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An Enhanced Multi-Hybrid Digital Image Watermarking Method for Authentication

[1]R. Arunmozhi and [2]P.D. Sathya

[1]*Assistant Professor, Department of Electrical Engineering, Annamalai University, Annamalai Nagar, Chidambaram-608002, Tamilnadu, India.*
[2]*Assistant Professor, Department of Electrical Engineering, Annamalai University, Annamalai Nagar, Chidambaram-608002, Tamilnadu, India.*

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ABSTRACT

The day-to-day improvement in the image and video processing sophisticate the end-user with the major concern of privacy management, security assurance and authenticity techniques. In this issue the watermarking method plays a vital role, where the techniques vary based on the application of the end-user. This paper presents a Multi-Hybrid watermarking technique, in which the combination of spatial domain method and transformation domain method are used. In this method, the watermark image is embedded in the sub band in the host image obtained by utilizing the Discrete Wavelet Transform (DWT). The proposed method is developed using Matlab and tested with various 512x512 host images such as Lena, Foster City, Splash, Earth, Oakland, Baboon, San Diego, Airplane, Sailboat and Pepper. In addition, the proposed method is evaluated in terms of Peak-Signal-to-Noise-ratio (PSNR), Mean Square Error (MSE), Image Fidelity (IF), Bit Error Rate (BER) and Accuracy Ratio (AR). The proposed methods show a remarkable improvement when compared to the conventional watermarking method such as Least Significant Bit (LSB), Most Significant Bit (MSB), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).

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INTRODUCTION

The vast developments in multimedia processing improve the sophistication in day-to-day human life. As the consequence of rapid development in the electronic management of valuable personal information such as bank details, medical report, and asset documents are vulnerable to attacks. To overcome the issues of privacy over the personal data a new research field is emerged namely information hiding. Information hiding falls under the category of data security system with cryptography (Rajput, A.S., 2013) as one of its contenders. The steganography (Cheddad, A., 2010) and watermarking (Bartolini, F. A. 2001) plays a vital role in the field of information hiding. Both steganography and watermarking will hide the data or information from attackers or the outer world, but the only difference is, the watermarking is performed for authentication where the watermarked image is both visible and non-visible. On the other hand, only the authenticated user or the particular receiver will have the knowledge of hidden image in steganography. The watermarking can be divided into many types based on domain, documents, reversibility and perception. The overall flow of watermarking is shown in Fig. 1. Based on the documents (i.e. Input format) the watermarking can be classified into four types namely image watermarking (Shijun Xiang, 2008), audio watermarking (Kirovski, D., H.S. Malvar, 2003), video watermarking (Koz, A., A.A. Alatan, 2008), text watermarking (Qadir, M.A., I. Ahmad, 2006). Again, based on the working domain it is classified as spatial domain watermarking (Mukherjee, D.P., 2004) and transform based watermarking (Hui-Yu Huang, 2010). The watermarking can classified into visible (Chun-Hsiang Huang, 2009), invisible (Holliman, M., N. Memon, 2000) and dual (Pei-Yu Lin, 2009) based on human perception. Finally, the reversibility nature of the watermarked image classifies them into two types, namely non-reversible and reversible watermarking (Lixin Luo, 2010). A robust watermarking scheme which shows high resistance over signal processing and geometric distortion attacks is proposed (Chih-Wei Tang, Hsueh-Ming Hang, 2003) based on the combination of image normalization and image feature extraction. The idea here, Mexican hat wavelet is utilized to extract the feature point and consider it for the

Corresponding Author: R. Arunmozhi, Assistant Professor, Department of Electrical Engineering, Annamalai University, Annamalai Nagar,Chidambaram-608002, Tamilnadu, India.

watermark embedding. In (Xiangyang Wang, 2007), the feature point is obtained using the Harris-Laplace detector, and this point is utilized to embed the watermarked image.

