Advances in Computational Sciences and Technology
ISSN 0973-6107 Volume 10, Number 5 (2017) pp. 1391-1404

http://www.ripublication.com

A blind watermarking algorithm based on DWT-DCT using gold sequence generator

Chaitanya Konda[1,*], Gangadhara Rao Kancherla[1, 2], Sreenivasa Reddy Edara[1, 3]

[1]*Assistant Professor,Department of CSE, ANU College of Engineering and Technology, Acharya Nagarjuna University, Guntur, Andhra Pradesh, India*

[2]*Associate Professor,Department of CSE, ANU College of Science, Acharya Nagarjuna University, Guntur, Andhra Pradesh, India*

[3]*Professor,Department of CSE, ANU College of Engineering and Technology, Acharya Nagarjuna University, Guntur, Andhra Pradesh, India*

Abstract

In modernistic days there is a fast growth in multimedia data like text, images and videos. Security is one of the most important aspects while transmitting the multimedia data specially images over cyberspace without any loss of information. Digital image watermarking is one of the many approaches to protect the digital images from unconstitutional manipulations. In this paper a new watermarking algorithm based on gold sequence generator is used. The suggested algorithm proposes multilevel discrete wavelet transform (DWT) to get the multi-resolution sub-bands and energy is determined for each sub-band. Depending on the energy, lowest energy sub-bands are preferred as they have little information when compare with other sub-bands. Further, discrete cosine transform (DCT) is applied to the lowest energy sub-band and mid frequency components are considered for embedding the watermark. Two preferred Pseudo-Noise (PN) sequences are used to generate number of gold sequences and these gold sequences are used to embed the attributes of arnold transformed watermark image. The outcome shows that the recommended method has improved performance when compared to current DWT, only DCT, only DWT-DCT approaches. Most of the current methods are suitable for embedding binary images into gray images where as the proposed method is useful for embedding gray level images into color images. The suggested method has enhanced imperceptibility and robustness against attacks.

Keywords: Discrete wavelet transform (DWT), discrete cosine transform (DCT), mid frequency components, arnold transform, pseudo-noise sequence (PN sequence), gold sequence generator.

1. INTRODUCTION

Now a day's people are using cyberspace for their financial transactions like online banking, medical etc. Security is one of the matters in this domain. Carrying of data through internet may be vulnerable to different attacks by intruders, hackers etc. Digital watermarking technique is one of the up-and-coming methods used to provide security in online transactions.

A digital watermarking system embeds the information (watermark) into a document or video or image and extracts the same information from the document or video or image [1, 2, 3]. Digital watermarks can be divided into two classes like visible watermarks and invisible watermarks. Visible watermarks are visible after embedding and invisible watermarks are invisible after embedding [4]. Digital watermarking techniques can be classified into text, image, video and audio watermarking [5]. The suggested paper implements invisible digital image watermarking .i.e., hide the watermark image into the cover image by using suggested watermarking algorithm and get watermarked image and then send to the destination. In the destination, watermark is extracted from the watermarked image. The embedding and extraction mechanism is shown in Figure 1.

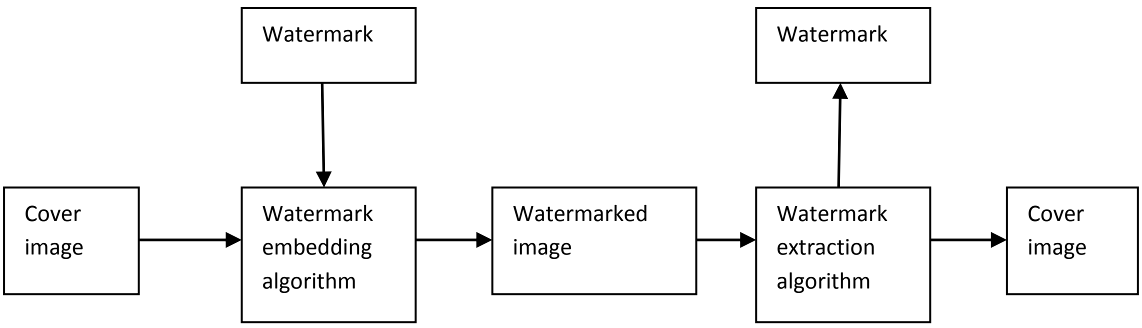

Figure 1. Watermark embedding and extraction process

Based on the applications, the cover image is or is not available at the destination side while extracting the watermark from the watermarked image. The techniques that do not require the cover image for recovering the watermark image is called blind watermarking techniques.

