Image Fusion Process for Multiple Watermarking Schemes against Attacks

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Abstract – This paper presents a multiple watermarking scheme for color and medical images. The proposed scheme is invisible watermarking based on discrete wavelet transforms. In the embedding process the two watermarks are fused into single watermark, after that embedding into the original image. In the extraction process the watermarks are extracted from the watermarked image. The experimental results show that the proposed algorithms give watermarked images with good visual quality and survival to number of image attacks such as salt and pepper noise, Gaussian noise, speckle noise, median filtering, cropping, rotation, translation and row column blanking.

Index Terms – Multiple watermarking, Discrete wavelet transforms, image fusion, embedding, extraction, peak signal to noise ratio, attacks

1. INTRODUCTION

Watermarking is the art of imperceptibly embedding information into a multimedia object (images, video, audio and text) as a technological support to digital right management. More than 700 years ago in Fabriano (Italy) paper watermarks appeared in handmade paper, in order to identify its provenance, format and quality. The digital image watermarking techniques can be grouped into two domains such as spatial -domain and frequency-domain techniques. The frequency domain techniques have been proved to be more effective in achieving imperceptibility and robustness. The frequency domain techniques are discrete cosine transform (DCT), Discrete Fourier Transform (DFT) and Discrete Wavelet Transform (DWT). Most watermarking algorithms supports single watermark embedding, but there are great limitations when single watermarking algorithms are tried into practical applications in few rare situation, like when multiple users share the copyright, it is need to support multiple users to embed their watermarks synchronously. To embed multiple watermarks into the same image achieve the robustness and to enhance the security level.

Xia, Boncelet, and Arce [1] proposed two–level wavelet decomposition using the haar wavelet filters. Their method the pseudo random noise codes are only added to the large coefficients of the middle and high frequency bands of the discrete wavelet transformed image. Jabade et al. [2] elaborated the suitability of wavelet transform based watermarking which is widely used today, approaches and analyses of wavelet based image watermarking techniques and also, their reviewed the applications and attributes of image watermarking. A DCT blind watermarking scheme based on spread spectrum communications is proposed in [3]. Their method proved to be highly resistant in cases of many common attacks, while preserving high PSNR for the watermarked images. Novel digital image watermarking scheme using bi-orthogonal wavelets are proposed in [4].

Mohananthini and Yamuna [5] presented a digital image watermarking based on Discrete Wavelet Transform (DWT). In their proposed method, the watermark as well as the cover image seldom loses the quality in both embedding and extraction process. Their scheme shows good performance on different types of cover images in terms of imperceptibility and resist to jpeg compression. Loukhaoukha [6] proposed the security of digital watermarking scheme based on SVD and Tiny-GA. They demonstrated that their watermarking algorithm is fundamentally flawed and has a very high probability of false positive detection of watermarks. A set of schemes and their analysis for multiple watermark placements that maximizes resilience to the above mentioned cropping attack proposed in [7].

Ahmed Mahmood, Charlie Obimbo, Tarfa Hamed and Robert Dony [8] proposed watermarking technique is based on dividing the medical image in to blocks and inserting the watermark to the ROI by shifting the blocks. Their watermarking approach does not effect on the ROI of the

medical image against some watermarking attacks such cropping, and noise. Rupinder Kaur [9] presented explores its applications as a quality indicator of a watermarked medical image when subjected to intentional (noise, cropping, alteration) or unintentional (compression, transmission or filtering) operations. The performance of their proposed method is evaluated by calculating MSE and PSNR of original and extracted mark. Nisar Ahmed Memon and Gilani [10] proposed a fragile watermarking technique to ensure the integrity of the medical image that avoids the distortion of the image in ROI by embedding the watermark information in RONI. Their watermark is composed of patient information, hospital logo and message authentication code computed using a hash function.

In this paper a multiple watermarking scheme based on wavelet transform for images is proposed. This paper is organized as follows; the related works are explained in section 2. The proposed schemes are explained in section 3. The results and discussions are explained in section 4. The comparison of existing scheme is discussed in section 5. Finally, conclusion of the present work is given in section 6.

2. A RELATED LITERATURE SURVEY

A handful of watermarking method, which uses multiple watermarking algorithms for improved performance, has been presented in the literature for protecting the privacy and more robustness. A brief literature survey of some recent researches is presented here.