The work claims that it is free from desynchronization attacks such as translation, scaling, column or row removal, cropping and rotation. In similar, the image is free from signal processing attacks such as noise adding, median filtering, JPEG compression and sharpening. The image watermarking in the field of defense and medical application is in need of distortion-free recovery of the original image. The reversible digital watermarking is used to accomplish this work, where the removal of watermarked image from the cover image is noise-free. In (Naskar, R., R.S. Chakraborty, 2012), the reversible watermarking algorithm is analyzed by injecting various error rates and it suggests the suitable algorithm based on the application concern. Binary-Phase-Only-Filter (BPOF) based watermarking (Jun Sang, M.S., Alam, 2008) is proposed for both fragile/semi-fragile image authentication. The Fourier spectrum of the image should be filtered using BPOF and the watermark image should be embedded in that region. In addition the Identical Ratio (IR) is evaluated to compute the authenticity efficiency of the algorithm. The traditional watermarking algorithm analyzed in terms of RGB color, which has the problem of correlation. In (Khalili, M., D. Austrian, 2013), the idea of using Discrete Wavelet Transform (DWT) in digital image watermarking is proposed for eight various color spaces. This work suggests the best color space, where the watermark image can be embedded with low correlation. A lossless digital watermarking scheme is proposed for commerce application (Sun Jianguo, 2014), which is based on the zero-perturbation on digital image maps. The proposed method is less complex with high robustness to geometric attacks. The watermarking scheme (Tsz Kin Tsui, 2008) based on quaternion Fourier transforms and complex Fourier transform is proposed for frequency domain embedding of watermarked image. The color image watermarking scheme is proposed to create a highly efficient watermarked image (Chun-Hsien Chou, Kuo-Cheng Liu, 2010). The watermarked signal is embedded in the distortion-tolerable signal, so that the resulting watermarked image produces high perceptual redundancy. The likelihood of obtaining noiseless image even after the removal of watermarked image from the original cover image is achieved by a novel reversible watermarking scheme (Lixin Luo, 2010). The novelty here is proposing a barely visible change in the watermarked image by utilizing interpolation technique. This work restores the quality of the image by only changing the small amount of image pixel. The authenticity of the digital image is considered based on watermarking, in (Xiaoyu Feng, 2011) the idea of injecting multiple watermark image into an original cover image is proposed. The evaluation of the proposed method is carried out by computing the SINR (Signal-Interference-plus-Noise-Ratio) and found to have high authenticity performance when compared to traditional methods. The watermarking algorithm (Zhe-Ming Lu, 2000) based on (VQ) is developed, in which the technique of codebook expansion is utilized. This algorithm is free from compression attacks and the major advantage is that the extraction of watermark image does not need the original image. The wavelet transform based watermarking is extended by utilizing the fractional wavelet transform in decomposing the image (Bhatnagar, G., 2005). The reference image is created by altering the frequency sub-bands of the decomposed original image. Here, the watermark image is embedded into the original cover image of certain secret rule set, which is known only to the creator/owner. The proposed watermarking method is robust to various signal processing and geometric distortion attacks. In (Ishikawa, Y., 2010), invisible watermarking is presented by applying the idea of orthogonal transform. In this work, (WHT) is used to generate the highest frequency components and one bit binary data is inserted into the 8x8 DCT decomposed image. The evaluated results show that the watermarked content is hard to read in the original cover image and moreover the original image is un-altered. The knowledge of the literature survey reveals that, many works have been put forward by the researchers based on spatial domain and transform domain, hence this work propose a multi-hybrid digital image watermarking techniques, which combines the idea of both spatial domain and transform domain based image watermarking.

2. Preamble to Spatial and Transformation based Techniques:

2.1 Least Significant Bit (LSB):

In general, the two vital categories of watermarking algorithm are based on transforming and spatial domain. In the spatial domain, the pixel value of the cover image is extracted and the watermark data is embedded with this pixel value to produce a watermarked image.

The well known conventional spatial domain technique is the (LSB) based watermarking, which is simple and fast. The unique advantage of this method is, we can embed several times, if the embedding data is small. This would lead to higher resistance towards the geometric distortion attack. On the other hand, this type of technique is less robust to lossy compression or noisy attack. In addition, the un-authorized user can change or modify the watermark content easily, once the technique leads to uncover. In LSB method (Celik, M.U., 2005), the pixel value of the host image is obtained followed by binarization of the decimal value. The watermark content is replaced with the (LSB) and then converts

them to decimal value to obtain the resultant watermark image. Local Binary Pattern (LBP) is a thriving technique used in image processing application such as crowd estimation, texture analysis and face recognition. In (Wenyin, Z.,), the idea of LBP is implemented in watermarking method which operates spatially. In LBP, the non overlapping square block is obtained from watermark image followed by extraction of local pixel contrast. In each block the spatial relation between the neighboring pixel and central pixel reveals the local pixel contrast, where the embedding data should be inserted. The LBP based method shows higher robustness towards the blurring and filtering attacks, contrast adjustment attacks and luminance change attacks which are not possible by the LSB based method. In Histogram modification, the watermark is embedded by analyzing the global feature of the host image. Here, the data is hidden by shifting the embedding information between maximum and minimum histogram points (Kaur, M., R. KAUR,). This method can be implemented easily, but the major drawback is that, the histogram points will dominate the embedding content or capacity.

The (LSB) is the simplest watermarking technique in spatial domain method. The block diagram for the LSB watermarking technique is shown in Fig. 1. The five steps involved in the LSB method are as follows,

(a) Obtain the pixel value of the original or the host image
(b) Convert the decimal pixel value to binary value
(c) convert the watermark image value to a binary value
(d) Swap the LSB of the host image with the watermark image
(e) Obtain the watermark image (i.e. By repeating (d))

For illustration, let us consider 3x3 pixel value of the image as shown in Fig. 2. Here, we are going to perform LSB for the pixel value 160, 40, 95 as shown in Fig. 3. Although, the method is easy to develop and implement, the method is effortlessly predictable and vulnerable to signal processing attacks. The idea of modifying the Most Significant Bit (MSB) will provide more robustness than LSB also combined with the transformation domain will be more efficient.