Digital image watermarking can be implemented in 2 different domains. They are spatial domain and frequency domain [6]. Spatial domain algorithms are simple to implement but embedding capacity is very less, quality of the image after embedding is also very less and also have limited security. Least significant bit watermarking technique is an example for spatial domain. In LSB method pixels are altered directly according to the information that is to be embedded [7]. In frequency domain the watermark is embedded in the frequency coefficients of the cover image. In frequency domain filters are used for embedding the information which modifies pixel values so that more security is achieved, embedding capacity is also high and it is more powerful than spatial domain watermarking. Some of the frequency domain transformations include discrete fourier transform (DFT), discrete wavelet transform (DWT), and discrete cosine transform (DCT). Discrete fourier transform is suffering from JPEG attacks. DWT and DCT are more robust compared to DFT. To get the robustness in DWT, watermark will be embedding at the high frequency sub-bands instead of low frequency sub-band.

In the suggested paper, DWT is used for decomposing the image into multi-resolution sub-bands [8]. By calculating energy, least energy sub-bands are selected. Further they are subdivided into 4×4 sub-blocks and DCT is applied for each block [9, 10]. DCT discriminates high resolution components from the low resolution elements and further watermark is embedded in mid frequency coefficients of these DCT blocks. Select the mid frequency coefficients for embedding the watermark as low frequency sub-bands involves most of the visual information and high frequency sub-bands are compressed due to DCT [11].

In the proposed method, the gold sequence generator is used for generating the gold sequences and to generate these gold sequences two proper PN Sequences of same length are used. These sequences are shifted cyclically to left and modulo 2 additions are performed to get the gold sequences. These gold sequences are used for embedding the watermark in the middle frequency coefficients of each DCT block. To get more security, apply arnold transform to the elements of the watermark and respective gold sequences are used to embed the watermark [12].

The rest of this paper is worked out as follows: Section 2 contains brief introduction about discrete wavelet transform, discrete cosine transform, mid frequency coefficients and arnold transform. Section 3 contains introduction about gold sequence generator, watermark embedding and extraction algorithm by using gold sequence generator. Section 4 contains description about performance measures used in watermarking. Section 5 contains results of proposed method and conclusion in Section 6.

2. FREQUENCY DOMAIN TRANSFORMATION

By using mathematical operators, a signal can be converted from time domain into frequency domain is called transforms. Different types of transforms are available for embedding the information like discrete wavelet transform, discrete cosine transforms. The main aspect of these transforms is embedding capacity is high and more robust.

2.1. Discrete Wavelet Transform

It is a wavelet transform in which signals are sampled discretely. Here the image is high-pass filtered then we get three large images and each three get changes in their brightness details of the original image. The suggested paper used the haar wavelet transform. It adds the input values then store the sum and passing the difference. This process is repeated recursively, pairing up the sums to provide the next scale: finally resulting in 2n − 1 differences and one final sum. One level Image quantization by using Discrete Wavelet Transform is shown in Figure 2.

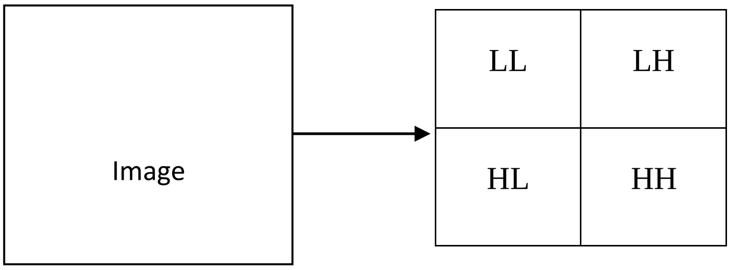

Figure 2. One level Image Quantization

2.2. Discrete Cosine Transform

It shows the fixed sequence of data points in terms of a sum of cosine functions in terms of different frequencies. Discrete cosine transform is mainly useful for lossy compression of images. Discrete cosine transform separate the image into different sub-bands with respect to the visual quality of the image. DCT converts the image from spatial domain to frequency domain. In the proposed method, it divides the original image into 4 × 4 blocks and applies 2D DCT to each block. We can compute the 2D DCT by compute 1D DCT vertically and by compute 1D DCT horizontally.

