International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

Improved Chaotic Systems based Watermarking Scheme Using Logistic and Arnold's Cat Map

Mehdi Khalili

Assistant Professor, Dept. Computer and Informatics Engineering, Payame Noor University, Tehran, Iran

*Corresponding Author's E-mail: *m.khalili@pnu.ac.ir*

Abstract

This paper presents an effective watermarking scheme which uses logistic and Arnold's cat map based chaotic systems to improve watermarking security, and DCT and YIQ properties to enhance the imperceptibility and robustness. In the proposed scheme, first, the watermark is sets up to an initial random configuration sequence and scrambled by the logistic map based chaotic system. Then, two separate pseudo-random number generators are used to encode "1" and "0" separately to reduce the change of false detection. Subsequently, the secured watermark is embedded into quantized DCT blocks coefficients of the intended YIQ channel of the host image which has been scrambled by Arnold's cat map based chaotic system. Experimental results show that the proposed algorithm improves the security and imperceptibility of watermark and has better robustness against most common signal processing attacks such as JPEG compression, cropping, different noises adding, filtering, scaling etc. attacks compared to the related existing methods.

Keywords: Logistic and Arnold's cat map based chaotic systems, quantized DCT block, YIQ, pseudo random number generator, watermarking.

1. Introduction

Nowadays, the authenticity of content or matter is crucial factors for solving the problem of copying, modifying, and distributing the intellectual properties in an illegal way. Watermarking can resolve the stealing problem of intellectual properties [1]. The goal of

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

digital watermarking is to embed a piece of secret information (the watermark) into the original data so that any change or tampering with the data would alter the watermark [2].

Digital watermarking is classified according to the embedding domain into two classes namely spatial and transform domain [3]. In spatial domain techniques, the watermark is directly inserted into the cover image by altering the pixel values [4]. The spatial domain watermarking is easy to implement from a computational point of view but too fragile to resist numerous attacks [1]. The frequency domain approaches are highly beneficial for Image Watermarking. In Transform domain technique the original cover image is transformed into transform coefficients by using various transforms like DCT, DFT and DWT etc [5]. Frequency domain techniques can embed more bits of the watermark and have better robustness against the common signal processing attacks. Therefore, it becomes one of study focuses in this community [6]. Among different transforms, DCT become popular for compression resilient watermarking, as common image compression standards such as JPEG are based on DCT. In this frequency domain, the watermark is embedded by modifying the middle frequency coefficients so that the visibility of the image will not be affected [7-9]. So far, many image watermarking methods have been developed, which employ DCT domain to embed the watermark. Amit Phadikar et al in [9] have proposed a watermarking method in which the watermark is embedded into visually significant regions of the image using quantization index modulation (QIM). Fang Ma et al in [10] proposed a based DCT watermarking in which Arnold chaotic scrambling is done to the watermarking before the embedding and then different methods to quantize the frequency coefficient of each sub-block are used. In [11], Shinfeng D. Lin et al have proposed a scheme that to preserve acceptable visual quality of watermarked images, the DCT low-frequency coefficients are adjusted by the concept of mathematical remainder. Chunhua Li et al in [12] have proposed an algorithm in which the watermark is embedded in the host image through adjusting the magnitude relationship of the chosen medium frequency coefficient which is easy to be implemented. Yonggang Fu in [13] has proposed an algorithm in which

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

the watermark bits are encoded by BCH code, and then embedded into the host by modulating the relationships between the selected DCT coefficients. In [14], Zhao Yantao et al have proposed a method in which firstly, the watermark is scrambled by one chaos map with keys; secondly, the scrambled watermark is embedded into the least signification bits (LSB) of the quantized DCT coefficients, which the watermark embedded into are determined by another map with another keys.