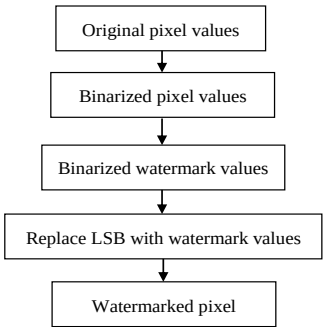

Fig. 1: Least Significant Bit.

120	135	25
160	40	95
35	125	105

Fig. 2: 3 x 3 Image Pixels:

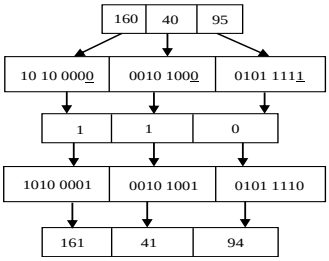

Fig. 3: 3 x 3 LSB Illustration.

3. Discrete Wavelet Transform (DWT):

The mathematical tool that is more powerful to be used in many applications is wavelet transform. The multi-domain representation of the wavelet transform made them a vital candidate for image processing application, particularly in watermarking approach (Keyvanpour, M.R., F. Merrikh-Bayat,). The image which experience the wavelet transform is divided into four subband frequencies namely, diagonal (HH_k), vertical (LH_k), horizontal (HL_k) and approximation (LL_k). The level of decomposition varies based on the application, which is denoted by 'k'. Further decomposition should be done on the approximation image (LL_k) as shown in Fig. 7. In an application like watermarking, the energy will be low in lower decomposition level, hence it will vulnerable to attack, the energy level of the each subunit can be determined by acne. (1),

$$E_k = \frac{1}{N_k M_k} \sum_i \sum_j |I_k(i,j)| \quad (1)$$

Where, the sub band coefficient is denoted by I_k, sub band dimension is represented by (M_k and N_k) and decomposition level is denoted by 'k'. From (1), the approximation image has higher energy, which is the perfect place for embedding the watermark, but it will reduce the quality of the image, hence we have to find out the next highest energy sub bands. To determine the sub band for watermarking the energy of the sub band is compared at the same level as described in eqn.(3), (4), (5),

$$E_3 = \frac{1}{L_3 L_3} \sum_i \sum_j |I_3(i,j)| \quad (2)$$

$$E_3 = \frac{1}{H_3 L_3} \sum_i \sum_j |I_3(i,j)| \quad (3)$$

$$E_3 = \frac{1}{L_3 H_3} \sum_i \sum_j |I_3(i,j)| \quad (4)$$

$$E_3 = \frac{1}{H_3 H_3} \sum_i \sum_j |I_3(i,j)| \quad (5)$$

It is clear from (12), that the horizontal sub band (HL) has second highest energy level when compared to the diagonal and vertical sub band. Hence, to achieve the robustness and image quality simultaneously,the horizontal sub band is the place for embedding the watermark image. Finally, compared to the DCT, wavelet based image watermarking produce less artifacts, since it does not need to decompose the image into blocks. And compared to DFT, the wavelet can simultaneously resolve the frequency and spatial information.

The proposed watermarking method has three various stages such as, watermark insertion, transmission and extraction. As mentioned earlier the LSB based watermarking technique is robust to attack, so we used both the ideas of LSB and MSB in the wavelet domain. The MSB based method used here is to show the large variance in the watermarked image. The flow of the MSB based method is shown in Fig. 5. The MSB based method has same five steps followed in LSB with minor variation such as,

Step-(a) Obtain the pixel value of the original or the host image
Step-(b) Convert the decimal pixel value to a binary value
Step-(c) convert the watermark image value to a binary value
Step-(d) Swap the MSB of the host image with the watermark image
Step-(e) Obtain the watermark image (i.e. By repeating (d)).

To explain in detail, let us consider the same 3x3 pixel value shown. Here, we are going to perform the MSB for the pixel value 160, 40, 95 as shown in Fig.5. As expected the MSB based method shows greater variance than LSB for the same pixel values (i.e. LSB (160, 40, 95) is (161, 41, 94) and LSB (160, 40, 95) is (32, 168, 223)).

To insert the watermark data or image, the host or original image is decomposed to certain levels based on the applications. The DWT coefficients of the original image are obtained using discrete wavelet transform and the watermark image is added using the LSB and MSB simultaneously as shown in Fig. 4. As mentioned in the previous section, watermark image is inserted in the horizontal sub band (HL) decomposed part of the host or the original image. By taking the Inverse Discrete Wavelet Transform (IDWT) of the decomposed image will results in watermarked image.

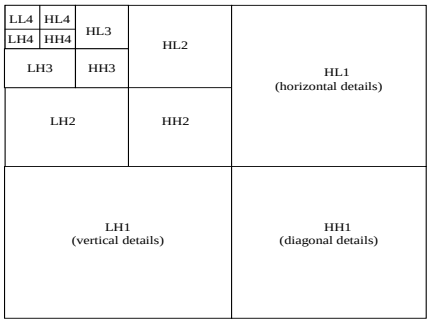

Fig . 4: DWT Coefficient.