The equation for 2D DCT is defined below in equation 1:

$$F(x,y) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} I(i).I(j).cos\left[\frac{\pi.x}{2.N}(2i+1)\right] cos\left[\frac{\pi.y}{2.M}(2j+1)\right].f(i,j) \quad (1)$$

Where $I(i) = 2^{-\frac{1}{2}}$ for i = 0

$= 1$ otherwise

2.3. Mid frequency coefficients

In the proposed method, the image is divided into 4 × 4 blocks for embedding the information. Apply DCT to each block. The block contains high frequency, low frequency and mid frequency coefficients. High frequency coefficients are removed if compression is done and low frequency coefficients contain the most visualized components. So, prefer mid frequency coefficients for embedding the watermark. Figure 3 shows low, mid and high frequency coefficients of a 4 × 4 DCT block.

Low	Low	Mid	Mid
Low	Mid	Mid	Mid
Mid	Mid	Mid	High
Mid	Mid	High	High
Mid	High	High	High

Figure 3. Frequency regions in 4X4 DCT block

2.4. Arnold Transform

The feature of arnold transform is that "the image being apparently randomized by the transformation but returning to its original state after a number of steps". Arnold transform is also called as arnold's cat map and normally it is advisable for N × N square images. The equation for the arnold transform is given below in equation 2:

$$\begin{bmatrix} u' \\ v' \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} mod\ 1 \qquad (2)$$

Where (u, v) is the location of the watermark image and (u', v') is the location of the watermark image after applying the arnold transform. The next iteration is obtained from the previous iteration by using the following equation 3:

$$Ti\ (u, v) = Ti\text{-}1(\text{mod}\ (2u+v, N), \text{mod}\ (u+ v, N)) \qquad (3)$$

3. WATERMARKING METHOD

The suggested watermarking method using the gold sequence generator for embedding the watermark into the original (cover) image is described below. The gold sequence generator produces a large class of sequences with periodic cross-correlation property.

3.1. Gold sequence generator

Gold sequence is a type of binary sequence and it has a better cross-correlation property. For generating Gold Sequences, it needs preferred pair of PN Sequences having same length. Consider the two PN Sequences X and Y, and we shift these vectors cyclically to the left and perform addition modulo 2 then get 2^n-1 number of gold sequences, where n is the degree of the preferred polynomial. The equation for generating gold sequences is given below in equation 4:

$$GS\ (X, Y) = (X, Y, X \oplus Y, X \oplus TY, X \oplus T^{2Y}, X \oplus T^{3Y} \ldots X \oplus T^{N-1}Y) \qquad (4)$$

GS (X, Y) is the gold sequence which contains N+2 sequences where N is 2^n-1, n is 7 and 2 PN Sequences. Figure 4 shows the generation of gold sequences form PN sequences.

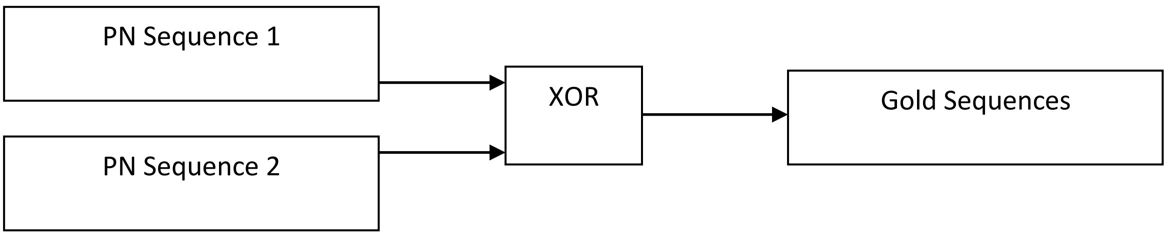

Figure 4. Generation of gold sequences from PN sequences

In the proposed method, 127 gold sequences + 2 PN sequences are generated using n as 7 and each gold sequence contains 7 bits. The proposed watermark image is a gray level image which contains 256 shades. For each two adjacent gray levels use one gold sequence for embedding in the mid frequency coefficients of each DCT component of the cover image.

