | Baby-2  | 51.75| 0.995|
| 24   | circles | 49.37| 0.987|
| 25   | Joker   | 49.83| 0.975|
| 26   | Milkdrop| 50.57| 0.961|
| 27   | Character| 49.85| 0.983|
| 28   | Seeds   | 52.02| 0.955|
| 29   | Tile    | 51.17| 0.969|
| 30   | Iris    | 50.63| 0.972|

Table 2. PSNR and NCC values of the proposed method when insert the logo of ‘AITAM’

| S.No | Image   | PSNR | NCC |
|------|---------|------|-----|
| 1    | Lena    | 49.74| 0.975|
| 2    | Barbara | 52.21| 1   |
| 3    | Monalisa| 54.74| 0.985|
| 4    | Cameraman| 51.16| 0.985|
| 5    | Terraux | 49.91| 0.983|
| 6    | House   | 49.65| 1   |
| 7    | Airplane| 50.4 | 0.975|
| 8    | Jetplane| 52.57| 0.985|
| 9    | Eagle-1 | 51.72| 0.986|
| 10   | Eagle-2 | 51.18| 0.945|
| 11   | MRI-1   | 50.78| 0.945|
| 12   | MRI-2   | 51.76| 1   |
| 13   | MRI-3   | 52.35| 0.957|
| 14   | Mandrill| 50.17| 0.965|
| 15   | CT-1    | 49.63| 0.979|
| 16   | Butterfly| 49.57| 0.975|
| 17   | Cheetah | 50.38| 1   |
| 18   | Landscape| 51.12| 0.945|
| 19   | Chips   | 51.86| 0.964|
| 20   | Paint   | 49.1 | 0.985|
| 21   | Peppers | 49.02| 0.992|
| 22   | Baby-1  | 49.49| 1   |
| 23   | Baby-2  | 52.3 | 0.98|
| 24   | circles | 49.92| 0.975|
| 25   | Joker   | 50.38| 0.975|
| 26   | Milkdrop| 51.12| 0.965|
| 27   | Character| 50.4 | 1   |
| 28   | Seeds   | 52.57| 0.965|
| 29   | Tile    | 51.72| 0.955|
| 30   | Iris    | 51.18| 0.967|

6. PROPOSED WLSBWM METHOD WITH ATTACKS

To find the effectiveness of the proposed WLSBWM method, find the two parameters values when attacks on the image. Watermarking techniques are usually tested against various robustness criteria. The proposed watermarking technique is tested by using the different geometric attacks and transformations on Barbara, Monalisa, MR-1 and Eagle-1. The resultant watermarked ‘Barbara’ with different attacks like salt and pepper noise, rotation, median filter, cropping, Gaussian noise, compression, Grey level blurring, Motion blurring and Sharpening are shown in Figure 12 (a) to 12 (i).

12(a) Attacked images when using 3x3, 5x5 and 7x7 masks in Median filter  
12(b) Attacked images when 5%, 10%, 15% Cropping  
12(c) Attacked images when Rotation (20, 40, 60)  
12(d) Attacked images when 10%, 15%, 20% Salt and pepper noise added
The PSNR and NCC values, for the binary logo of ‘GITAM’ and ‘AITAM’ with different attacks on Barbara, Monalisa, MR-1 and eagle-1 images are listed out in Table 3 and 4.