Ibrahim Nasir et al. [11] proposed novel and robust color image watermarking technique in spatial domain based on embedding four identical watermarks into the blue component of the host image. In the extraction process, the original image is accessible and five watermarks can be recovered from different regions of the watermarked image and only one watermark is detected from the five watermarks according to the maximum value of normalized cross correlation (NCC). The experimental results show that their proposed scheme is robust for several attacking operations including median filter, JPEG2000, JPEG-loss compression, image cropping, image scaling, rotation, rotation-scaling, rotation- cropping, randomly removal of some rows and columns lines and self-similarity. Their proposed technique is also secure, and only the one with the correct key can extract the watermark.

Peining Tao et al [12] generalized an idea in a recent paper that embeds a binary pattern in the form of a binary image in the LL and HH bands at the second level of Discrete Wavelet Transform (DWT) decomposition and a comparison of embedding a watermark at first and second level decompositions. Embedding the watermark in lower frequencies is robust to a group of attacks (JPEG compression, blurring, adding Gaussian noise, rescaling, rotation, cropping, pixilation, and sharpening) and embedding the watermark in higher frequencies is robust to another set of attacks (histogram equalization, intensity adjustment, and gamma correction). The re-watermarking and collusion attacks, the watermarks extracted from all four bands are identical. Their experiments indicate that first level decomposition appear advantageous for two reasons: The area for watermark embedding is maximized, and the extracted watermarks are more textured with better visual quality.

A novel image watermarking technique in the wavelet domain is recommended in [14]. To achieve more robustness and security, their proposed techniques rely on using two watermarks that are embedded into the image to be watermarked. A primary watermark in the form of a PN sequence is first embedded into an image (secondary watermark) before being embedded into the original image. Their method is implemented using Daubechies mother wavelets where an arbitrary embedding factor α is introduced to enhance the robustness and invisibility. A multiple watermarking scheme on DWT is proposed in [14]. In the embedding process, the multiple watermarks are embedded to original image. In the extracting process, the original watermarks are retrieved from the watermarked image. Their proposed method has good imperceptibility on the watermarked image and superior in terms of Peak Signal to Noise Ratio (PSNR).

Mintzer and Braudaway [15] discussed about three types of watermarking applications in the setting of multiple watermarking and classify different ways how to employ and to construe multiple watermarking. Multiple watermarks can be worn to address one or multiple applications may be tended to a few times. For example, a first watermark could make used to implant proprietorship information, a second one to integument verification, what's more a third person to captioning. On the other hand, there can be multiple copyright watermarks, multiple verification watermarks, or multiple watermarks for multiple captions. Focusing on the way how single watermarking techniques are actually fused into multiple watermarking schemes, Sheppard, Shafavi-Naini, and Musrrat Ali et al., [16] applied differential evolution (DE) algorithm to balance the tradeoff between robustness and imperceptibility by exploring multiple scaling factors in image watermarking. The original image is partitioned into blocks and the blocks are transformed into Discrete Cosine Transform (DCT) domain. Experimental results show that their proposed scheme maintains a satisfactory image quality and watermark can still be identified from a seriously distorted image. Ogunbona [18] distinguished category of composite watermarking is all watermarks are combined into a single watermark which is subsequently embedded in one single embedding step. The second category of re-watermarking is the watermarks are embedded one after the other. The third method of segmented watermarking is the original data is partitioned into disjoint segments a priory and each watermark is

embedded into its specific share. Mohananthini and Yamuna [19] compared single and multiple watermarking techniques by using different embedding methods and discrete wavelet transform. In single watermarking the watermark is embedded in a host image and the multiple watermarking the watermarks are embedded one after the other. The different embedding methods are multiplicative, additive and hybrid watermarking with importance on its imperceptibility versus the robustness of the watermark. The aim of quality metrics is established that, the additive embedding method achieves better performance against watermarks attacks on multiple watermarking technique.

Giakoumaki, Pavlopoulos, and Koutsouris [19] discussed the perspectives of digital watermarking in a range of medical data management and distribution issues simultaneously addressed medical data protection, archiving, and retrieval, as well as source and data authentication. The experimental results show that the transparency and efficiency of their scheme, which conforms of the strict necessities that apply to areas of symptomatic importance. Woo, Du and Pham [20] proposed a multiple digital image watermarking method which is suitable for privacy control and tamper detection in medical images. Their visual quality of watermarked image is very good.