3.2. Embedding procedure

The following steps are used for embedding the watermark image into the cover image:

1. Divide the cover image into Red, Green and Blue components.
2. Select Blue component as only 2% of cones are sensitive to Blue color and apply DWT then get four sub-bands O1, H1, V1 and D1.
3. Calculate energy and select the sub-band which contains less energy and apply second level DWT to the selected sub-band, then get O2, H2, V2 and D2.The energy is calculated by using equation 5 given below:

$$\text{Energy } E=\sum_{i,j} M(i,j)^2 \quad \text{where M is the sub-band} \tag{5}$$

4. Again calculate the energy for H2, V2 and D2, based on the least energy select the second level sub-band (H2/V2/D2).
5. Divide the selected sub-band into 4 × 4 cells and apply DCT to each cell.
6. Take the watermark image and apply arnold transform.
7. Select two preferred PN sequences and based on the two PN sequences generate gold sequences.
8. Obtain the unique gray levels in the image. For two adjacent gray levels appearing in the watermark image one unique gold sequence of size 7 bits is used for embedding. The embedding is done in the seven mid-frequency coefficients of each DCT component.(As the gold sequences generated are 128, and maximum gray levels in the watermark image is 256 , here two adjacent gray level are considered so that for two consecutive gray levels one gold sequence can be used for embedding.)
9. After embedding, apply inverse DCT to each cell and combine the cells into matrix and then apply two levels inverse DWT then we get the modified Blue component.
10. Combine Red, Green and modified Blue component and get the watermarked image.

The Figure 5 shows the watermark embedding process.

3.3. Extraction procedure

The following steps are used for extracting the watermark image from the watermarked image:

1. Decompose the watermarked image into Red, Green and Blue components.
2. Apply DWT to the Blue channel and based on the least energy apply second level DWT to the selected component.
3. Divide the selected components into 4 × 4 cells and apply DCT to each cell.
4. Extract the mid frequency coefficients and compare this value with the list of Gold Sequences which are generated by the two preferred PN Sequences.
5. If value is found in the list then identify the location.
6. Extract all those locations and apply inverse arnold transform and then get the extracted watermark.

The Figure 6 shows the watermark extraction process.