In aforementioned works the security, imperceptibility and the robustness of watermark under some common attacks are performed acceptable. However, in high attacked images under widespread signal processing attacks such as JPEG compression, different noises adding, cropping, rotation, filtering etc., the embedded watermarks may be destroyed seriously. In this paper, to overcome this problem, an effective technique has been proposed in which the watermark, it is sets up to an initial random configuration sequence and scrambled by logistic map based chaotic system and adopted with two random binary sequences using two pseudo-random number generators to increasing the security of the watermark. These two separate sequences are used to encode "1" and "0", separately. Then, the secured watermark is embedded into the quantized DCT blocks coefficients of the intended YIQ channel of the host image which has been scrambled by Arnold's cat map based chaotic system. It has to be mentioned that using two separate PN sequences has the advantage of not requiring a "blind" choice of threshold, as the pattern with the higher correlation is chosen. Furthermore, by careful choice of these two patterns to be as un-correlated as possible, we can reduce the change of false detection significantly. Also, the other subtle advantage is that the approach makes better use of the HVS in spreading its noise throughout the image.

2. Logistic and Arnold's Cat Map Chaotic Systems

In recent years, chaotic systems have been used for digital watermarking to increase the security. Chaotic systems are deterministic systems that are governed by nonlinear

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

dynamics. The most attractive features of chaos in information hiding are its extreme sensitivity to initial conditions, in the sense that two chaotic systems generated from different initial conditions and parameters are uncorrelated statistically and seem random. These special characteristics make chaotic systems excellent candidates for watermarking and encryption. Chaotic system is used as the fundamental equations to generate chaotic sequences [15]. Logistic map is one of the chaotic systems. It shows complex behavior and the map is highly sensitive to the initial conditions. Different initial conditions generate different sequences. In this paper, the logistic map is used to generate an initial random configuration of the watermark image with the size of M×N as the secret key K1. It is described as follow [16]:

$$X_{i+1} = \mu X_i (1-X_i) \qquad (1)$$

where, $0 < \mu \leq 4$. After generating the sequences using eq.1 the map is round-off into M×N size.

Arnold cat map is the other chaotic system which has proposed by V.I. Arnold in his ergodic theory study. If an image is transformed according to the mapping principle of ring automorphism, its semantic characteristics is also changed, which implements the effect of scrambling, so as to improve the robustness and security of digital image. The discrete Arnold transformation is defined as follows [17, 18]:

$$\begin{bmatrix} X_{n+1} \\ Y_{n+1} \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} X_n \\ Y_n \end{bmatrix} = A \begin{bmatrix} X_n \\ Y_n \end{bmatrix} \mod N \qquad (2)$$

where, a, b, c and d are positive integers, and $|A| = ad - bc.1$, so only three among the four parameters of a, b, c and d are independent. X_{n+1}, Y_{n+1}, X_n and Y_n are integers in {0,1,2,...,N-1}. In this paper, the number of iteration is used as the secret key K2.

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

3. Introduction YIQ Color Space

The YIQ color space is a device-dependent color space which means the actual color you see on your monitor depends on what kind of monitor you are using and what its settings are. In this color space, Y-component stands for luminance or brightness; the I-component seems to mimic mostly shifts from blue, through purple, to red colors (with increasing I), and the Q-component seems to mimic mostly the value of green. I and Q components jointly represent the chromatic attributes. The de-correlation of R, G and B component images makes the Y, I and Q component images complementary to each other. The transform from RGB to YIQ and the backward transform are respectively as follow [17, 19]:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \quad (4)$$

4. Discrete Cosine Transform

As it was mentioned before, DCT is one of the methods used for robustness of watermarking. DCT decomposes a signal into three different frequency band which are low, middle and high frequency bands. By exploiting the properties of the image, we can select the band in which the watermark should be inserted. DCT has a special property referred as "Energy compaction Property" which says that most of the visually significant information of the image is concentrated in just a few coefficients of the DCT. Low frequency components are the high energy components and contain the most important

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

visual part of an image. High frequency components are generally more prone to attacks. That's why middle frequency components are generally chosen for watermark embedding. In Fig.1, FM is the middle frequency component of the 8x8 DCT block, FL is the low frequency component, and FH is the high frequency components. FM is chosen as the embedding region so that the visibility of the image is not affected and the watermark cannot be easily removed by attacks [20, 21].

