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Procedia Computer Science 93 (2016) 462 – 468

Procedia Computer Science

6th International Conference On Advances In Computing & Communications, ICACC 2016, 6-8 September 2016, Cochin, India

A Secure & Invisible Image Watermarking Scheme Based on Wavelet Transform in HSI color space

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Abstract

Digital watermarking is an efficient technique to protect copyright and ownership of digital information. This paper, presents a novel digital image watermarking based on wavelet transform in HSI color space. Initially, the one level wavelet coeffiects are generated (LL, LH, HL, & HH) to the intensity component of HSI color space cover image. This LL coefficient and gray watermark image are undergoes 8*8 block processing. These each block entropies of both images are compared and scaled with a scaling factor 'α' (Embedding Process). Finally the watermarked image is inverse wavelet transform of above said embedded coeffiects. At the receiver the inverse process is carried to extract the watermark image. Experimental results show that, the proposed watermarking scheme is robust to noise attacks. Experimental results show an improvement over existing methods n terms of Peak Signal to Noise Ratio (PSNR) and Mean square error (MSE) .

Peer-review under responsibility of the Organizing Committee of ICACC 2016

Keywords: Digital Image Watermarking, Discrete Wavelet Transform, HSI conversion, Peak Signal to Noise Ratio(PSNR), Mean square error (MSE).

1. Introduction

Digital image watermarking is defined as the process to hide the information into host image, which is to be protected and extracted for copy right protection and its verification. There are two types of digital image watermarking schemes i.e. visible watermarking and invisible watermarking. The invisible watermarking requirements are imperceptibility and robustness. Similarly the requirements of visible watermarking should be visible that means easy to identify the hiding data[1].

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Peer-review under responsibility of the Organizing Committee of ICACC 2016
doi:10.1016/j.procs.2016.07.234

Now a day the internet plays very important role in the human life. It is very useful for easy to share the data information in different forms like images, audio, & video. Due to this problem of security and authentication of digital information to provide sufficient security for multimedia information while providing protection against various forms of forgery in an efficient manner with respect to speed of verification process[2].

Two categories of digital watermarking algorithms are spatial domain (time domain) techniques & frequency domain techniques. The best example of spatial domain technique is LSB (least significant bit) which is directly perform the operation and modify the pixels. The frequency domain techniques transform the image into set of coefficients i.e. to perform operation on transform coefficients. The frequency domain techniques are DCT (Discrete cosine transform)[3,4], DWT (Discrete Wavelet Transform)[5,6], SVD (Singular Value Decomposition)[7,8,9] etc. The frequency domain based watermarking is known as more robust and imperceptions (invisible) than background.

2. Preliminaries

Discrete wavelet transform is a mathematical tool, used to decompose a function into a set of basic functions called wavelets. Wavelets are created by translation and dilation of a fixed function, called the mother wavelet. Wavelet provides frequency as well as time information of a function. Wavelet transforms are able to provide multi resolution analysis of digital images. This transform is used to overcome the drawbacks of exists basic image like Fourier transform, short term Fourier transform, Fourier series etc with the functionality of scaling & wavelet concept. By using DWT the image is transformed into sub bands (like *LL, LH, HL &HH*). This is the first level discrete wavelet transform. The second level process the LL band is decomposed into (*LL1, LH1, HL1 &HH1).* Continuing the process up to nth level a pyramid is obtained[5,12,13].

3. Proposed method

The digital image watermarking is one of important research fields to protect the data in unauthorized persons. The main specialty of image watermarking is to embed the data in host image using scaling factor. The purpose of the proposed embedding algorithm is: not to be perceptible and should have high robustness.

The proposed embedding watermarking scheme is as follows:

3.1 Watermark embedding process

Step 1: Read the color cover image & gray level watermark image *IN &W* respectively.

Step 2: The color cover image (RGB) is transformed into HSI image. This decouples the intensity information from the Color, while hue & saturation correspond to human Perception.

Step 3: Apply one-level DWT on I component of cover image *IN*. This is decomposed into four sub-bands low frequency (LL) and high frequency (LH, HL, HH) coefficients are denoted by

$$I \in \{I_{LL}, I_{LH}, I_{HL}, I_{HH}\} \tag{1}$$

Step 4: To perform watermark embedding process the entropies of each 8*8 blocks of two images (LL coefficient of *I* component of cover image IN & watermark image W) are compared and scaled with alpha (α)

$$I'_{LL} = \begin{cases} I_{LL}(i,j) + (\alpha * W(i,j)) & for\, E1 >= E2 \\ I_{LL}(i,j) - (\alpha * W(i,j)) & otherwise \end{cases} \tag{2}$$

Where

E1, E2 are Entropy values of each block of LL coefficient of input image and watermark image.

Where scaling factor (α) is defined as:

$$\alpha = \frac{\sigma_i}{(\sigma)^2} \tag{3}$$

Where σ_i is the standard deviation of each block of LL coefficient of cover image.