| Type of Attack               | PSNR | NCC | PSNR | NCC | PSNR | NCC | PSNR | NCC |
|------------------------------|------|-----|------|-----|------|-----|------|-----|
| Median filter (3x3)          | 48.31| 0.901| 46.83| 0.902| 47.7 | 0.903| 49.07| 0.897|
| Median filter (5x5)          | 44.21| 0.851| 45.51| 0.832| 44.66| 0.833| 44.79| 0.837|
| Median filter (7x7)          | 41.65| 0.761| 40.99| 0.732| 40.49| 0.743| 40.59| 0.747|
| Cropping 5%                  | 46.65| 0.871| 48.15| 0.872| 46.62| 0.873| 49.06| 0.867|
| Cropping 10%                 | 43.28| 0.841| 43.86| 0.802| 44.17| 0.803| 43.93| 0.807|
| Cropping 15%                 | 40.65| 0.751| 41.19| 0.732| 40.83| 0.733| 40.62| 0.737|
| Rotate 2°                    | 48.76| 0.921| 47.75| 0.922| 46.65| 0.923| 49.77| 0.917|
| Rotate 4°                    | 45.55| 0.861| 44.91| 0.752| 43.75| 0.813| 44.98| 0.817|
| Rotate 6°                    | 42.09| 0.781| 40.86| 0.712| 40.18| 0.733| 41.77| 0.717|
| Salt and Pepper Noise 10%    | 48.43| 0.941| 48.82| 0.902| 49.44| 0.903| 47.94| 0.897|
| Salt and Pepper Noise 15%    | 45.18| 0.871| 43.74| 0.832| 44.08| 0.813| 45.23| 0.827|
| Salt and Pepper Noise 20%    | 39.95| 0.791| 41.31| 0.742| 38.99| 0.743| 44.08| 0.747|
| Gaussian noise 10%           | 48.65| 0.901| 47.84| 0.922| 48.81| 0.893| 48.99| 0.927|
| Gaussian noise 15%           | 44.45| 0.851| 44.93| 0.872| 45.09| 0.813| 44.43| 0.807|
| Gaussian noise 20%           | 40.99| 0.791| 41.69| 0.752| 41.38| 0.763| 41.24| 0.727|
| JPEG Compression 90%         | 49.87| 0.931| 48.88| 0.902| 47.93| 0.923| 49.33| 0.887|
| JPEG Compression 80%         | 45.29| 0.841| 46.21| 0.792| 43.83| 0.833| 44.75| 0.817|
| JPEG Compression 70%         | 41.09| 0.751| 39.85| 0.722| 40.76| 0.763| 39.72| 0.747|
| Gaussian Blur 5%             | 47.62| 0.921| 48.96| 0.902| 48.99| 0.903| 47.34| 0.897|
| Gaussian Blur 10%            | 44.31| 0.841| 42.75| 0.832| 44.36| 0.843| 42.79| 0.807|
| Gaussian Blur 15%            | 39.22| 0.751| 40.17| 0.732| 40.24| 0.773| 40.43| 0.717|
| Motion blurring 5%           | 47.31| 0.921| 47.95| 0.872| 47.95| 0.883| 47.96| 0.877|
| Motion blurring 10%          | 42.83| 0.801| 43.87| 0.822| 44.07| 0.793| 44.24| 0.787|
| Motion blurring 15%          | 39.1| 0.741| 40.14| 0.712| 39.99| 0.743| 40.71| 0.717|
| Sharpening 5%                | 49.24| 0.921| 48.78| 0.862| 50.22| 0.883| 46.76| 0.887|
| Sharpening 10%               | 45.18| 0.831| 44.19| 0.832| 44.81| 0.833| 43.16| 0.807|
| Sharpening 15%               | 41.22| 0.761| 40.18| 0.742| 40.59| 0.703| 40.13| 0.737|
| Average                      | **44.48**| **0.841**| **44.46**| **0.815**| **44.32**| **0.821**| **44.59**| **0.813**|

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From the above study, observe that the proposed WLSBWM method gives good results and got reasonable values of PSNR and NCC values when various attacks on watermark images. The proposed method is tested when two watermark images are inserted in 30 different images. From the above study, observe that the proposed method is most suitable for inserting the watermark image.

Comparison of the proposed method with other existing methods:

To evaluate the efficiency, the proposed method is compared with the existing watermarking approaches [46,47, 48]. The method proposed by Zhu Yuefen get.al [46] inserts and extracts the water mark image using dual transformation and self-recovery approach. This approach analyzes inserting positions by using DC coefficient and inserts the water mark image into original image. Saravjit Kaur [47] proposed water marking technique based on DWT. The insertion and extraction of the watermark image in the grey scale images are accomplished by transform methods. Thirugnanam et.al. [48] Proposed a technique using DWT and Independent Component Analysis (ICA). The performance results of the proposed WLSBWM method and other existing methods are listed in table 5. Table 5 clearly indicates the WLSBWM method outperforms the other existing methods. The graphical representation of the performance of the WLSBWM method and other existing method is shown in Figure 13.

