Imprecise Reversible Dual Watermarking Scheme

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Abstract— **Most of the Buyer Seller Watermarking (BSW) Protocol found in literature utilize dual watermarking system for copy protection, copyright protection, and piracy tracking purpose. The proposed state-of-art presents a dual watermarking mechanism in which two separate watermark is inserted. The proposed work embeds a visible watermark in spatial domain and another invisible watermark in transform domain. Visible watermark is widely used for copy protection but are susceptible to image inpainting and common signal processing attacks. By embedding invisible watermark with visible watermark the dual watermark content can resist these attacks. The proposed mechanism allows a legal customer to remove the visible watermark only, then also invisible watermark protects the copyright and helps in piracy tracking problem. The higher experimental value of SSIM shows the visual fidelity of original image is well protected in proposed scheme.**

Index Terms—**Dual Watermarking, Copy right protection, Reversible Watermarking, Discrete Wavelet Transform, Singular Value Decomposition.**

I. Introduction

Buyer Seller Watermarking Protocol [1] is a digital right management system for distributing copyrighted multimedia content over internet. Digital Images are widely shared on social networking sites, and are major component of multimedia content. With the success of internet and more efficient computational tools these images can be copied, modified and distributed illicitly. Resulting more and more digital forgery/crimes are increasing. Digital watermarking is a potentially good tool in enabling content protection and copyright solution. Encryption can offer confidentiality and integrity in content protection, but it doesn't provide security to decrypted content. The decrypted content can be further protected using digital watermarks. Tracking the root of piracy is also a critical issue related to a copyright protection system. An efficient digital watermarking solution must tackle the problems of ownership right protection, client's right protection and trace of pirate copy. On the basis of perceptibility of embedded watermark, watermarking scheme can be classified as visible or invisible. An invisible watermark is embedded into digital media to protect copyright of the owner. On finding any illegal copy the owner can trace the root of piracy. But all these scheme do not provide copy protection, and can be consider as drawback of all these scheme. On the counterpart visible watermarking scheme consist of clearly perceptible watermark logo preventing unauthorized access of copyrighted item. Thus provide copy protection as well as copy right protection. Since watermark is visible in this case so it is vulnerable to different attacks. If a visible watermark is used it must be reversible in nature so a legal user can access the original content. There is a possibility that a legal user can redistribute the content after recovering the watermark. So a invisible semi-fragile watermark should be inserted along with visible watermark. The dual watermarking scheme provides copyright protection, copy protection and can be used as forensic evidence in legal cases. In literature there are not many dual watermarking methods found as compared to single watermark methods. This could be due to the complexity in designing. However, the increased protection functions in a Dual watermarking method may have encouraged some research work to be published. Most of the dual watermarking methods use a robust watermark for copyright protection, and a fragile watermark for tamper detection. They are summarized in Table 1.

doi:10.4304/jait.4.4.166-171

TABLE I.
SUMMARY OF DIFFERENT DUAL WATERMARKING SCHEME

	Dual watermarking	Embedding Domain	Extraction/ Detection	Reversible	PSNR Of Restored Image	Remark
Mohanty et al	Visible+Invisible	Spatial +Spatial	detection	no	no	[2]
Shih et al	Invisible +Invisible	Spatial +DCT	extrection	no	27dB	[3]
Hu et al	Visible+Invisible	DWT +DWT	extraction	no	34 dB	[4]
Sharks et al	Invisible +Invisible	Spatial +DWT	extraction	no	54dB	[5]
Wang et al	Invisible +Invisible	DCT +DWT	extraction	no	35dB	[6]
Lin et al	Visible+Invisible	Spatial +DCT	extraction	yes	55dB	[7]
Sadreazami et al	Invisible +Invisible	DWT +DWT	extraction	no	47dB	[8]
Zhang et al	Invisible +Invisible	Spatial +DWT	extraction	no	41dB	[9]
Rahimi et al	Invisible +Invisible	SVD+Contourlet	extraction	yes	56dB	[10]