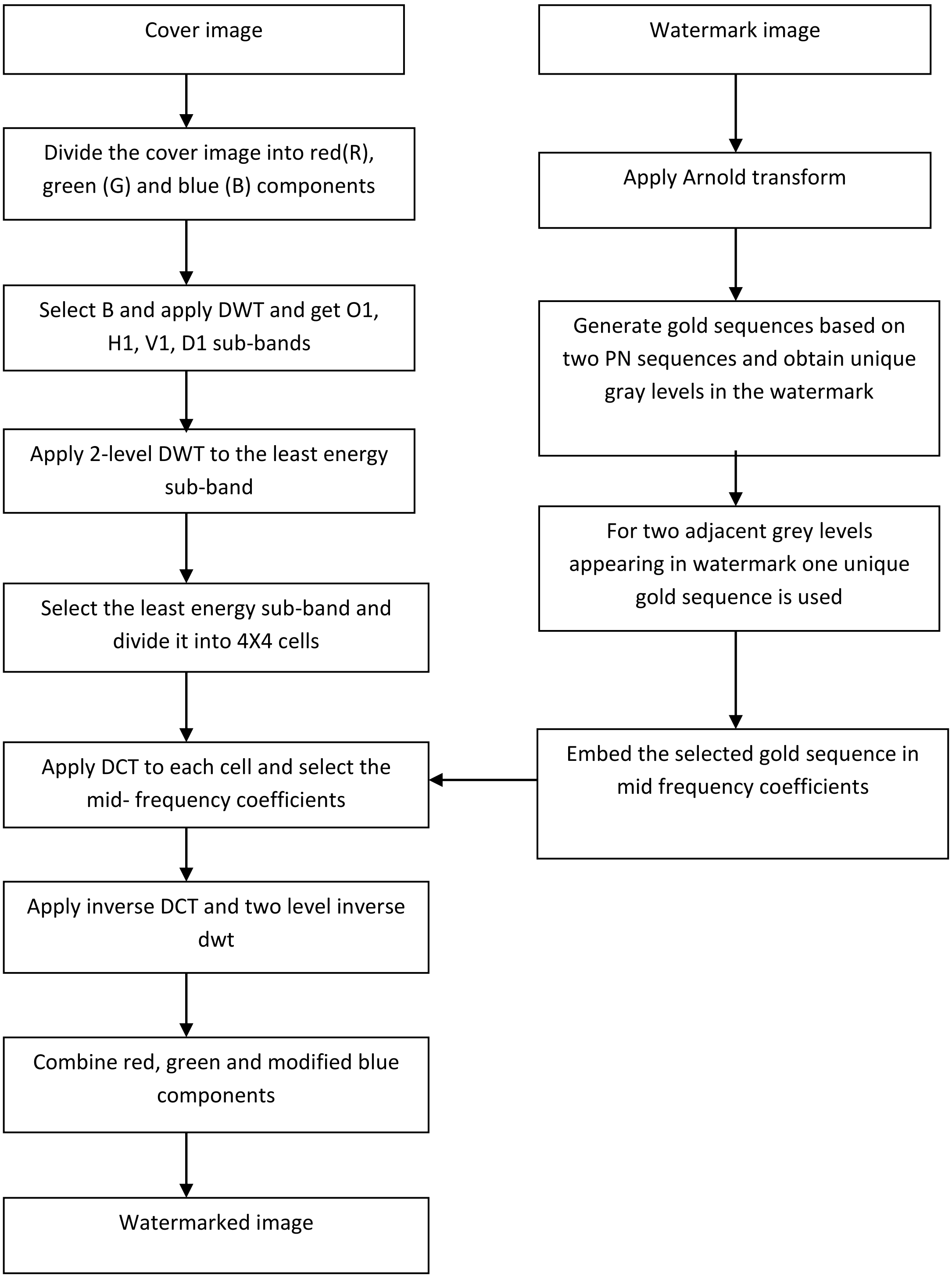

Figure 5. Watermark embedding process

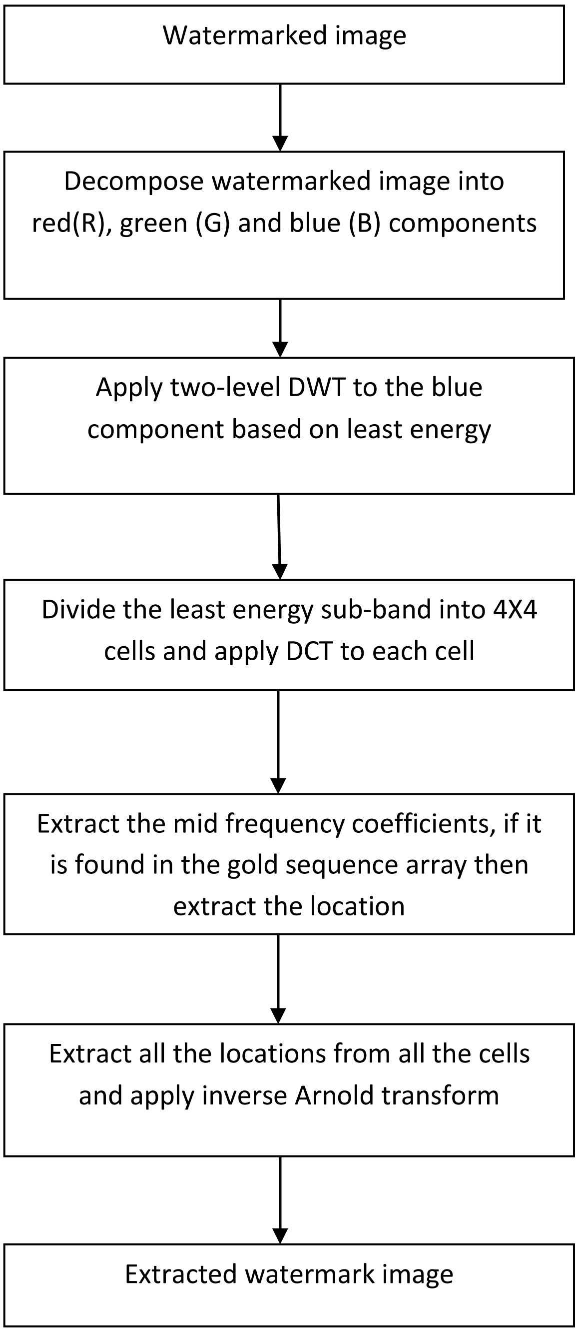

Figure 6. Watermark extraction process

4. PERFORMANCE ANALYSIS

Matlab R2013a is used for implementing the proposed method. The quality of the watermarked image is known by the performance measures. The perceptual quality of the watermarked image and robustness of the extracted watermark image is calculated by the peak signal to noise ratio, normalized correlation, average difference, maximum difference, structural content, mean absolute error, image fidelity.

4.1. Peak signal to noise ratio

Peak signal to noise ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation .Peak Signal to Noise Ratio (PSNR) between Original image (x) and watermarked image (y) is given by the following equation 6:

$$\text{PSNR}=10 \quad \log_{10}\left(\frac{R^2}{MSE}\right) \tag{6}$$

Where R is the maximum fluctuation in the input image data type. For an 8-bit unsigned data type R is 255

Mean square error (MSE) is calculated by the following equation 7:

$$\text{MSE}=\frac{1}{mn} \quad \sum_{i=1}^{m}\sum_{j=1}^{n}(x(i,j)-y(i,j))^2 \tag{7}$$

4.2. Normalized Correlation

Normalized Correlation (NC) is used to know the difference between watermark image (x) and extracted watermark image (y).NC is calculated by the equation 8.

$$\text{NC}=\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(x[i,j]y[i,j])}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}(x[i,j])^2 \quad \sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}(y[i,j])^2}}} \tag{8}$$

4.3. Average Difference

Average Difference (AD) is to find the average of difference between the original image and watermarked image and to find the average difference between watermark and extracted watermark image.AD is calculated by the equation 9.

$$\text{AD}=\frac{1}{mn} \quad \sum_{i=1}^{m}\sum_{j=1}^{n}(x(i,j)-y(i,j)) \tag{9}$$

4.4. Maximum Difference

Maximum Difference (MD) is the maximum error between the original image and watermarked image and to find the average difference between watermark and extracted watermark image. MD is calculated by the equation 10.