3. PROPOSED SCHEMES

The proposed scheme is embeds multiple watermarks by decomposing the original image using discrete wavelet transform. The discrete wavelet transform, watermark embedding and extraction process are discussed below:

3.1. Discrete Wavelet Transform

The wavelet analysis is the heart of multi resolution analysis decomposition of an image into sub images of different size resolution levels. Multi resolution dissection is intended to give good time resolution and poor frequency resolution at high frequencies and good frequency resolution and poor time resolution at low frequencies. Good for signal having high frequency components for short durations and low frequency components for long duration.

For two-dimensional DWT, every level of decomposition produces four bands of data, one corresponding to the low pass band (LL) and three other corresponding to vertical (LH), horizontal (HL) and diagonal (HH) sub-bands. The decomposed image shows an approximation image in the lowest resolution low pass band and three detail images in higher bands. Fig. 1 shows two levels of wavelet decomposition of original image. The approximation sub-band can further be decomposed to obtain another level of decomposition. The proposed method choosing LL_2 sub-bands because, it containing high information and best visual quality compared to other sub-bands.

Original image One level Two level

Figure 1 Two levels of Wavelet Decomposition

3.2. Watermarking Embedding Process

The block diagram of watermark embedding process is shown in Figure 2. The watermarking embedding steps are given bellow:

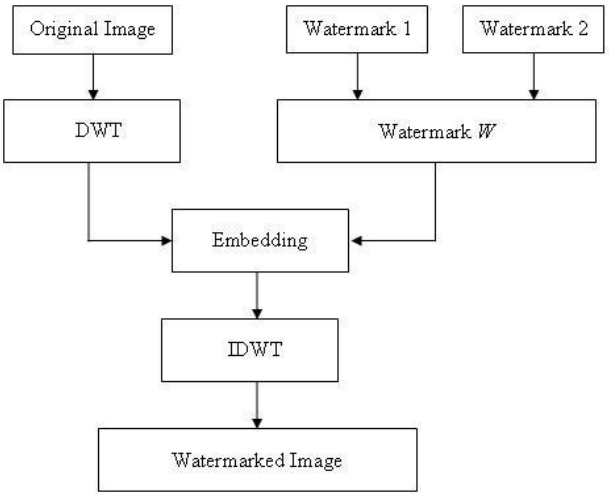

Figure 2 Watermark Embedding Process

1. The original image is decomposed by two levels using discrete wavelet transform.

2. The first watermark X is a square matrix with m rows and m columns, so that it can be written as

$$X = \begin{bmatrix} x_{1,1} & x_{1,2} & \cdots & x_{1,m} \\ x_{2,1} & x_{2,2} & \cdots & x_{2,m} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ x_{m,1} & x_{m,2} & \cdots & x_{m,m} \end{bmatrix} \quad (1)$$

3. The second watermark Y is a square matrix with n rows and n columns, so that it can be written as

$$Y = \begin{bmatrix} y_{1,1} & y_{1,2} & \cdots & y_{1,n} \\ y_{2,1} & y_{2,2} & \cdots & y_{2,n} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ y_{n,1} & y_{n,2} & \cdots & y_{n,n} \end{bmatrix} \quad (2)$$

4. The original watermark W is the combination two watermarks into one watermark, containing from all concatenated collections.

$$W = [X \quad Y] \quad (3)$$

5. The watermark W is applied to the color original image in LL_2 sub-bands. The watermarked image can be obtained by the following equation.

$$WI(i, j) = I(i, j) + \alpha \times W(i, j) \quad (4)$$

Where, WI = watermarked image,
W= watermark and
I = original Image.
α = scaling factor

6. The inverse wavelet transform is performed to get the watermarked image.

3.3. Watermarking Extraction Process

The watermark extraction processes are the inverse process of watermark embedding, shown in Figure 3. The steps for watermark extraction as bellow:

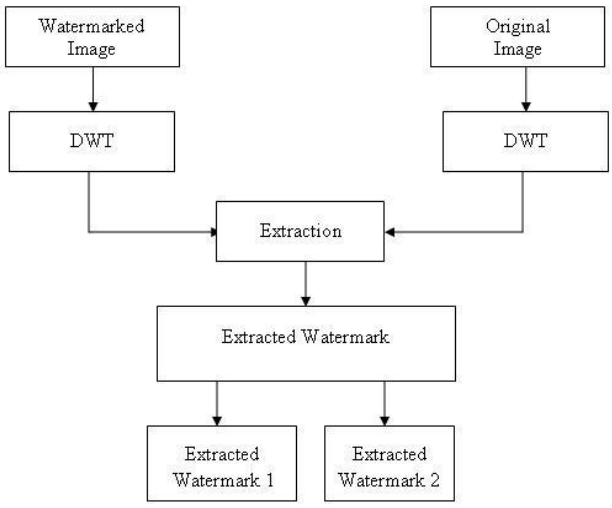

Figure 3 Watermark Extraction Process

1. The watermarked and the original image are decomposed by two levels using discrete wavelet transform
2. The multiple watermarks can be extracted from the watermarked image sub-bands (LL_2). After that it is divided by the watermark strength factor α. This is summarized as follows:

$$w'(i, j) = (WI(i, j) - I(i, j)) \,/\, \alpha \quad (5)$$

4. RESULTS AND DISCUSSION

In this paper, a multiple watermarking technique is proposed based on wavelet domain for color images. The proposed approach is implemented in MATLAB. The proposed technique has been tested with two standard test color images and two medical images as shown in Fig. 4. In our experiments, we use the 512×512 Lena, Baboon, MRI and CT scan as the original images and a 32×32 size logo is used as watermark images such as watermark1 and watermark2.

4.1. Performance Analysis

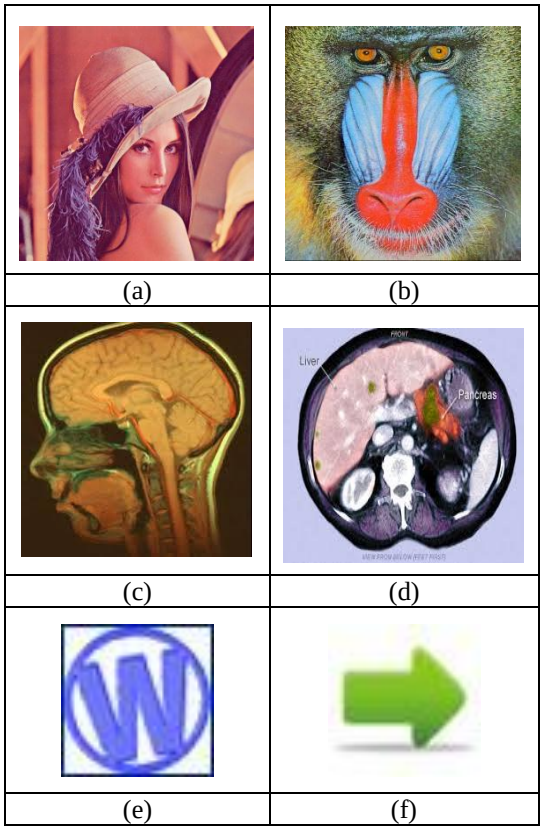

Figure 4 (a) Lena image (b) Baboon image (c) MRI image (d) CT scan image (e) Watermark1 (f) Watermark2

The performance evaluation of the proposed work is defining watermarking techniques are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and the Normalized Correlation (NC). The quality of watermarked image is qualitatively decided by visual objects in watermarked image. Peak Signal to Noise Ratio (PSNR) is used to measure quality of watermarked image, it is given by

$$PSNR(dB) = 10\log_{10}\frac{255^2}{MSE} \qquad (6)$$

The Mean Square Error (MSE) between a watermarked image I_w and cover image I.