As can be observed in the few methods found, Dual watermarking is not a well-explored area. Most of the scheme mainly use a robust watermark for copyright protection and ownership claim. Additionally, a fragile/semi-fragile watermark is usually applied in authentication, tamper detection, and tamper localization. A Dual watermarking method that provides the extra function of approximate content recovery is difficult to find. Such a function is desirable because the recovered content can provide useful forensic information in an investigation. Recently, most image processing techniques, including image hiding, steganography, image authentication, and digital watermarking , mainly focus on achieving reversible protection [8-22]. The reversibility allows the owner to restore the distorted watermarked image to a lossless original image after validating the copyright of multimedia. Due to the content of the original image is valuable, once we embed the watermark information into the original image, the content of original image is inevitably distorted. As the protected media are artistic and valuable imagery, such distortion is intolerable. Hence, to design a lossless reversible watermarking mechanism [18-20] that allows legal users to restore an unmarked image with high fidelity becomes an important and emergent issue in dual watermarking mechanisms. To satisfy the essentials of explained above, the proposed state-of-the-art tries to provide a novel dual watermarking mechanism with removability. The visible logo of the new scheme can clearly indicate the ownership of the protected image, while the invisible one can prevent the watermarked image from malicious attacks.

II. PROPOSED SCHEME

In proposed method we embed a lossless reversible visible watermark in spatial domain and a binary invisible watermark by modifying Singular values in frequency domain of the host image. Visible watermark provides copyright as well as copy protection. As the watermark is visually perceptible it is vulnerable to various attacks. An authorized user can remove the visible watermark to access the hinder free copyrighted content. So there is a need of invisible watermark along with reversible visible watermark. A semi-fragile invisible watermark provides authentication, tamper detection, and tamper localization and can be used for piracy tracking. If a malicious user illegally trying to redistribute the copyrighted material, will be traced with the help of invisible watermark. The proposed scheme is implemented in two steps, in first step a invisible watermark is embedded by using discrete wavelet transform and in second step another imprecise reversible watermark is embedded in spatial domain. The embedding and extraction process is described below.

Watermark Embedding and Extraction Algorithm

A. Visible Watermark Embedding Algorithm

The visible watermark insertion process is based on pixel mapping method. In proposed work the alternate pixel values of pixels are modified according to embedding factor (1-α) and watermark pixels. The four nearest neighbour pixel of embedded pixel is scaled down by scaling factor. In the proposed work value of α is kept constant but it may be varied according to contrast sensitive function of image. The embedding algorithm is as follows:

Let I[m,n] is the original image matrix , and W[p,q] is the watermark image matrix. Ideally, the watermark image, W[p,q], should be embedded within the original image, I[m,n]. So the size of the watermark image, W, is less than or equal to the size of the original image, I. Let the Value of I_{mn} pixel of I[m,n] be i_{mn} and value of W_{mn} pixel of W[m,n] be w_{mn}. L[row,col] is Location map with corresponding value of $L_{row,col}$ is $l_{row,col}$

Step 1: Starting from m=n=0 and p=q=0
If m+n is an odd integer
Then the new value of X_{pq} is modified by taking the average pixel value (including the four nearest neighbours)and assigning the value as $X_{pq}= a_{pq}$
Reiterate until p=p and q=q

Step 2: (a) Starting from m=n=0 and p=q=0
If m+n=0 or an even integer
Then the new value of X_{pq} is
$z= (\alpha * x_{pq})$
Assign the new value as X_{pq}

(b) Starting from m=n=0 and p=q=0
If m+n is an odd integer
Then the new value of X_{pq} is
$z= [y_{pq}+ a_{pq}(1- \alpha)]_{mod256}$

If 0≤ Z≤256 go to step 3 otherwise
Pixel value remain unchanged and mark 0 in corresponding position in location map

Step 3: Modify the pixel value of X_{pq} until m=p and n=q.
mark 1 in corresponding position in location map

Step 4: Set the values as appropriate for the rest of the pixels within the (m-p)*(n-q) set.