$$\text{MD}=\text{MAX}|x(i,j)-y(i,j)| \tag{10}$$

4.5. Structural Content

Structural content (SC) is used to find the similarity between the original image and watermarked image and to find the average difference between watermark and extracted watermark image. SC is calculated by the equation 11.

$$\text{SC}=\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(y(i,j))^2}{\sum_{i=1}^{m}\sum_{j=1}^{n}(x(i,j))^2} \qquad (11)$$

4.6. Mean Absolute Error

Mean Absolute Error (MAE) is average of absolute difference between the original image and watermarked image and to find the average difference between watermark and extracted watermark image. MAE is calculated by the equation 12.

$$\text{MAE}=\frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}|x(i,j)-y(i,j)| \qquad (12)$$

4.7. Image Fidelity

Image Fidelity (IF) is to find how close the original image and watermarked image and to find how close watermark and extracted watermark image. IF is calculated by the equation 13.

$$\text{IF}=1-\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(x(i,j)-y(i,j))^2}{\sum_{i=1}^{m}\sum_{j=1}^{n}(x(i,j))} \qquad (13)$$

5. Results and Analysis

The proposed method used three color images Orange flower, Tulips and Color flowers of size 1024 × 1024 as cover images and three watermark images Lady, Toy and Wheel of size 64 × 64 for embedding. A figure 7 shows the original and watermarked images. Figure 8 shows the Watermark and Extracted Watermark images.

The proposed method used PSNR, NC, AD, MD, SC, MAE and IF quality metrics to analyze the results. The results of the proposed method was compared with the existing method [13] which has PSNR value is 53.29%.

(a) (b) (c)

(d) (e) (f)

Figure 7. The figure shows (a) (b) (c) Original images and (d) (e) (f) Watermarked images

(a) (b)

(c) (d)

(e) (f)

Figure 8. The figure shows (a) (c) (e) Original Watermarks and (b) (d) (f) Extracted Watermarks

Table 1 shows the results of various quality metrics for the original image and watermarked image. Table 2 shows the results of various quality metrics for the watermark image and extracted watermark image.