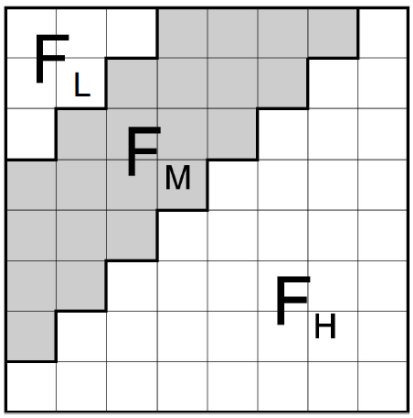


Figure 1: DCT regions

5. Proposed Algorithm

5.1. Watermark Embedding

The steps of watermark embedding in the proposed method are described as follows:

1. Scramble the original image by applying K2 times iterations of two dimensional Arnold's cat map.

2. Convert the scrambled host image from RGB to YIQ color space as follows:

3. Divide the first channel of converted image to 8×8 blocks and use DCT to transform each block.

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

4. Define the middle-band frequencies (FM) of the DCT blocks.

5. Set-up the watermark with an initial random configuration W0. The size of W0 should be equal to the size of the watermark image W. This initial random configuration W0 of size M×N is generated by using logistic map. Two initial values of logistic map act as secret key K1.

6. Adopt two random binary sequences R1 and R2 of size n using two pseudo-random number generators to encrypt the W0. R1 is for encoding "1" and R2 is for encoding the "0".

7. To achieve extra robustness of watermark to JPEG compression, use the standard JPEG quantization table, which is listed in table 1, to quantize each DCT-transformed block. The result can be denoted as Ci (a, b) = quantizate (Di (a, b) / P(a, b)) , where Di (a, b) and P(a, b) are pixel values of the DCT coefficient and the quantization table respectively.

Table 1: Standard JPEG quantization table

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

8. Embed the watermark bits with the Zigzag scan order shown in Fig.2, by the correlation properties of additive pseudo-random noise patterns according to equation shown in below:

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

$$I_{W\,x,y}(u,v)=\begin{cases} I_{x,y}(u,v)+k*W_{x,y}(u,v), & u,v\in F_M \\ I_{x,y}(u,v), & u,v\notin F_M \end{cases} \quad (5)$$

where k denotes a gain factor for completely controlling the imperceptibility of watermarked images and the robustness of watermarks, and IW is the resulting watermarked image. It should be mentioned that if watermark bit contains 1, R1 and if it contains 0, R2 will be embedded into mid-band components of DCT blocks. The embedding result is Ci'.

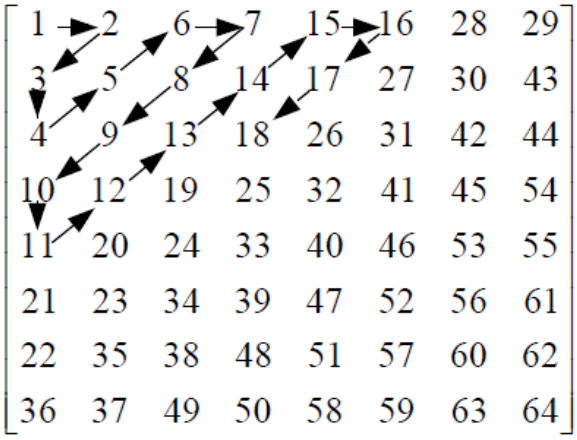


Figure 2: Zigzag scan order

9. Use the standard JPEG quantization table. The result is denoted as Di' (a, b) = Ci' (a, b) × P(a, b) .

10. Perform an IDCT on each watermarked DCT block.

11. Combine the watermarked channel with the other two channels.

12. Reconvert the image form YIQ color space to RGB color space.

13. Re-scramble the reconverted image by applying Arnold's cat map to generate the watermarked image.

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

5.2. Watermark Extracting

In the proposed method, the restored image can achieve with the secret information {K, K1, K2, JPEG quantization table and PN sequences}, where k demonstrates the Kth zigzag position in the middle-frequent band. This restoring procedure occurs as follows:

1. Scramble the watermarked image by using Arnold cat map for K2 times.

2. Convert the scrambled watermarked image from RGB color space to YIQ as follows:

3. Break up the first channel of converted image into those same 8×8 blocks and perform the DCT on each block.

4. Use the standard JPEG quantization table, to quantize each pixel. The result can be denoted as Ci′(a, b) = Di′(a, b) / P(a, b) , where P(a, b) is pixel values of the standard JPEG quantization table.

5. Compare the same PN sequences to the values of the quantized blocks and compute each block with the threshold T, separately by Zigzag scan re-order.

6. Extract the sequence encrypted watermark as follows:

$$\begin{cases} W_i = 1 & if \quad C_i \rangle T \\ W_i = 0 & Othetwise \end{cases} \tag{6}$$

7. Use Key K2 to generate initial random configuration W0.

8. Re-configure the W0 with the size of M×N to access the watermark image.

6. Experimental Results and Analysis

The performance of the proposed methodology has been authenticated using MATLAB R2012b (8.0.0.7873), by simulating on the standard image “Lena” with the size of 512×512 as the host image and a binary image with the size of 15×45 as the watermark image. The cover image and watermark used are shown in Fig. 3 (a-b). The value of gain factor “k” is kept fixed 20 in the experiments. Increasing the value of “k” may improve

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

chances of watermark insertion in the attributes. As a result, watermark capacity, distortion, and false positive detection will be increased. In general, at the same time, an important thing is to verify the imperceptibility and robustness of the proposed watermarking scheme. Imperceptibility refers to the ability of the watermarking method to embed watermarks without significantly lowering the host signal quality [22, 23]. In this paper, the peak signal to noise ratio (PSNR) is used to measure the imperceptibility of the proposed method or the damage degree to the original image caused by embedding watermark. Generally, if PSNR value is greater than 35 dB, the watermarked image is within acceptable degradation levels and the watermark is almost invisible to human visual system (HVS) [8]. It is defined in [24]. On the other hand, robustness denotes the capability of the watermarking method to extract the embedded watermarks under common attacks [22, 23]. The robustness of a watermarking method can be evaluated by performing attacks on the watermarked image and evaluating the similarity of the extracted message to the original one. This paper measured the similarity between the original watermark and the watermark extracted from the attacked image using normalized correlation (NC) value given in [6]. Fig. 3(c-d) shows the results of test image after embedding the invisible watermark.

The simulation results of imperceptibility and the performance comparison of proposed scheme with the earlier works in [8, 10, 12 and 14] are given in table 2. It can be seen that the proposed scheme satisfies imperceptibility more than the mentioned works. PSNR value for the proposed method is 61.64 dB while in the other work is less. Also NC value is 1. It means the embedded watermark is extracted without any error bit rate (EBR), While in [12] is 0.9769.

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

Figure 3: (a) Original Host Image; (b) original watermark; (c) watermarked image and (d) extracted watermark

Table 2: Comparison of the proposed method in term of imperceptibility

	[8]	[10]	[12]	[14]	Proposed
PSNR	50.60	35.52	38.27	35.43	61.64
NC	1.00	1.00	0.9769	1.00	1.00

To verify the robustness of the proposed watermarking, the watermarked image is performed by both the image processing operations (such as JPEG compression, adding noises, filtering) and geometrical distortions (such as cropping, scaling and rotation). Table 3 shows the obtained results of applying different attacks on the watermarked image and Figs. 4 and 5 illustrate the robustness of the proposed method under different attacks. It could be found that the proposed scheme satisfies robustness property even under high attacks. So that the extracted watermarks from attacked images are clearly recognizable as well.