Table 5. Performance results of the proposed WLSBWM method with the existing methods in terms of PSNR

| S.No | Test Images | Zhu Yuefen Method | Saravjit Kaur Method | Thirugnanam. Method | Proposed WLSBWM |
|------|-------------|-------------------|----------------------|---------------------|-----------------|
| 1    | Lena        | 39.63             | 40.67                | 39.98               | 49.74           |
| 2    | Mandrill    | 37.2              | 38.64                | 34.45               | 50.17           |
| 3    | Peppers     | 36.54             | 42.12                | 36.56               | 49.02           |
| 4    | House       | 37.89             | 40.19                | 34.95               | 49.65           |
| 5    | Barbara     | 36.45             | 41.12                | 41.62               | 52.24           |
| 6    | Milkdrop    | 37.64             | 40.61                | 39.14               | 51.12           |
| 7    | Airplane     | 33.12             | 40.23                | 41.15               | 50.4            |
| 8    | Cameraman   | 35.69             | 39.95                | 40.32               | 51.16           |

The table 3 and 4 clearly indicate the robustness and quality of the image is not degraded for all attacks by the proposed method.

From the above results observe that the proposed method gives good results and got reasonable values of PSNR and NCC values when various attacks on watermark image. The proposed method is tested when two watermark images are inserted in 30 different images. From the above study, observe that the proposed method is most suitable for inserting the watermark image.
A Hybrid Digital Watermarking Approach Using Wavelets and LSB (V. Ashok Kumar)

7. CONCLUSIONS

The present paper derived a hybrid scheme called WLSB for embedding the watermark. The proposed scheme uses three stages for embedding the watermark. In the first stage, shuffled image is generated by using alphabet patterns and PCM for protection from attacks. In the second stage, the DCT is applied and then N level DWT is applied until size of the LH1 sub band size matches with water mark image. Insert the watermark bits into LSB of the LH1 sub band values row by row and column by column. The proposed scheme guarantees high authentication. The present approach is simple and reliable and provides more security. The extraction process is also handy with simple steps. The experimental results on various images with various attacks show that the proposed technique provide good image quality and robustness when compared to other methods.

REFERENCES

[1] Watermarking Technique for Protecting Digital Images*, 3rd IEEE International Conference on Computer Science and Information Technology (ICCSTI), Volume: 7, year 2010 pp. 226 – 233.
[2] Saeed Amirgholipour Kasmani, Ahmadreza Naghsh-Nilchi, “A New Robust Digital Image Watermarking Technique Based On Joint DWT-DCT Transformation”, 3rd International Conference on Convergence and Hybrid Information Technology, Vol. 2, year 2008, pages 539-544.
[3] Sukanti B. Mardolkar, and Nayana Shenvi “Joint Dwt-Dct Based Blind And Robust Digital Watermarking Approach For Copyright Protection”, International Journal Of Pure And Applied Research In Engineering And Technology, Volume 4, issue:9 2016 pp: 218-226
[4] A.F.ElGamal, N.A.Mosa and W.K.ElSaid, “Block-based Watermarking for Color Images using DCT and DWT”, International Journal of Computer Applications, Volume 66– No.15, March 2013, pp. 33-40
[5] Gurpreet Kaur, and Kamaljit Kaur, “Implementing LSB on Image Watermarking Using Text and Image”, International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 8, August 2013.
[6] P. Ramesh Kumar and K.L.Sailaja, “Watermarking Algorithm Using Sobel Edge Detection”, Int. J. Advanced Networking and Applications, Volume: 02, Issue: 05, Pages: 861-867, 2011.
[7] Deepayan Bhowmik, Charith Abhayaratne (2009), “A framework for evaluating wavelet based watermarking for scalable coded digital item adaptation attacks”, in Proc. SPIE Wavelet Applications in Industrial Processing VI, Vol.7248.P.72480M
[8] Lang Zhai (2011), “Researches on digital image watermarking algorithm in DWT domain with chaotic encryption”, Inf. English Department, Jilin Bus &Technol.Coll., Changchun, China, Pages(s):3321-3324,August.
[9] Mei Jiasheng, Li Sukang, Tan Xiaomei (2009), A Digital Watermarking Algorithm Based On DCT and DWT, Proceedings of the 2009 International Symposium on Web Information Systems and Applications (WISA’09) Nanjinch, P. R. China, May 22-24, pp. 104-107.
[10] Ratna Bhargavi V, Ranjan K. Senapati, “Bright Lesion Detection in Color Fundus Images Based on Texture Features”, Bulletin of Electrical Engineering and Informatics, March 2016 Vol. 5, No. 01, March 2016, pp. 92-100.
[11] Lu. C. S, Sun. S. W, Hsu. C. Y, Chang. P. C (2006), “Media hash-dependent image watermarking resilient against both geometric attacks and estimation attacks based on false positive-oriented detection”, IEEE Trans. Multimedia, vol. 8, no. 4, pp. 668–685, August.
[12] Seo. J. S and Yoo.C. D (2006), “Image watermarking based on invariant regions of scale-space representation,” in IEEE Trans. Signal Process., vol. 54, no. 4, pp. 1537–1549, April.
[13] Yeo. I. K and Kim. H. J (2003), “Generalized patchwork algorithm for image watermarking”, Multimedia System, vol. 9, no. 3, pp. 261–265.
[15] Lin, C. H., Chan, D. Y., Su, H., Hsieh, W. S. (2006), “Histogram-oriented watermarking algorithm: Colour image watermarking scheme robust against geometric attacks and signal processing”, in Proc. IEEE Vis. Image Signal Process., vol. 153, no. 4, August.