B. Invisible Watermark Embedding Algorithm

Most practical application demands the dual watermarks to be orthogonal. Both the watermark must be extracted separately causing, minimum distortion to each other. In proposed state-of-art secondary watermark is inserted in visible watermarked image by using Discrete Wavelet Transform. The DWT separates an image into lower resolution approximation Image LL, and high resolution band LH,HL,HH. These high resolution bands contain information which is less sensitive to human visual system. Proposed work use these high resolution band for embedding watermark. The embedding algorithm is described below

Step 1. Apply DWT to decompose the visible watermark image into four non-overlapping multi-resolution sub-bands: LL_1, HL_1, LH_1, and HH_1.

Step 2. Apply DWT to the HL_1sub-band to get four smaller sub-bands, and choose the sub-band HL_2.

Step 3. Divide the sub-band HL_2 (into 4x4 blocks).

Step 4. Apply SVD to each block in HL_2according to $A = u.s.v^T$,

where A in the equation refers to any block in the chosen sub-band.

Step 5. Re-formulate the grey-scale watermark image into a vector of zeros and ones.

Step 6. Modify the singular values matrix S of each block according to the value of the watermark bit. If the watermark bit is 0, S is modified according to the watermark embedding formula given in Equation 2, where ā is a scaling factor that has a value in the range 1 >ā>O

$$S' = S(1 + \bar{a})$$

otherwise, if the watermark bit is 1, S remains unchanged S'=S

Step 7. Apply inverse SVD (ISVD) to each block A by multiplying the orthogonal matrices U and VT with the modified matrix S', as shown in Equation 4.

$$A = u.s'.v^T$$

Step 8. Apply the inverse DWT (IDWT) on the DWT transformed image, including the modified sub-band, to produce the watermarked cover host image.

C. Visible Watermark Extraction Algorithm

VW_{mxn} is the watermarked image, S_{pxq} is the area of the orignal image corresponding to W_{pxq}.

Step 1: Get the value of α, and the original watermark image and location map.

Step 2: (a) Starting from m=n=0

If m+n=0 or an even integer

Then the new value assigned to S_{pq} is

z= (x_{pq}/ α)

Modify the pixel value of S_{pq} until m=p and n=q

(b) Starting from m=n=0

If m+n is an odd integer and

(i) if corresponding value of location map is 0

Keep pixel value unchanged

(ii) else if corresponding value of location map is 1

$$? = \left(\frac{\mathrm{Spq} - \mathrm{wpq}}{(1 - \alpha)}\right) \mathrm{mod}256$$

Then the new value assigned to S_{pq} is

z= [5a-sum of the four nearest neighbours]

Step 3: Modify the pixel value of S_{pq} until m=p and n=q.

Step 4: Set the values as appropriate for the rest of the pixels within the (m-p)*(n-q) set.

D. Invisible Watermark Extraction Procedure

Step 1. Decompose the watermarked image using DWT into four non-overlapping multi-resolution sub-bands: : LL_1, HL_1, LH_1, and HH_1. Again we apply DWT to the HL_1 sub-band to get sub-band HL_2

Step 2. Get the original image decompose the original image using DWT into 4 non-overlapping multi-resolution sub-bands LL_1, HL_1, LH_1, and HH_1. Again we apply DWT to the HL_1 sub-band to get sub-band HL_2

Step 3. Divide sub-band LL2 of the original image and watermarked images into 4X4 BLOCKS

Step 4. Apply SVD to each block in the chosen subband of the watermark image and extract the singular value matrix S1. Similarly, apply SVD to each block in the subband of the original image and extract the singular value matrix S2.

Step 5. Find the difference between all singular values in S1and S2. If the difference exceeds the threshold value of 0.5 take the extracted watermark bit as 0 otherwise, take it as bit 1.

Step 6. Reconstruct the watermark using the extracted watermark bits.