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

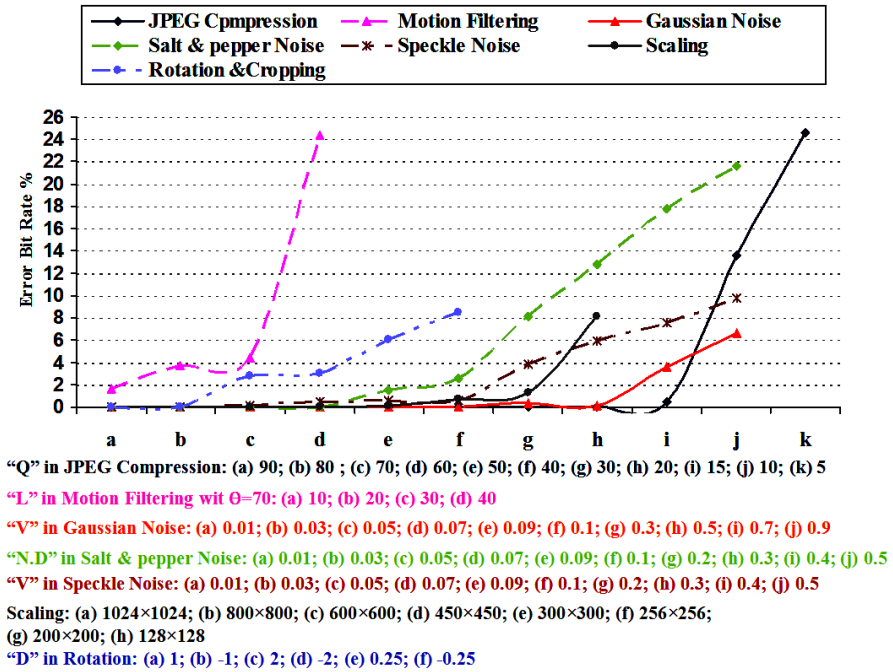


Figure 4: Error bit rate values of the extracted watermarks after applying different attacks.

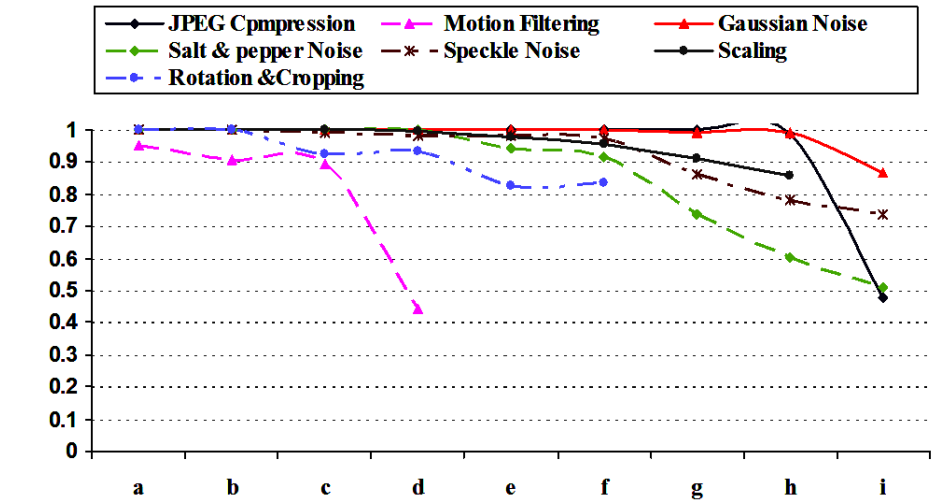
To illustrate the enhancement of the proposed method in term of robustness against JPEG compression, it is compared with the earlier works in [11, 13] and the performance comparison is given in tables 4, 5. Also, table 6 shows the comparison results of the proposed scheme with the other existed work in [9] in term of the robustness against JPEG compression, adding different noises and low pass filtering. It can be observed that the proposed method provides better results in JPEG compression in comparison to [11, 13] and is much more robust in comparison to [9] in all the cases.