4. Proposed Multi-Hybrid Watermarking Technique:

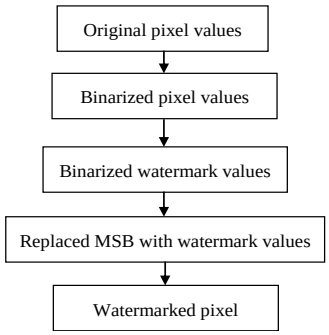

Fig. 5: Most Significant Bit (MSB).

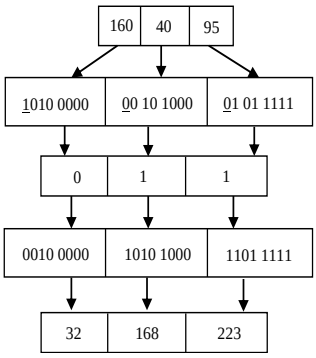

Fig. 6: 3x 3 MSB Illustrations.

4.1 Insertion of Watermark Image:

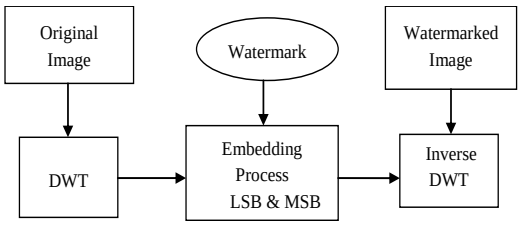

Fig. 7: Proposed Watermarking Method.

4.2 Transmission:

The transmission of watermarked image depends on the application or data it is implemented. The commercial video can be broadcast using television channel; the defense data can be transmitted by using the private secure bandwidth. In similar the medical information, which consists of patient's data, shall be sent through particular domain which is particularly accessible particularly to the physician. The transmitted watermarked image is extracted at the receiver end.

4.3 Extraction of Watermark Image:

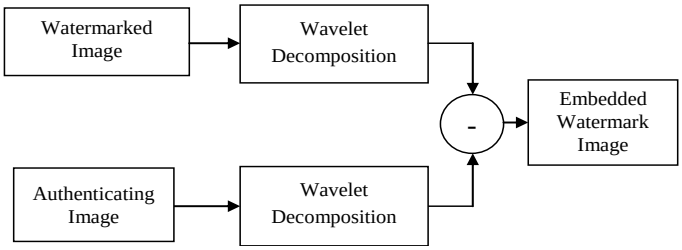

Fig. 8: Watermark Extraction.

The original image is extracted by removing the embedded watermark image, it may be reversible or irreversible based on the requirements. To extract the host image in precise, the wavelet transformation is used to decompose the authenticating image as well as watermarked image, then subtraction of authenticating image from the watermarked image results in the original image as shown in Fig. 8. Finally, the extracted original image is analyzed for its efficiency, which is discussed in the next section of the paper.

5. Experimental Result:

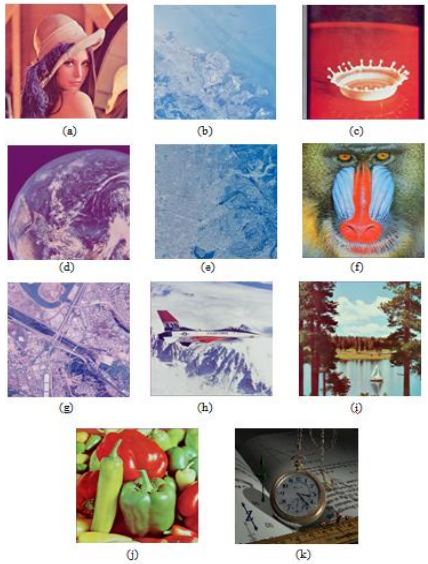

Fig. 9: (a) Lena (b) Foster City (c) Splash (d) Earth (e) Oakland (f) Baboon (g) San Diego (h) Airplane (i) Sailboat (j) Pepper (k) Authenticating Image

The proposed digital image watermarking technique is developed using Matlab with various input images such as Lena, Foster City, Splash, Earth, Oakland, Baboon, San Diego, Airplane, Sailboat and Pepper. The entire image is resized to dimension of 512x512 with an authenticating image as shown in Fig. 12. The result evaluation is carried out in two different ways that is the proposed method is evaluated both for watermarked image and the extracted watermark image. The metrics for these two different evaluations varies based on the quality, error rate, noise, fidelity and accuracy.