III. RESULTS AND PERFORMANCE EVALUATION

The proposed watermarking scheme has been implemented in MATLAB and tested on 512x512 pixels standard gray scale images and has achieved satisfactory results. Here the results of commonly used grayscale images “Lena” and “F-16” are provided. Watermark of different size has been added for testing maximum PSNR achievable in reference of watermark area and embedded bits per pixel. To subjectively assess the visual quality of the visible watermarked image we uses WPSNR and Structural SIMilarity model in this paper[11,12]. The experimental results are tabulated in table 2,3,4. From data of PSNR column in the table2, we can see that, with the increase in payload PSNR value gradually decreases. Similarly in table 3 with increase in payload the value of WSNR decrease gradually. This suggest the watermark is more clear and the visual fidelity of original image is degraded. We extract the visible watermark before extraction of invisible watermark. This causes distortion in invisible watermark and can be verified by seeing figure 1. This might be thought as drawback of proposed scheme. But the recovered watermark can be easily correlated with the original invisible watermark. The value of Structure similarity index in table 4 shows that the reconstructed image has approximate visual fidelity as compare to original image.

TABLE II.
PERFORMANCE COMPARISON OF DUAL WATERMARK IMAGES AND VISIBLE WATERMARK IMAGES ON THE BASIS OF PSNR AT DIFFERENT WATERMARK COVERAGE AREA

Original Image	Invisible Watermark image size	Visible Watermark image size	PSNR of Visible Watermark image	PSNR of Dual Watermark image
F-16	64X64	32X32	54.97	39.12
		64X64	48.15	38.66
		128X128	42.35	37.64
		256X256	35.47	34.32
		509X509	29.86	29.82
Lena	64X64	32X32	55.59	38.17
		64X64	48.42	34.49
		128X128	40.34	32.84
		256X256	34.58	30.51
		509X509	28.37	27.63
F-16	128X128	32X32	54.97	38.91
		64X64	48.15	38.47
		128X128	42.35	37.38
		256X256	35.47	34.20
		509X509	29.86	29.73
Lena	128X128	32X32	55.59	39.42
		64X64	48.42	37.76
		128X128	40.34	35.29
		256X256	34.58	33.86
		509X509	28.37	27.12

TABLE III.
PERFORMANCE COMPARISON OF DUAL WATERMARK IMAGES AND VISIBLE WATERMARK IMAGES ON THE BASIS OF WSNR AT DIFFERENT WATERMARK COVERAGE AREA

Original Image	Invisible Watermark image size	Visible Watermark image size	Visible Watermark image	Visible and Invisible Dual Watermark image
F-16	64X64	32X32	54.98	37.17
		64X64	47.44	36.80
		128X128	40.89	35.87
		256X256	34.20	32.69
		509X509	27.82	27.82
Lena	64X64	32X32	52.22	36.94
		64X64	48.42	36.17
		128X128	35.51	35.07
		256X256	29.75	29.51
		509X509	22.19	22.03
F-16	128X128	32X32	54.98	36.68
		64X64	47.44	36.36
		128X128	40.89	35.37
		256X256	34.20	32.46
		509X509	27.82	27.69
Lena	128X128	32X32	52.22	36.39
		64X64	48.42	35.88
		128X128	35.51	34.76
		256X256	29.75	28.83
		509X509	22.19	21.67

TABLE IV.
PERFORMANCE COMPARISON OF DUAL WATERMARK IMAGES AND VISIBLE WATERMARK IMAGES ON THE BASIS OF WSNR AT DIFFERENT WATERMARK COVERAGE AREA

Original Image	Invisible Watermark image size	Visible Watermark image size	Visible Watermark image	Dual Watermark image
F-16	64X64	32X32	0.9911	0.9877
		64X64	0.9844	0.9863
		128X128	0.9795	0.9702
		256X256	0.9695	0.9584
		509X509	0.9266	0.9167
Lena	64X64	32X32	0.9910	0.9854
		64X64	0.9843	0.9835
		128X128	0.9786	0.9686
		256X256	0.9730	0.9673
		509X509	0.9243	0.9202
F-16	128X128	32X32	0.9911	0.9816
		64X64	0.9844	0.9745
		128X128	0.9795	0.9705
		256X256	0.9695	0.9617
		509X509	0.9266	0.9198
Lena	128X128	32X32	0.9910	0.9810
		64X64	0.9843	0.9739
		128X128	0.9786	0.9664
		256X256	0.9730	0.9605
		509X509	0.9243	0.9184