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

The robustness of watermarked image is qualitatively analyzed by visual objects in extracting watermark in case of visually meaningful logo watermark. Likewise quantitative measures, following metrics are used in case of binary sequence or logo watermark. Normalized Cross Correlation is used to measure the quality of watermark after recovery. The NC between the embedded watermark W (i, j) and the extracted watermark W' (i, j) is defined as

$$NC = \frac{\sum_{i=1}^{H}\sum_{j=1}^{L}W(i,j)\times W'(i,j)}{\sum_{i=1}^{H}\sum_{j=1}^{L}[W(i,j)]^2} \qquad (8)$$

4.2. Imperceptibility Evaluation

Table 1 shows the performance measures on four different watermarked images and extracted watermarks such as Lena, Baboon, MRI and CT scan images of PSNR and NC values.

Images	Watermarked image PSNR(dB)	Extracted watermark1 (NC1)	Extracted watermark2 (NC2)
Lena	50.4317	0.9240	0.8835
Baboon	50.4199	0.9240	0.8835
MRI	50.4118	0.9239	0.8835
CT scan	50.4118	0.9239	0.8835

Table 1 PSNR and NC values for watermarked Images and Extracted Watermarks

4.3. Robustness Evaluation

To prove the robustness of the proposed method common image processing attacks has been applied. The watermarked images are tested for salt and pepper noise, Gaussian noise, median filtering, cropping, rotation, translation and row column blanking.

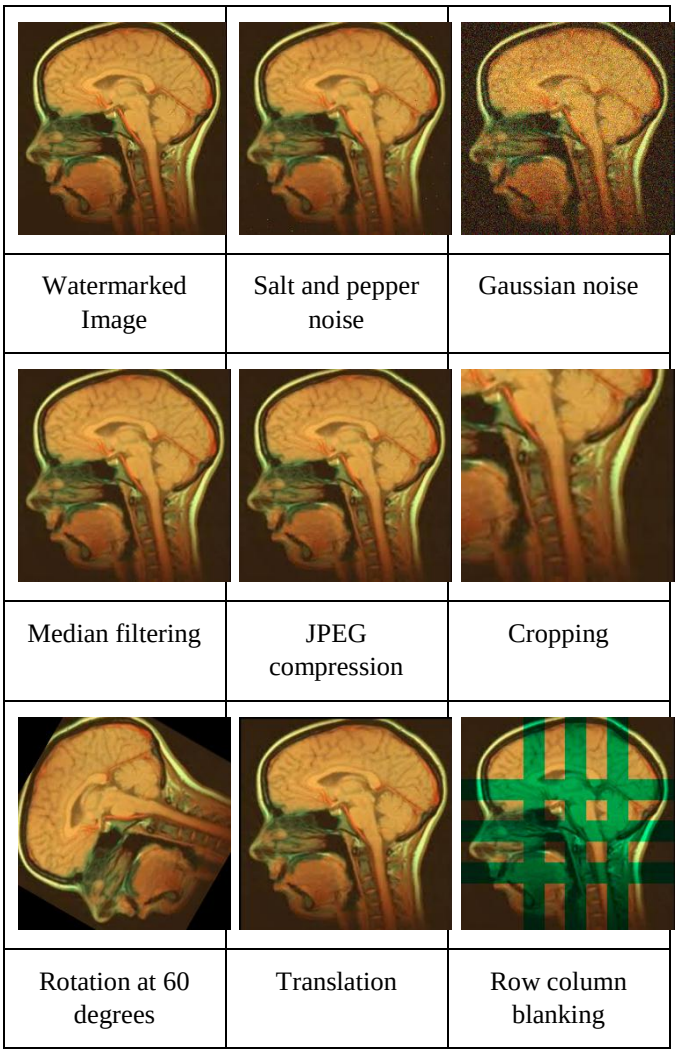

Table 2 Watermarked Images on MRI image against attacks

Attacks	Watermarked image PSNR(dB)			
	Lena	Baboon	MRI	CT scan
Salt and pepper noise at the density of 10%	34.6860	35.4072	34.4814	34.7073
Gaussian noise of variance 2%	17.4143	17.3025	17.9385	17.6873

Median filtering for 3x3 filter size	35.0674	24.4114	36.8249	43.5980
JPEG compression	46.9126	39.5888	41.7176	42.6822
Cropping	10.9554	10.2040	7.0816	13.4916
Rotation at 60 degrees	9.8496	9.4760	6.2142	13.5058
Translation	16.7915	15.0209	13.3582	19.3429
Row column blanking	10.1271	12.0709	11.8496	12.1705

Table 3 PSNR values of common image processing attacks

Table 2 shows the watermarked images against attacks for MRI image. Table 3 and 4 shows the PSNR and NC values for common image processing attacks on Lena, Babbon, MRI and CT scan images.