5.1 Evaluation of watermarked Image:

5.1.1 Peak Signal to Noise Ratio (PSNR):

The Peak Signal to Noise Ratio (PSNR) between the watermarked image and the host image is expressed by eqn. (6),

$$PSNR = 10X \log_{10} \frac{(max_I^2)}{MSE} \quad (6)$$

Table 1: Evaluation of PSNR

Peak Signal to Noise Ratio (PSNR)					
Methods	DCT	DWT	LSB	MSB	Proposed
Lena	38.15	39.45	37.19	36.23	40.85
Foster City	38.55	39.37	37.89	36.40	40.48
Splash	38.61	39.71	37.93	36.28	40.74
Earth	38.09	39.28	37.72	36.36	40.44
Oakland	38.49	39.63	37.09	36.49	40.84
Baboon	38.62	39.81	37.75	36.10	40.70
San Diego	38.59	39.38	37.83	36.60	40.69
Airplane	38.84	39.42	37.96	36.45	40.18
Sailboat	38.19	39.17	37.78	36.33	40.05
Pepper	38.13	39.29	37.65	36.76	40.55

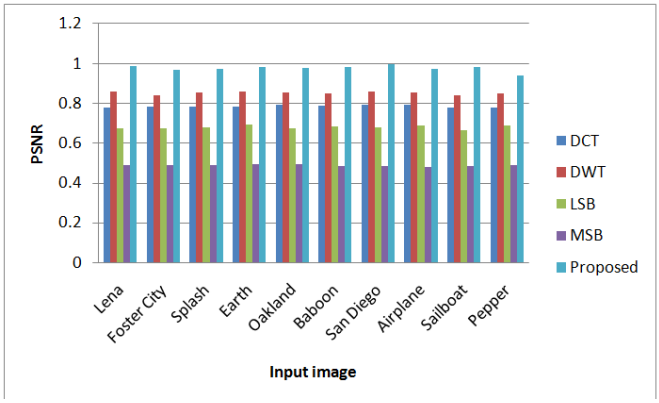

Fig. 10: Comparison of PSNR Values.

Where, the host image with a maximum possible pixel value is denoted by MAX_I. The PSNR values for various 512x512 images are shown in Table 1. For all the images are the Most Significant Bit (MSB) based image watermarking technique has least PSNR value when compared to Least Significant Bit (LSB) based methods. The proposed method achieves highest PSNR for all test images when compared to the conventional techniques.

The Mean Square Error (MSE) between the watermarked image and host image is expressed by eqn. (7)

$$MSE = \frac{1}{MN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}(I(i,j) - I_w(i,j))^2 \qquad (7)$$

The MSE for various 512x512 images is shown in Table 2. The MSB based image watermarking technique achieves the highest MSE, which degrades the performance of the watermarking process. The DWT based watermarking technique achieves second lowest MSE when compare to LSB and DCT based watermarking techniques. The evaluated results in terms of MSE show that the proposed method achieves least MSE when compared to the conventional watermarking method. Moreover the image with least MSE will improve the performance of the system.

5.1.2 Mean Square Error (MSE):

Table 2: Evaluation of MSE

Mean Square Error (MSE)					
Methods	DCT	DWT	LSB	MSB	Proposed
Lena	9.95	7.38	12.41	15.49	5.34
Foster City	9.07	7.51	10.57	14.89	5.82
Splash	8.95	6.95	10.47	15.31	5.48
Earth	10.09	7.67	10.99	15.03	5.87
Oakland	9.20	7.08	12.70	14.59	5.35
Baboon	8.93	6.79	10.91	15.96	5.53
San Diego	8.99	7.50	10.71	14.22	5.54
Airplane	8.49	7.43	10.40	14.72	6.23
Sailboat	9.86	7.87	10.84	15.13	6.42
Pepper	10.00	7.65	11.17	13.71	5.72

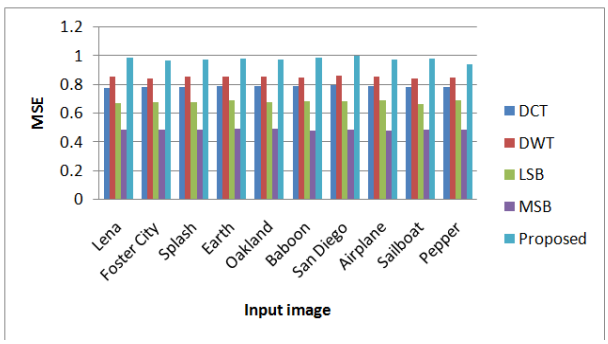

Fig. 11: Comparison of MSE Values.

5.1.3 Image Fidelity (IF):

The Image Fidelity (IF) is computed to recognize the similarity between non-watermarked image and watermarked image. The similarity between the two images will be high if the Image Fidelity (IF) is high and vice versa. The Image Fidelity (IF) between two images is computed by eqn.(8),

$$I_F = 1 - \frac{\sum_{i,j}(I(i,j) - I_W(i,j))^2}{\sum_{i,j}(I(i,j))^2} \quad (8)$$

Table 3: Evaluation of IF.