IV. CONCLUSION

For the most of the Buyer seller watermarking protocol dual watermarking mechanism is mandatory. These dual watermark must be orthogonal to each other. The proposed state-of-art utilizes visible and invisible watermarking to provide copy protection along with copyright protection. Even when the visible watermark has been removed the owner's right is protected by invisible watermark. The extraction of visible watermark may cause distortion in invisible watermark and can be verified by seeing figure 1. This might be thought as drawback of proposed scheme. But the recovered watermark can be easily correlated with the original invisible watermark. Further the extraction of invisible watermark follows from random matrix thus adding extra security to watermark image. From experimental results we can say the proposed state-of art well preserve the visual fidelity of image. The value of Structure similarity index in table 4 shows that the reconstructed image has approximate visual fidelity as compare to original image

(a) (b) (c) (d)

Figure 1. (a) and (b) are recovered Invisible watermark after removal of visible watermark (c) and (d) are original watermark image

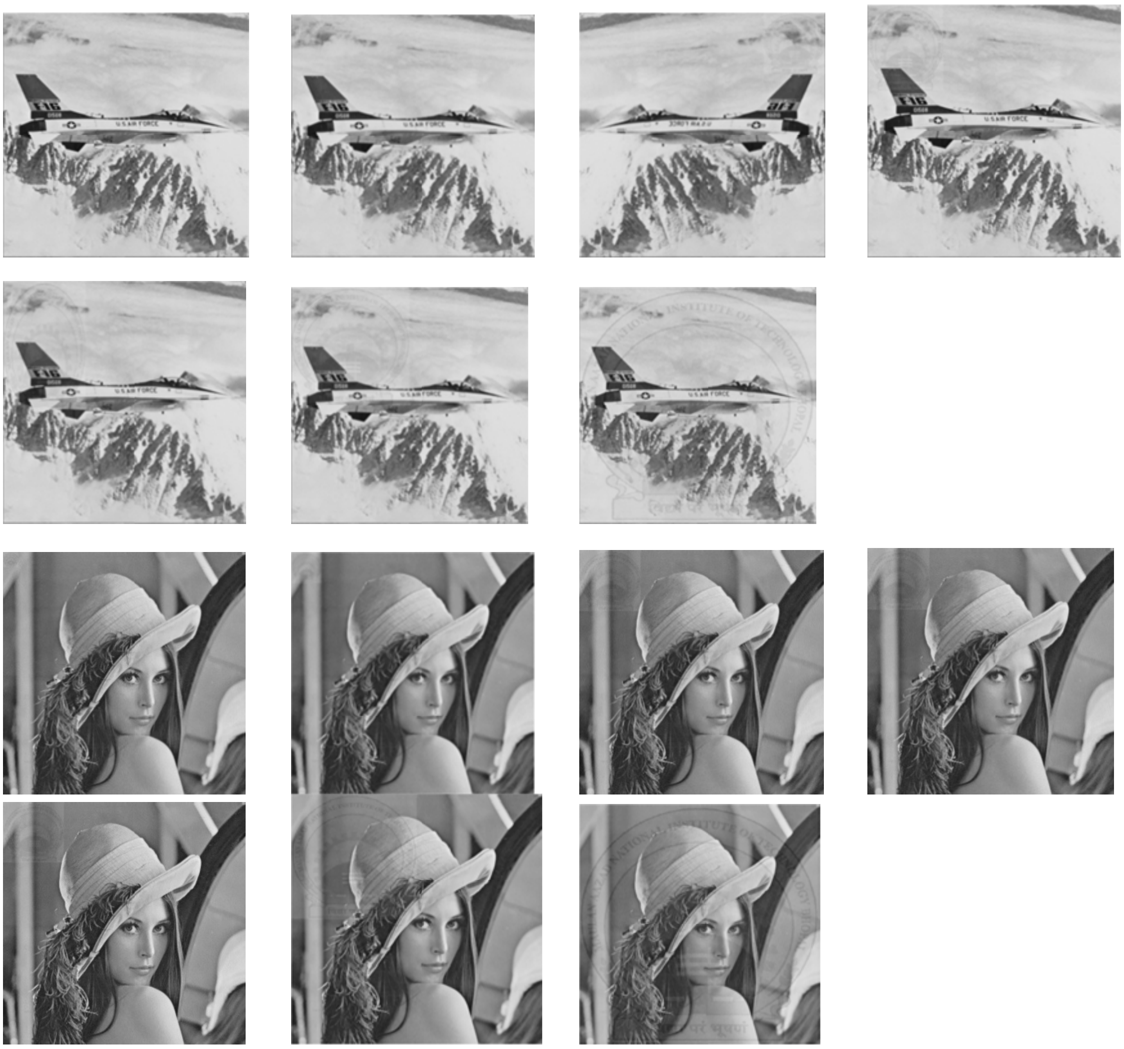

Figure 2. F-16 and Lena Images with different size of visible and invisible watermark embedded

REFERENCES

[1] A. Rial, J. Balasch, and B. Preneel, "A Privacy-Preserving Buyer – Seller Watermarking Protocol Based on Priced Oblivious Transfer," vol. 6, no. 1, pp. 202-212, 2011.

[2] S. P. Mohanty and M. Kankanhalli, "A Dual Watermarking Technique for Images," in ACM Multimedia, 1999, no. 2, pp. 49-51.

[3] Y. Shih and Y. T.Wu, "Combinational image watermarking in the spatial and frequency domains," Pattern Recognition, vol. 36, no. 4, pp. 969– 975, Apr. 2003.