The proposed method, discrete wavelet transform based image watermarking algorithms possess multi-resolution description characteristics and achieves high imperceptibility. The image fusion process are used in the proposed image watermarking scheme helps in addressing different problems like high security and more robustness.

The experimental results presented here give a good indication of the capabilities of the proposed method for various attacks. The gain of proposed method has preferable performance of image quality and robustness to common image processing operations.

Attacks	Lena		Baboon		MRI		CT scan	
	NC1	NC2	NC1	NC2	NC1	NC2	NC1	NC2
Salt and pepper noise at the density of 10%	0.8594	0.8344	0.8481	0.8411	0.8412	0.8330	0.8613	0.8358
Gaussian noise of variance 2%	0.7441	0.6481	0.7559	0.7446	0.5637	0.7213	0.8637	0.8593
Median filtering for 3x3 filter size	0.8676	0.9240	0.7550	0.7852	0.8921	0.8917	0.9011	0.9218
JPEG compression	0.8423	0.9058	0.8594	0.9096	0.8982	0.9260	0.8938	0.9147
Cropping	0.6582	0.5771	0.6851	0.4830	0.4425	0.6562	0.6330	0.5053
Rotation at 60 degrees	0.6627	0.3977	0.4770	0.4675	0.4899	0.5215	0.6380	0.3787
Translation	0.6187	0.7029	0.6728	0.7120	0.6653	0.7131	0.7055	0.8141
Row column blanking	0.6856	0.6271	0.6856	0.6271	0.6866	0.6277	0.6860	0.6279

Table 4 NC values of common image processing attacks

5. COMPARISON TO EXISTING SCHEME

Jaishri Guru et al., [21] introduced fusion of DWT digital watermarking techniques for robustness. The watermark is embedded in the singular values of the red component of the cover images in DWT sub-bands and then combined with the other two components to yield the watermarked image. Their watermarking algorithms have a drawback of imperceptibility against attacks.

Scaling Factor	Watermarked image			
	Existing Scheme PSNR (dB)		Proposed Scheme PSNR (dB)	
	Salt and pepper noise	Speckle noise	Salt and pepper noise	Speckle noise
0.01	21.80	20.98	34.6860	34.3656
0.03	21.65	20.32	34.3727	33.9432
0.05	20.40	19.93	33.7331	33.1538
0.07	19.88	18.67	33.1987	32.9849
0.09	19.20	17.60	32.0322	31.7081

Table 5 Comparison to Existing Scheme for different scaling factor

For solving this problem, the DWT based image fusion process of multiple watermarking is proposed. The PSNR values of salt and pepper noise and speckle noise are listed in Table 5, and it is evident that the imperceptibility performance of the proposed scheme is superior to existing scheme for Lena color images.

6. CONCLUSION

In this paper, a multiple watermarking techniques are proposed in color images. The embedding and extraction process using multi-resolution analysis of wavelet transform for medical images. In the embedding process, the multiple watermarks are embedded into the original image. In the extracting process the original watermarks are extracted from the watermarked image. The multiple watermarking vividly shows achieve better visual quality on watermarked image and robustness on extracted watermarks. The performance of the proposed scheme is analyzed by comparing with the existing scheme. As a future initiative, compare the multiple watermarking techniques (successive, segmented and composite) using genetic algorithms.

REFERENCES

[1] X. Xia, C. Boncelet, and G. Arce, "A multiresolution watermark for digital images", Proc. IEEE Int. Conf. Image Processing 1997(ICIP'97), Vol.1, Santa Barbara, 1997, pp. 548-551.

[2] Vaishali S. Jabade and Dr. Sachin R. Gengaje, "Literature Review of Wavelet Based Digital Image Watermarking Techniques", International Journal of Computer Applications (0975 – 8887), Vol. 31, No. 1, 2011.

[3] Amir Hossein Taherinia, Mansour Jamzad, "A robust spread spectrum watermarking method using two levels DCT", International Journal of Electronic Security and Digital Forensics (IJESDF), Vol. 2, No. 3, 2009.