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543

Available online at: http://www.aeuso.org

© Austrian E-Journals of Universal Scientific Organization



"Q" in JPEG Compression: (a) 90; (b) 80 ; (c) 70; (d) 60; (e) 50; (f) 40; (g) 30; (h) 20; (i) 15

"L" in Motion Filtering wit Θ=70: (a) 10; (b) 20; (c) 30; (d) 40

"V" in Gaussian Noise: (a) 0.01; (b) 0.03; (c) 0.05; (d) 0.07; (e) 0.09; (f) 0.1; (g) 0.3; (h) 0.5; (i) 0.7

"N.D" in Salt & pepper Noise: (a) 0.01; (b) 0.03; (c) 0.05; (d) 0.07; (e) 0.09; (f) 0.1; (g) 0.2; (h) 0.3; (i) 0.4

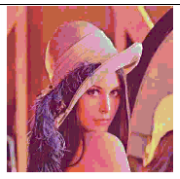
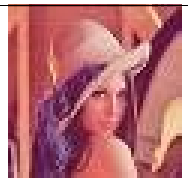
"V" in Speckle Noise: (a) 0.01; (b) 0.03; (c) 0.05; (d) 0.07; (e) 0.09; (f) 0.1; (g) 0.2; (h) 0.3; (i) 0.4

Scaling: (a) 1024×1024; (b) 800×800; (c) 600×600; (d) 450×450; (e) 300×300; (f) 256×256; (g) 200×200; (h) 128×128

"D" in Rotation: (a) 1; (b) -1; (c) 2; (d) -2; (e) 0.25; (f) -0.25

Figure 5: NC values of the extracted watermarks after applying different attcks.

Table 3: The experimental results of applying different signal processing attacks on the proposed scheme

Attacks	JPEG Compression Q=20		Gaussian Noise V=0.7		Salt&Pepper Noise N.D=0.1		Speckle Noise V=0.1		Lowpass Filtering 3×3	
Attacked Image										
Extracted Watermark	NC=0.9845 EBR%=0.5		NC=0.8664 EBR%=4.44		NC=0.9162 EBR%=2.51		NC=0.9724 EBR%=0.59		NC=1.00 EBR%=0	
Attacks	Motion Filtering		Scaling 256×256		Histogram		Cropping 50%		Rotation &Cropping	

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543

Available online at: http://www.aeuso.org

© Austrian E-Journals of Universal Scientific Organization

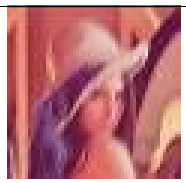
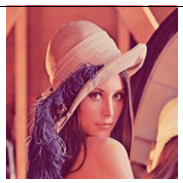
	L=30, θ=70				Equalization				D=3°	
Attacked Image										
Extracted Watermark	NC=0.8938		NC=0.9535		NC=1.00		NC=0.6830		NC=0.8335	
	EBR%=3.55		EBR%=0.7404		EBR%=0		EBR%=14.96		EBR%=6.07	

Table 4: Comparison of the proposed method in term of JPEG compression for NC value

	NC			
	Q=90	**Q=60**	**Q=30**	**Q=20**
[11]	1.00	0.99	0.98	0.98
Proposed	1.00	1.00	1.00	1.00

Table 5: Comparison of the proposed method in term of JPEG compression for error bit rate

	EBR %				
	Q=70	**Q=60**	**Q=50**	**Q=40**	**Q=30**
[13]	0.01	0.047	0.071	0.092	0.18
Proposed	0	0	0	0	0

Table 6: Comparison of the proposed method in term of different attacks fo NC values

Attack	factor	[9]	proposed
Low Pass Filter	**-----**	0.98	1.00
Gaussian Noise	**V=0.01**	0.94	1.00
	V=0.03	0.83	1.00
	V=0.05	0.79	1.00
Salt and Paper Noise	**N.D=0.01**	0.96	1.00