Table 1. Results of various quality metrics for the original image and watermarked image

Image name	PSNR	AD	MD	SC	MAE	IF
Orange flower	63.6701	-4.1220e-05	2.6667	1.0000	0.0200	0.9991
Tulips	67.5072	-4.7133e-04	1.3333	1.0000	0.0100	0.9996
Color flowers	62.2636	-3.3675e-04	2.3333	1.0000	0.0326	0.9989

Table 2. Results of various quality metrics for the watermark image and extracted watermark image

Image name	NC	AD	MD	SC	MAE	IF
Lady	1	0.5007	1	1.0074	0.5007	0.9957
Toy	1	0.6279	1	1.0056	0.6279	0.9971
Wheel	1	0.5544	1	1.0070	0.5544	0.9948

Table 3. The results of the proposed method after applying attacks

Attacks	Proposed method
No attack	63.56(average)
Salt & Pepper noise	39.0500
Gaussian noise	39.1964
Blurring	48.5377
Sharpening	36.0687
Cropping	62.3380
Motion blurred	48.0779

The proposed gold sequence generator technique applied on 35 images and on average 63.56% PSNR is obtained. The values in Table 3 show that the proposed method provides results with different attacks.

6. CONCLUSION

The proposed method for watermarking produces on average of 63.56% PSNR with minimum loss during extraction of watermark images. The proposed method used lower energy DWT sub-bands and mid frequency DCT components to embed watermarking and hence, completely hides the watermark without any illumination.

The gold sequence generator generated one sequence for each two successive gray levels maintaining the quality of the watermark. The proposed technique for watermarking is very difficult to predict by the hacker due to the gold sequences.

BIBLIOGRAPHY

1. Tao H, Chongmin L, Zain JM, Abdalla AN. Robust image watermarking theories and techniques: A review. J APPL RES TECHNOL. 2014 Feb 28;12(1):122-38.
2. Khan A, Siddiqa A, Munib S, Malik SA. A recent survey of reversible watermarking techniquesINFORM SCIENCES. 2014 Sep 20;279:251-72.
3. Verma VS, Jha RK. An Overview of Robust Digital Image Watermarking. IETE TECH REV. 2015 Nov 2;32(6):479-96.
4. Craver, Scott, et al. "Resolving rightful ownerships with invisible watermarking techniques: limitations, attacks, and implications." IEEE J SEL AREA COMM .16.4 (1998): 573-586.
5. Cox IJ, Kilian J, Leighton FT, Shamoon T. Secure spread spectrum watermarking for multimedia IEEE T IMAGE PROCESS. 1997 Dec;6(12):1673-87.
6. Atawneh S, Almomani A, Sumari P. Steganography in digital images: Common approaches and tools. IETE TECH REV. 2013 Jul 1;30(4):344-58.
7. Nissar A, Mir AH. Classification of steganalysis techniques: A study. DIGIT SIGNAL PROCESS. 2010 Dec 31;20(6):1758-70.
8. Jane O, ELBAŞI E. A new approach of nonblind watermarking methods based on DWT and SVD via LU decomposition. TURK J ELECTR ENG CO. 2014 Sep 3;22(5):1354-66.
9. Singh AK, Dave M, Mohan A. Hybrid technique for robust and imperceptible image watermarking in DWT–DCT–SVD domainNATL ACAD SCI LETT. 2014 Aug 1;37(4):351-8.
10. Fazli S, Moeini M. A robust image watermarking method based on DWT, DCT, and SVD using a new technique for correction of main geometric attacks. OPTIK. 2016 Jan 31;127(2):964-72.
11. Parameswaran L, Anbumani K. Content-based watermarking for image authentication using independent component analysis. INFORMATICA. 2008;32(3).
12. Sun L, Xu J, Zhang X, Tian Y. An Image Watermarking Scheme Using Arnold Transform and Fuzzy Smooth Support Vector Machine. MATH PROBL ENG. 2015 Oct 11;2015.
13. Saeed, F., Zahedan, M. G., & Azimi, M. A Blind Watermarking Algorithm Based On DCT-DWT And Arnold Transform. Department Of Telecommunications, IJCSE, 2(06).