[4] Yamuna Govindarajan and Sivakumar Dakshinamurthi, "A Novel Digital Image Watermarking Scheme Using Biorthogonal Wavelets", ICTACT Journal on Image and Video processing, May 2011, Vol. 1, Issue 4, pp. 236-240.

[5] Mohananthini. N, Yamuna. G, "A Robust Image Watermarking Scheme based Multiresolution Analysis", International Journal of Image, Graphics and Signal Processing, Vol. 4, No. 11, 2012, pp. 09-15.

[6] Khaled Loukhaoukha, "On the Security of Digital Watermarking Scheme Based on SVD and Tiny-GA", Journal of Information Hiding and Multimedia Signal Processing, Vol. 3, No. 2, 2012, pp. 135 – 141.

[7] Keith Frikken and Mikhail Atallah, "Cropping-Resilient Segmented Multiple Watermarking", Algorithms and Data Structures Lecture Notes in Computer Science, Vol. 2748, 2003, pp 231-242.

[8] Ahmed Mahmood, Charlie Obimbo, Tarfa Hamed and Robert Dony, "Improving the Security of the Medical Images", International Journal of Advanced Computer Science and Applications, Vol. 4, No. 9, 2013.

[9] Rupinder Kaur, "A Medical Image Watermarking Technique for Embedding EPR and Its Quality Assessment Using No-Reference Metrics", International journal of Information Technology and Computer Science, Vol. 02, 2013, pp. 73-79.

[10] Nisar Ahmed Memon & S. A.M. Gilani, "Watermarking of chest CT scan medical images for content authentication", International Journal of Computer Mathematics, Vol. 88, Issue 2, 2011, pp.265-280.

[11] Ibrahim Nasir, Ying Weng, Jianmin Jiang, "Novel Multiple Spatial Watermarking Technique in Color Images", IEEE Fifth International Conference on Information Technology: New Generations, 2008.

[12] P. Tao and A.M. Eskicioglu, "A robust multiple watermarking scheme in the discrete wavelet transform domain, Quality of Service and Control of Next-Generation Communication Networks II", Proceedings of the SPIE, Vol. 5601, 2004, pp. 133-144.

[13] Maha Sharkas, Dahlia R. ElShafie, and Nadder Hamdy, "A Novel Dual-Purpose Image Watermarking Technique", International Journal of Signal Processing, Vol. 3, No. 4, 2006.

[14] Mohananthini. N and Yamuna. G, "Color Image Multiple Watermarking Scheme based on Discrete Wavelet Transform", IJERT - International Conference on Science, Engineering and Management (ICSEM '13), 2013, pp 783 – 787.

[15] F. Mintzer and G. W. Braudaway, "If one watermark is good, are more better?", in Proceedings of the International Conference on Accoustics, Speech, and Signal Processing, 1999, pp. 2067–2070.

[16] Musrrat Ali, Chang Wook Ahn, and Millie Pant, "A robust image watermarking technique using SVD and differential evolution in DCT domain", International Journal for Light and Electron Optics, Vol. 125, No. 1, 2014, pp. 428 - 434.

[17] N. P. Sheppard, R. Shafavi-Naini, and P. Ogunbona, "On mul-tiple watermarking", in Proceedings of the ACM Multimedia and Security Workshop (MMSW), 2001, pp. 3 - 6.

[18] Mohananthini Natarajan and Yamuna Govindarajan, "Performance Comparison of single and multiple watermarking techniques", International Journal of Computer Network and Information Security, Vol. 6, No.7, 2014, pp. 28 - 34.

[19] Giakoumaki, A, Pavlopoulos, S. and Koutsouris, D, "Multiple Image Watermarking Applied to Health Information Management", IEEE Transactions on Information Technology in Biomedicine, Vol.10 , 2006, pp. 722 - 732.

[20] C.-S. Woo, J. Du, B. Pham, "Multiple watermark method for privacy control and tamper detection in medical images", in Proc. APRS Workshop on Digital Image Computing, Australia, 2005, pp.59-64.

[21] Jaishri Guru, Hemant Dhamecha and Brajesh Patel, "Fusion of DWT and SVD digital watermarking Techniques for robustness", International

Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, No. 9, 2014, pp. 791 – 797.

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