[4] Y. Hu, S. Kwong, and J. Huang, "Using invisible watermarks to protect visibly watermarked images," in Proc. 2004 Int. Symp. Circuits Syst., vol. 5. pp. 584–587.

[5] D. R. Elshafie, M. Sharkas, and N. Hamdy, "An Energy-Based Dual Image Watermarking Technique with Application to Color Images," Science And Technology, pp. 602-605, 2006.

[6] Z. Wang and s. Marshall, "dual watermarking algorithm exploiting the logarithmic characteristic of the human eye '

s sensitivity to luminance," in 14th european signal processing conference (eusipco 2006), florence, italy, september 4-8, 2006.

[7] P.-yu Lin, J.-san Lee, and C.-chen Chang, "Dual Digital Watermarking for Internet Media Based on Hybrid Strategies," IEEE Transactions on Circuits and Systems, vol. 19, no. 8, pp. 1169-1177, 2009.

[8] H. Sadreazami, "Dual Wavelet Watermarking Using Principal Component Analysis," in ICSP 2010, pp. 1821-1824.

[9] J. Zhang, "Dual Watermarking Scheme Based on Dynamic Feature Set," in 2011 International Conference on Mechatronic Science, Electric Engineering and Computer August 19-22, 2011, Jilin, China, 2011, pp. 1818-1821.

[10] F. Rahimi and H. Rabbani, "A dual adaptive watermarking scheme in contourlet domain for DICOM images," BioMedical Engineering OnLine, vol. 10, no. 1, p. 53, 2011.

[11] N.D.Venkata,T.D.kite,W.S.Geisler,B.L.Ivons, A.C.Bovik, "Image Quality Assesment based on degradation model", IEEE Transaction on Image Processing, Vol.9,No.4,pp 636-650,April 2000.

[12] Z.Wang,A.C.Bovik,H.R.Sheikh,E.P.Simoncelli, "Image Quality Assesment:From Error Visiblity to Structure Simmilarity", IEEE Transaction on Image Processing, Vol.19,No.4,pp 1-13,April 2004.

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