σ is the total standard deviation of LL coefficient of cover image

Step 5: Apply Inverse DWT of $I_{LL}^{'}, I_{LH}, I_{HL}$ & I_{HH} coefficients to obtain new intensity image. Finally the new intensity coordinate of image is transformed into RGB coordinates with original coordinates of Hue & Saturation to obtain watermarked image (WD).

3.2 *Watermark Extraction process*

Step 1: The watermarked image WD (RGB) is transformed into HSI color space. This decouples the intensity information from the Color, while hue & saturation correspond to human Perception.

Step 2: Apply one level DWT on the intensity component of watermarked image to decompose into four sub bands low frequency (IW_{LL}) and high frequency ($IW_{LH}, IW_{HL}, IW_{HH}$) coefficients.

Step 3: To perform watermark extraction process the 8*8 block entropies of LL coefficient of watermarked image and LL coefficient of input images are compared and divided with the scaling factor (α). Finally the watermark is extracted.

$$IW_{LL}^{'} = \begin{cases} (IW_{LL}(i,j) - I_{LL}(i,j))/\alpha & for\, E1 >= E2 \\ (IW_{LL}(i,j) + I_{LL}(i,j))/\alpha & otherwise \end{cases} \tag{4}$$

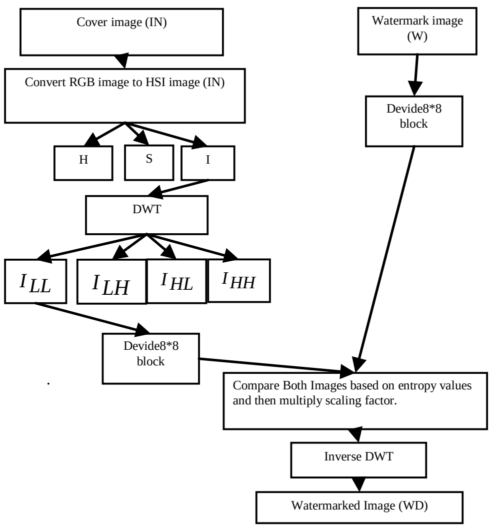


Fig 1 (a) Flow chart of Watermark Embedding process

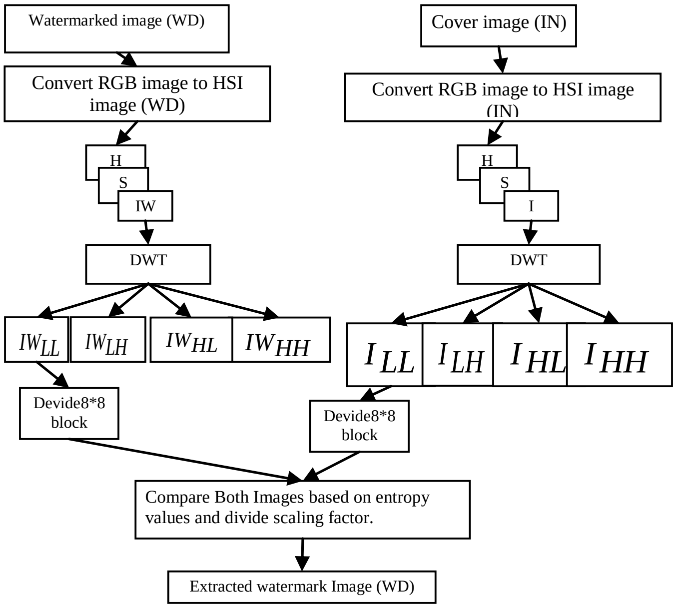


Fig 1 (b) Flow chart of Watermark Extraction process

4. Experimental results and discussions

The proposed scheme simulated in MATLAB. The 512X512 & 256X256 are color image and gray level watermark image respectively. The host images, watermark, embedding & extraction images are displayed in Fig 2 & 3. The noise attacked watermarked & extracted watermark images are displayed in Fig 4. The graphical Representation of PSNR & MSE values are displayed in Fig 5. The performance of proposed method is compared with the following measures and shown in Table 1 & 2

4.1. Peak Signal to Noise Ratio (PSNR)

PSNR (Peak Signal to Noise Ratio) is a metric for the ratio between the maximum possible power of a signal and power of corrupting noise that affects the fidelity of its representation. It is used to measure the quality of reconstructed images[11].

$$PSNR(dB) = 10 * \log_{10}\left[\frac{(255)^2}{\frac{1}{M \times N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left(R(m,n) - F(m,n)\right)^2}\right] \quad (5)$$

4.2. Mean Square Error (MSE)

$$MSE = \frac{1}{m \times n}\sum_{i=1}^{m}\sum_{j=1}^{n}\left[x(i, j) - y(i, j)\right]^2 \quad (6)$$

Where x(i,j) is the host image and y(i,j) is watermark image[12] .

Fig 2 (a) –(e) are the sample input cover images; (f) watermark image; (g)-(k) are the watermarked images; (l)-(p) are the watermark extracted images. This is Existing method.

Fig 3 (a) –(e) are the sample input cover images; (f) watermark image; (g)-(k) are the watermarked images ; (l)-(p) are the watermark extracted images. This is the proposed method.