Image Fidelity (IF)					
Methods	DCT	DWT	LSB	MSB	Proposed
Lena	1.1970	1.2426	0.8840	0.7865	1.3130
Foster City	1.1985	1.2684	0.8721	0.7438	1.3349
Splash	1.1753	1.2765	0.8965	0.7671	1.3949
Earth	1.1951	1.2951	0.8583	0.7942	1.3964
Oakland	1.1446	1.2948	0.8649	0.7980	1.3840
Baboon	1.1880	1.2490	0.8346	0.7219	1.3821
San Diego	1.1750	1.2860	0.8655	0.7350	1.3780
Airplane	1.1453	1.2113	0.8241	0.7098	1.3668
Sailboat	1.1651	1.2942	0.8483	0.7468	1.3745
Pepper	1.1305	1.2585	0.8168	0.7799	1.3779

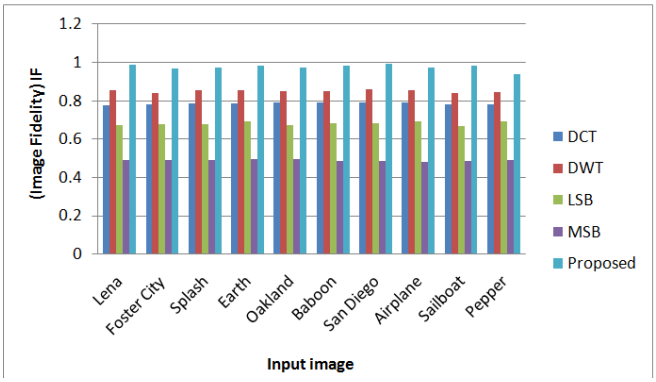

Fig. 12: Comparison of IF Values.

The Image Fidelity (IF) for various 512x512 images is shown in Table 3. In relation to our previous results, the MSB based image watermarking technique achieves lowest IF, which shows that the similarity between the image before and after watermarking will be low. The degradation in IF is due to the large variance achieved by changing the most significant bit. In similar, the DWT based watermarking method achieves second highest value in terms of IF, when compared to DCT and LSB based watermarking method. The performance metrics, particularly IF will support the efficiency of the proposed system. Although we have used LSB and MSB in the transformed coefficients, the similarity between the watermarked image and non watermark image is high in the proposed system.

5.2 Extracted Watermark:

To complicate the evaluation process and to show the efficiency of the proposed system, we compute the Bit Error Rate (BER) and Accuracy Ratio (AR) for extracted watermark.

5.2.1 Bit Error Rate (BER):

In watermarking method the Bit Error Rate (BER) is computed by eqn.(9),

$$BER = \frac{DB}{NB} \quad (9)$$

Table 4: Evaluation of BER.

Bit Error Rate (BER)					
Methods	DCT	DWT	LSB	MSB	Proposed
Lena	0.321	0.215	0.490	0.722	0.115
Foster City	0.389	0.243	0.420	0.737	0.122
Splash	0.365	0.205	0.435	0.656	0.109
Earth	0.398	0.285	0.445	0.784	0.103
Oakland	0.338	0.273	0.419	0.679	0.145
Baboon	0.340	0.210	0.480	0.685	0.162
San Diego	0.318	0.249	0.472	0.698	0.199
Airplane	0.350	0.228	0.486	0.727	0.150
Sailboat	0.361	0.256	0.428	0.739	0.133
Pepper	0.325	0.298	0.441	0.743	0.140

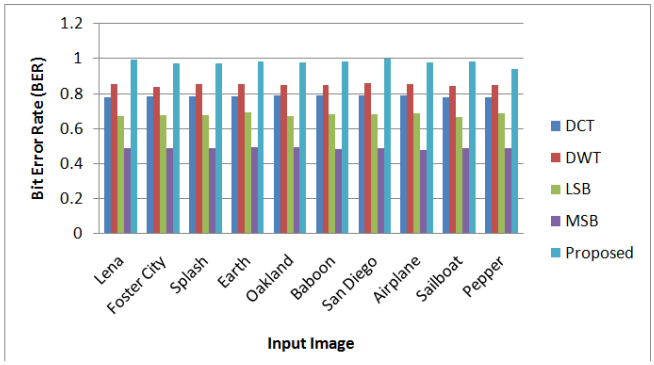

Fig. 13: Comparison of BER Values.

Where, the sum of original bit is denoted by (NB) and the sum of erroneous decoded bit is denoted by (DB). The performance of the watermarking system is high if the BER is low and vice versa. The Bite Error Rate (BER) of various 512x512 images is shown in Table 4. As usual, the MSB based watermarking method has highest BER when compared to LSB, which will degrade the system performance. In addition, the DWT based watermarking technique achieves second least bit error rate when compared to the LSB and DCT based watermarking methods. The proposed method achieves more moderate BER when compared to DWT and DCT based method and high BER when compared to LSB and MSB based method.

5.2.2 Accuracy Ratio (AR):

The similarity between the watermarked image and the host image (i.e. Obtain after extraction) is computed by Accuracy Ratio (AR) as expressed in eqn.(10),

$$AR = \frac{CB}{NB} \qquad (10)$$

Table 5: Evaluation of AR.