[16] Lee, S., Suh, Y., and Ho, Y. (2004), “Lossless data hiding based on histogram modification of difference images,” in Proc. 2004 Pacific-Rim Conf. Multimedia, vol. 3, pp. 340–347.

[17] Ni, Z., Shi, Y., Ansari, N., Su, W. (2006), “Reversible data hiding”, in IEEE Trans. Circuits Syst. Video Technol., vol. 16, no. 3, pp. 354–363, March.

[18] Xiang, S., Huang, J. (2007), “Histogram-based audio watermarking against time-scale modification and cropping attacks”, IEEE Trans. Multimedia, vol. 9, no. 7, pp. 1357–1372, November.

[19] Xiang, S., Huang, J., Yang, R. (2006), “Time-scale invariant audio watermarking based on the statistical features in time domain”, in Proc. 8th International Workshop Information Hiding, vol. LNCS 4437, pp. 93–108.

[20] Coskun, B., Sankur, B., Memon, N. (2006), “Spatio-temporal transform based video hashing,” IEEE Trans. Multimedia, vol. 8, no. 6, pp. 1190–1208, December.

[21] Xiang, S., Kim, H. J., Huang, J. (2007), “Histogram-based image hiding robust against geometric deformations”, in Proc. 9th ACM Multimedia Security Workshop, Sep., pp. 121–128.

[22] Lang Zhai (2011), “Researches on digital image watermarking algorithm in DWT domain with chaotic encryption”, Inf. English Department, Jilin Bus & Technol.Coll.Changchun, China, Pages(s):3231-3324,August.

[23] Deepayan Bhowmik, Charith Abhayaratne (2009), “A framework for evaluating wavelet based watermarking for scalable coded digital item adaptation attacks”, Proc. SPIE 7248, Wavelet Applications in Industrial Processing VI, 72480M (January 27); doi:10.1117/12. 816307.

[24] Qi, X., Qi, J. (2007), “A robust content-based image watermarking scheme”, Signal Processing, Elsevier, Vol. 87, Issue 6, Pp. 1264-1280.

[25] Sumalatha L., et.al (2012), “A Simple Block Based Content Image Watermarking Scheme for Image Authentication and Tamper Detection”, in International Journal of Soft Computing and Engineering (IJSCCE), Vol. 2(4).

[26] Sumalatha, L., Venkata Krishna. V., Vijaya Kumar. V. (2012), “Local Content Based Image Authentication for Tamper Localization”, in International Journal of Image, Graphics and Signal Proc., Vol.9, pp. 30-36.

[27] Walton. S (1995), “Information authentication for a slippery new age”, Dr. Dobbs J., Vol.20 (4), pp:18–26

[28] Chang C.C., Hu Y.S. (2006), “A watermarking-based image ownership and tampering authentication scheme”, Pattern Recognition Letter, Vol.27 (5), pp: 39–446

[29] Fethi Belkhouche and Uvais Qidwai (2003), “Binary image encoding using 1D chaotic maps”, IEEE International Conference on Image Processing (ICIIP2003), volume I, pages 205–208.

[30] Guosheng Gu, Guoqiang Han (2006), “An Enhanced Chaos Based Image Encryption Algorithm”, in IEEE Proceedings of the First International Conference on Innovative Computing, Information and Control (ICICIC’06).