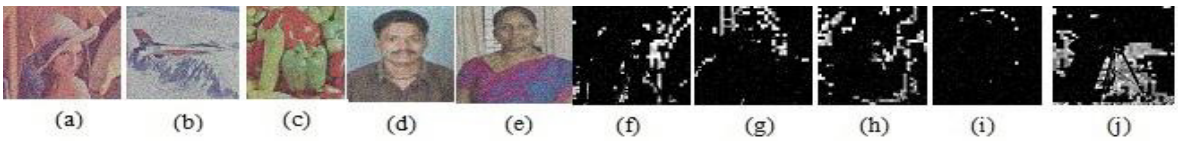


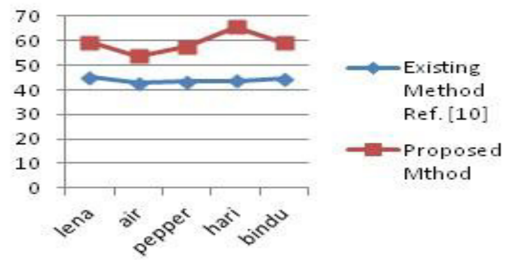
Fig 4 (a) –(e) are the watermarked images from salt and pepper noise with variance 0.5; (f)-(j) Extracted watermark images from salt and pepper noise with variance 0.5.

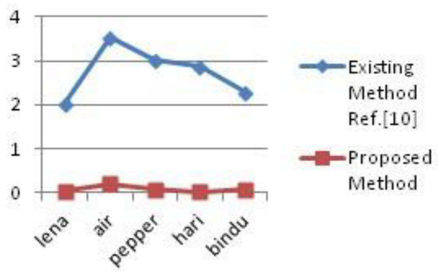
Table 1: Performance results in terms of PSNR & MSE

Images	Existing method Ref.[10]		**Proposed method**	
	PSNR	MSE	**PSNR**	**MSE**
Lena	45.0833	2.0172	**59.4482**	**0.0409**
Air	42.6519	3.5310	**53.6332**	**0.2**
Pepper	43.3428	3.0116	**57.4758**	**0.0694**
Hari	43.5493	2.8718	**65.5593**	**0.0189**
Bindu	44.5579	2.2766	**58.9159**	**0.0712**

Table 2: Performance results in terms of PSNR & MSE of noise attacked images

noise		Proposed method									
		PSNR					MSE				
	Density	**Lena**	**Air**	**Pepper**	**Hari**	**Bindu**	**Lena**	**Air**	**Pepper**	**Hari**	**Bindu**
Salt& pepper noise	**0.001**	34.77	34.73	35.40	34.58	34.91	20.11	21.92	22.56	23.39	21.47
	0.01	24.91	25.04	25.42	25.40	25.11	197.14	212.17	205.5	206.1	202.3
	0.1	14.81	14.93	15.39	15.17	15.14	1965.2	2.26.3	2100.0	2128.2	2037.2
	0.5	7.87	7.98	8040	8.13	81.10	9817.8	1056.3	1044.3	1066.2	1018.3
Speckle noise	**0.3**	10.00	10.07	1073	11.42	11.11	4376.3	6554.9	3722.7	4534.1	4343.0
	0.5	8.33	8.45	9.12	9.79	9.45	6490.1	9506.0	5437.1	6621.6	6374.6
	0.01	20.37	20.16	20.06	20.21	20.21	621.8	619	605.1	601.6	607.49
Gaussian noise	**0.05**	14.21	14.11	13.70	13.83	13.92	2673.7	2476.8	2547.7	2521.7	2612.7
	0.1	11.78	11.75	11.36	11.49	11.58	4597.3	4266.7	4407.8	4352.2	4495.3
	0.5	7.81	7.82	7.89	7.81	7.84	1065.5	1074.5	1073.3	1081.7	1073.3
Brightness	**3**	38.27	37.86	38.17	38.64	38.42	9.32	10.69	9.52	8.94	9.19
	5	33.97	33.73	33.91	34.33	34.11	25.49	27.61	25.82	24.66	24.95
	7	31.11	30.93	31.06	31.33	31.24	49.63	52.53	50.12	48.05	48.45
	10	28.07	27.93	28.01	28.26	28.18	100.73	104.91	101.56	97.14	98.18





(a) (b)

Fig 5 (a) PSNR values of different images without noise attack; (b) MSE values of different images without noise attack.

5. Conclusion

In this paper a modified image watermarking method was proposed. The proposed algorithm is verified with various resoloutional images. For each image the quality of extracted watermark is observed. The performance measure (PSNR, MSE) values are showing the effectiveness of proposed method. The robustness of proposed method is also verified by adding various density noises like salt and pepper, speckle, Gaussian & brightness on the watermarked image. Moreover the efficiency of proposed method is also verified. Future work will focus on extending the algorithm using advanced transformation techniques to improve reliability.

Acknowledgements

The authors would like to express their cordial thanks to Management of QIS college of Engineering and Technology, providing facilities to carry this work.

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