Accuracy Ratio (AR)					
Methods	DCT	DWT	LSB	MSB	Proposed
Lena	0.780	0.860	0.675	0.489	0.992
Foster City	0.785	0.843	0.677	0.490	0.972
Splash	0.786	0.856	0.681	0.491	0.975
Earth	0.788	0.860	0.695	0.496	0.985
Oakland	0.793	0.855	0.676	0.495	0.979
Baboon	0.791	0.853	0.685	0.484	0.986
San Diego	0.795	0.863	0.683	0.488	0.999
Airplane	0.793	0.859	0.692	0.480	0.978
Sailboat	0.782	0.845	0.669	0.486	0.985
Pepper	0.783	0.850	0.692	0.490	0.941

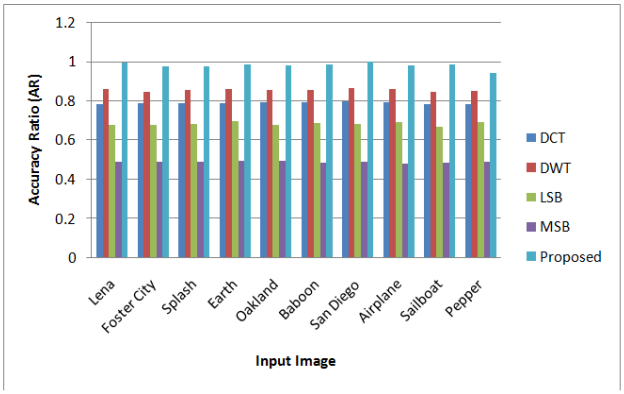

Fig. 14: Comparison of AR Values.

Where, the sum of original bit is denoted by (NB) and the sum of correct bit is denoted by (CB). The similarity between the images is low, if the AR is far away from 1 and vice versa. The Accuracy Ratio (AR) of various 512x512 images is shown in Table 5. The final metric also reveals that the MSB

based watermarking method has low performance when compared to the LSB based method. Again the DWT based method has second highest values that are closer to 1, when compared to LSB and DCT based methods. The proposed method achieves higher Accuracy Ratio (AR) which is closer to 1. This reveals that the proposed method has a high similarity rate when compared to the conventional watermarking method.

6. Conclusion:

The Multi Hybrid watermarking technique is proposed in this paper. In this method the watermarking process is performed by the combination of spatial domain and transformation domain method. In the spatial domain method, the Least Significant Bit (LSB) and Most Significant Bit (MSB) are used, whereas in transform domain Discrete Wavelet Transform (DWT) is utilized. The proposed method is developed using Matlab and verified with various test images of size 512x512. The proposed system is evaluated in terms of Peak-Signal-to-Noise-Ratio (PSNR), Mean Square Error (MSE), Image Fidelity (IF), Bit Error Rate (BER) and Accuracy Ratio (AR). Throughout the evaluation process, from the above comparison and graph, it can be derived that the proposed method can be considered as the most efficient method compared with the conventional methods such as Least Significant Bit (LSB), Most Significant Bit (MSB) Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).

REFERENCES

Sun Jianguo, Zheng Chonghui, Gao Di, 2014. Lossless digital watermarking scheme for image maps, Communications, China, 11(8): 125-130.

Khalili, M., D. Asatryan, 2013. Colour spaces effects on improved discrete wavelet transform-based digital image watermarking using Arnold transform map, Signal Processing, IET, 7(3), 177-187.

Rajput, A.S., N. Mishra, S. Sharma, 2013. Towards the growth of image encryption and authentication chemes, Advances in Computing, Communications and Informatics (ICACCI), International Conference on, 22(25): 454-459.

Cheddad, A., J. Condell, K. Curran, P. Mc Kevitt, 2010. Digital image steganography: Survey and analysis of current methods. Signal processing, 90(3): 727-752.

Bartolini, F. A. Tefas, M. Barni, I. Pitas, 2001. Image authentication techniques for surveillance applications, Proceedings of the IEEE, 89(10): 1403-1418.

Shijun Xiang, HyoungJoong Kim, Jiwu Huang, 2008. Invariant Image Watermarking Based on Statistical Features in the Low-Frequency Domain, Circuits and Systems for Video Technology, IEEE Transactions on, 18(6): 777-790.

Kirovski, D., H.S. Malvar, 2003. Spread-spectrum watermarking of audio signals, Signal Processing, IEEE Transactions on, 51(4): 1020-1033.

Koz, A., A.A. Alatan, 2008. Oblivious Spatio-Temporal Watermarking of Digital Video by Exploiting the Human Visual System, Circuits and Systems for Video Technology, IEEE Transactions on, 18(3), 326-337.

Qadir, M.A., I. Ahmad, 2006. Digital Text Watermarking: Secure Content Delivery and Data Hiding in Digital Documents, Aerospace and Electronic Systems Magazine, IEEE, 21(11): 18-21.

Mukherjee, D.P., S. Maitra, S.T. Acton, 2004. Spatial domain digital watermarking of multimedia objects for buyer authentication, Multimedia, IEEE Transactions on, 6(1): 1-15.

Hui-Yu Huang, Yang, Cheng-Han, Wen-Hsing Hsu, 2010. A Video Watermarking Technique Based on Pseudo-3-D DCT and Quantization Index Modulation, Information Forensics and Security, IEEE Transactions on, 5(4): 625-637.