Vol. 4(13), Oct, 2014, pp. 1788-1804, ISSN: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

	N.D=0.03	0.92	1.00
	N.D=0.05	0.87	1.00
Speckle Noise	**V=0.01**	0.97	1.00
	V=0.03	0.89	0.99
	V=0.05	0.83	0.98
JPEG Compression	**Q=60**	1.00	1.00
	Q=50	1.00	1.00
	Q=40	0.88	1.00

Conclusions

In the proposed algorithm firstly the watermark is sets up to an initial random configuration sequence and scrambles by logistic map based chaotic system. Then, to increasing the security of the watermark, it will be adopted with two random binary sequences using two pseudo-random number generators. These two separate sequences are used to encode "1" and "0", separately. The encrypted watermark is embedded into the quantized DCT blocks coefficients of the intended YIQ channel of the host image which has been scrambled by Arnold's cat map based chaotic system. Extensive experimental results show that the proposed watermarking technique yields strong robustness to the geometrical and image processing attacks such as JPEG compression, adding different noises, motion and low pass filtering, rotation and cropping, scaling, histogram equalization and cropping. Also, the imperceptibility of the watermarked image is promising. The watermarks can be extracted from the distorted image after most of the common image processing attacks with high normalized correlation value and low percentage of error bit rate. Performance of the proposed method has been also compared with the earlier works in [8-14]. It outperforms methods [8, 10, 12 and 14] in imperceptibility, algorithms [11 and 13] in JPEG compression and method [9] under various image processing attacks.

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

References

[1]. A. Afroja, N. E. Tajnina, and U. M. Ahsan, "Digital image watermarking based on DWT-DCT: Evaluate for a New Embedding Algorithm," Int. Conf. on Informatics, Electronics & Vision, (2014) May , Dhaka, Bangladesh, pp. 1-6.

[2]. C. J. Cheng, W. J. Hwang, H. Y. Zeng, and Y. C. Lin, "A Fragile Watermarking Algorithm for Hologram Authentication," Journal of Display Technology, vol. 10, 4 (2014), pp. 263-271.

[3]. M. Ebrahimi Moghaddam, N. Nemati, "A Robust Color Image Watermarking Technique Using Modified Imperialist Competitive Algorithm," Forensic Science International, vol. 233, 2013, pp. 193-200.

[4]. A. Musrrat, C. W. Ahn, and M. Pant, "A Robust Image Watermarking Technique Using SVD and Differential Evolution in DCT Domain," International Journal for Light and Electron Optiks, vol. 125,1 (2014), pp. 428-434.

[5]. G. Pradeepkumar, S.Usha, "Effective Watermarking Algorithm to Protect Electronic Patient Record Using Image Transform," Int. Conf. on Information Communication and Embedded Systems, (2013) Feb., Chennai, pp. 1030-1034.

[6]. J. Lang, and Z-G. Zhang, "Blind Digital Watermarking Method in the Fractional Fourier Transform Domain," Optics and Lasers in Engineering, vol. 53, 2014, pp. 112-123.

[7]. Q. Su, Y. Niu, Q. Wang, and G. Sheng, "A Blind Color Image Watermarking Based on DC Component in Thespatial Domain," International Journal for Light and Electron Optiks, vol. 124, 23 (2013), pp. 6255–6260.

[8]. N. Aherrahrou, and H. Tairi, "A New Robust Watermarking Scheme Based on PDE Decomposition," ACS International Conf. on Computer Systems and Applications, (2013) May, Ifrane, pp. 1-5.

[9]. A. Phadikar, S. P. Maity, and B. Verma, "Region Based QIM Digital Watermarking Scheme for Image Database in DCT Domain," Computers and Electrical Engineering, vol. 37,3 (2011), pp. 339–355.