[31] Podesser, M., Schmidt, HP and Uhl, A (2002), “Selective Bitplane Encryption for Secure Transmission of Image Data in Mobile Environments”, 5th Nordic Signal Processing Symposium, on board Hurtigruten, Norway, October 4-7

[32] Pranab Kumar Dhar, Mohammad Ibrahim Khan, Jong Myon Kim (2010), “A New Audio Watermarking System using Discrete Fourier Transform for Copyright Protection”, IJCNS International Journal of Computer Science and Network Security, Vol. 10 Number 6, June.

[33] Tassa. T (2004), “Hierarchical Threshold Secret Sharing”, in Proceeding of the Theory of Cryptography Conference, MIT, Cambridge MA, USA, February 2004, LNSC 2951, Springer-Verlag, 473–490.

[34] Ting, G.C.W (2006), “Ambiguity Attacks on the GanicEkscioglu Robust DWT-SVD Image Watermarking Scheme”, proceedings of Information Security and Cryptology (ICISC 2005), Seoul, Korea, LNCS 3935, Springer Berlin/Heidelberg, Germany, pp. 378–389.

[35] Shereen H. Ali, Ali I. El Desouky, Ahmed I. Saleh’A New Profile Learning Model for Recommendation System based on Machine Learning Technique”, Indonesian Journal of Electrical Engineering and Informatics (IJEI) Vol. 4, No. 1, March 2016, pp. 81–92

[36] Tian, J (2003), “Reversible data embedding using a difference expansion”, IEEE Transactions on Circuits and Systems for Video Technology, Vol.13, No.8, Pp.890-896.

[37] Pell’s cap Chen Y-L. et al. (2013), A maximum entropy-based chaotic time-variant fragile watermarking scheme for image tampering detection, Entropy, Vol 15 pp 3170-3185

[38] Lin, S. D., Shie, S. C., and Guo, J. Y. (2011), “Improving the robustness of DCT-based image watermarking against JPEG compression”, Journal of Computer Standards & Interfaces, vol.32, pp. 54-60, 2010.

[39] Jose, S., Roy, R. C., and Shashidharan, S., “Robust Image Watermarking based on DCT-DWT-SVD Method”, International Journal of Computer Applications, vol.58, no.21, pp. 0975-8887, November 2012.

[40] Xijin, W., Linxiu, F., "The Application Research of MD5 Encryption Algorithm in DCT Digital Watermarking", International conference on Solid State Devices and Materials Science, Journal of Physics Procedia, vol.25, pp.1264-1269, 2012.

[41] Tao, B., Dickinson, B., "ADAPTIVE WATERMARKING IN THE DCT DOMAIN", IEEE International Conference on Acoustics, Speech, and Signal Processing, pp. 21-24, 1997.

[42] Potdar, V. M., Han, S., and Chang, E., "A Survey of Digital Image Watermarking Techniques", 3rd IEEE International Conference on Industrial Informatics (INDIN), pp. 709-716, 2005.
[43] Eswaraiah, R., Edara, S. A., and Reddy, E. S., “Color Image watermarking Scheme using DWT and DCT Coefficients of R, G and B Color Components”, International Journal of Computer Applications, vol.50, no.8, pp. 0975-8887, July 2012.35

[44] Kashyap, N., SINHA, G. R., “Image Watermarking Using 3-Level Discrete Wavelet Transform”, I.J.Modern Education and Computer Science, vol.3, pp. 50-56, 2012.

[45] Pardhan and rath, “Digital Watermarking technique using DWT and Cross Chaos”, Journal of processing technology, vol.6, pp:897-904, 2010

[46] Zhu Yueleng and Lin Li “Digital Image Watermarking Algorithms Based On Dual Transform Domain And Self-Recovery”, International Journal On Smart Sensing And Intelligent Systems Vol. 8, No. 1, March 2015.

[47] Saravjit Kaur and Research Scholar, “A Digital Image Watermarking Technique Based on DWT”, International Journal of Computer &IT, Pages1-8, 2015.

[48] Thirugnanam.G, Arulselvi.S, “Robust Digital Image Watermarking Scheme Based on DWT and ICA,” Global Journal of Computer Science and Technology, Vol.10, 2010.

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