Chun-Hsiang Huang, Shang-Chih Chuang, Yen-Lin Huang, Ja-Ling Wu, 2009. Unseen Visible Watermarking: A Novel Methodology for Auxiliary Information Delivery via Visual Contents, Information Forensics and Security, IEEE Transactions on, 4(2): 193-206.

Holliman, M., N. Memon, 2000. Counterfeiting attacks on oblivious block-wise independent invisible watermarking schemes, Image Processing, IEEE Transactions on, 9(3): 432-441.

Pei-Yu Lin, Jung-San Lee, Chin-Chen Chang, 2009. Dual Digital Watermarking for Internet Media Based on Hybrid Strategies, Circuits and Systems for Video Technology, IEEE Transactions on, 19(8): 1169-1177.

Lixin Luo, Zhenyong Chen, Ming Chen, Xiao Zeng, Zhang Xiong, 2010. Reversible Image Watermarking Using Interpolation Technique, Information Forensics and Security, IEEE Transactions on, 5(1), 187-193.

Chih-Wei Tang, Hsueh-Ming Hang, 2003. A feature-based robust digital image watermarking scheme, Signal Processing, IEEE Transactions on, 51(4): 950-959.

Xiangyang Wang, Jun Wu, PanpanNiu, 2007. A New Digital Image Watermarking Algorithm Resilient to De-synchronization Attacks, Information Forensics and Security, IEEE Transactions on, 2(4): 655-663.

Naskar, R., R.S. Chakraborty, 2012. Performance of reversible digital image watermarking under error-prone data communication: a simulation-based study, Image Processing, IET, 6(6), 728-737.

Jun Sang, M.S., Alam, 2008. Fragility and Robustness of Binary-Phase-Only-Filter-Based Fragile/Semifragile Digital Image Watermarking, Instrumentation and Measurement, IEEE Transactions on, 57(3): 595-606.

Tsz Kin Tsui, Xiao-Ping Zhang, D. Androutsos, 2008. Color Image Watermarking Using Multidimensional Fourier Transforms, Information Forensics and Security, IEEE Transactions on, 3(1): 16-28.

Chun-Hsien Chou, Kuo-Cheng Liu, 2010. A Perceptually Tuned Watermarking Scheme for Color Images, Image Processing, IEEE Transactions on, 19(11): 2966-2982.

Lixin Luo, Zhenyong Chen, Ming Chen, Xiao Zeng, Zhang Xiong, 2010. Reversible Image Watermarking Using Interpolation Technique, Information Forensics and Security, IEEE Transactions on, 5(1): 187-193.

Xiaoyu Feng, Hongting Zhang, Hsiao-Chun Wu, Yiyan Wu, 2011. A New Approach for Optimal Multiple Watermarks Injection, Signal Processing Letters, IEEE, 18(10): 575-578.

Zhe-Ming Lu, Jeng-Shyang Pan, Sheng-he Sun, 2000. VQ-based digital image watermarking method, Electronics Letters, 36(14): 1201-1202.

Bhatnagar, G., B. Raman, Q.M.J. Wu, 2012. Robust watermarking using fractional wavelet packet transform, Image Processing, IET, 6(4): 386-397.

Ishikawa, Y., K. Uehira, K. Yanaka, 2010. Practical Evaluation of Illumination Watermarking Technique Using Orthogonal Transforms, Display Technology, Journal of, 6(9): 351-358.

Suhail, M.A., M.S. Obaidat, 2003. Digital watermarking-based DCT and JPEG model, Instrumentation and Measurement, IEEE Transactions on, 52(5): 1640-1647.

Celik MU, Sharma G, Tekalp AM, Saber E, (2005). Lossless gneralized-LSB data embedding. IEEE Trans Image Process, 14(2): 253–266.

Wenyin, Z., F.Y. Shih, Semi-fragile spatial watermarking based on local binary pattern operators. Opt Commun, 284(16–17): 3904–3912.

Kaur, M., R. KAUR, Reversible watermarking of medical images authentication and recovery-a survey. J InfOperManag, 3(1): 241–244.

Shui, P.L., 2009. Image denoising using 2-D separable oversampled DFT modulated filter banks, Image Processing, IET, 3(3): 163-173.

Ramkumar, M., A.N. Akansu, A.A. Alatan, 1999. A robust data hiding scheme for images using DFT, in Image Processing, 1999. ICIP 99. Proceedings. International Conference, 211–215.

Cedillo-Hernandez, M., F. Garcia-Ugalde, M. Nakano-Miyatake, H. Perez-Meana, 2011. Robust watermarking method in DFT domain for effective management of medical imaging. SIViP, 1–16.

Ali, M., C.W. M. Ahn Pant, 2014. A robust image watermarking technique using SVD and differential evolution in DCT domain. Opt Int J Light Electron Opt, 125(1): 428–434.

Keyvanpour, M.R., F. Merrikh-Bayat, Robust dynamic block-based image watermarking in DWT domain. Procedia ComputSci, 3: 238–242.