[10]. F. Ma, J. P. Zhang, and W. Zhang, "A Blind Watermarking Thchnology Based on DCT Domain," Int. Conf. on Computer Science and Service System, Nanjing, (2012) Aug., China, pp. 397-400.

[11]. S. D. Lin, S. C. Shie, and J. Y. Guo, "Improving the Robustness of DCT-Based Image Watermarking Against JPEG Compression," Computer Standards & Interfaces, vol. 32, 1-2 (2010), pp. 54–60.

[12]. C. Li , and Z. Qin, "A Blind Digital Image Watermarking Algorithm Based on DCT," IET Int. Conf. on Smart and Sustainable City, Shanghai, (2013) Aug., China, pp. 446-448.

[13]. Y. Fu, "Robust Oblivious Image Watermarking Scheme Based on Coefficient Relation," International Journal for Light and Electron Optiks, vol. 124, 6 (2013), pp. 517– 521.

Vol. 4(13), Oct, 2014, pp. 1788-1804, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org
© Austrian E-Journals of Universal Scientific Organization

[14]. Z. Yantao, M. Yunfei, and L. Zhiquan, "A Robust Chaos-based DCT-domain Watermarking Algorithm," Int. Conf. on Computer Science and Software Engineering, vol. 3, (2008) Dec. 2008, Wuhan, Hubei, pp. 935-938.

[15]. J. T. Wang, W. H. Yang, P. C. Wang, and Y. T. Chang, "A Novel Chaos Sequence Based 3D Fragile Watermarking Scheme," Int. Symp. Computer, Consumer and Control, (2014) June, Taichung, pp. 745-748.

[16]. Moniruzzaman, A.K. Hawlader, and F. Hossain, "Watermarking Scheme Based on Game of Life Cellular Automaton," Int. Conf. on Informatics, Electronics & Vision, (2014) May, Dhaka, Bangladesh, pp.1-6.

[17]. M. Khalili, and D. Asatryan, "Colour Spaces Effects on Improved Discrete Wavelet Transform-based Digital Image Watermarking Using Arnold Transform Map," IET signal Processing, vol. 7, 3 (2013), pp. 177-187.

[18]. R. Zhang, and Y. Wang, "Scrambling Image Watermark Algorithm Based on DCT and HVS," Int. Conf. on Information Technology and Applications, (2013) Nov., Chengdu, pp. 54-57.

[19]. P. Singh, S. Agarwal, and A. Pandey, "A Hybrid DWT-SVD Based Robust Watermarking Scheme for Color Images and its Comparative Performance in YIQ and YUV Color Spaces," 3rd Int. Advance Computing Conference, (2013) Feb., Ghaziabad, pp. 1213-1218.

[20]. V. Tomar, A. Kumar, and A. Choudhary, "Conception & Implementation of a Novel Digital Image Watermarking Algorithm using Cascading of DCT and LWT," Int. Conf. on Reliability, Optimization and Information Technology, (2014) Feb., India, pp. 501-505.

[21]. A. T. Erozan, S. G. Başkır, and B. Ors, "Hardware/Software Codesign for Watermarking in DCT Domain," 21st Signal Processing and Communications Applications Conf., (2013) April, Haspolat, pp. 1-4.

[22]. Y. Xiang, S. Guo, W. Zhou, and S. Nahavandi, "Patchwork-Based Audio Watermarking Method Robust to De-synchronization Attacks," IEEE/ACM Trans. on Audio, Speech, and Language Processing, vol. 22, 9, (2014) September, Haspolat, pp. 1413-1423.

[23]. J. S. Lee, B. Li, "Self-Recognized Image Protection Technique that Resists Large-Scale Cropping," MultiMedia, vol. 21, 1 (2014), pp. 60-73.

[24]. H. V. Dang, and W. Kinsner, "An Intelligent Digital Colour Image Watermarking Approach Based on Wavelets and General Regression Neural Networks'" Proc. Int. Conf. Cognitive Informatics & Cognitive Computing, (2012) August, Kyoto, Japan, pp. 115-123.