International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:6, No:8, 2012

Fragile Watermarking for Color Images Using Thresholding Technique

Kuo-Cheng Liu

***Abstract*—**In this paper, we propose ablock-wise watermarking scheme for color image authentication to resist malicious tampering of digital media. The thresholding technique is incorporated into the scheme such that the tampered region of the color image can be recovered with high quality while the proofing result is obtained. The watermark for each block consists of its dual authentication data and the corresponding feature information. The feature information for recovery iscomputed bythe thresholding technique. In the proofing process, we propose a dual-option parity check method to proof the validity of image blocks. In the recovery process, the feature information of each block embedded into the color image is rebuilt for high quality recovery. The simulation results show that the proposed watermarking scheme can effectively proof the tempered region with high detection rate and can recover the tempered region with high quality.

***Keywords*—**thresholding technique, tamper proofing, tamper recovery

I. Introduction

IN the recent years, many watermarking methods [1]-[7] were developed to achieve the image tamper proofing. By utilizing the embedding watermark information, the image authentication can be used to detect the tampered region. Various watermarking method [3]-[7] were further proposed to authenticate the image and recover the tampered region while the image is forged. Nevertheless, the watermarking techniques described above are designed to achieve tamper proofing and recovery for gray scale images.

The color image watermarking schemes for tamper detection and recovery can be found in [8]-[13]. Wang *et al*. [8] proposed a watermarking scheme for color image tamper detection and recovery, where a majority-vote technique takes all authentication data into account to detect tampered blocks. In [9], the watermarking scheme embeds the watermark into the wavelet domain and spatial domains, respectively, of the red and blue color channels of the original image such that the ownership can be proved and the altered blocks can be detected. In [10], the local features of imageblocks and the global features of the original colorimage are embedded into red, green, and blue color channels for authentication. Through block mapping and a color model, the recovery data bits are [1]generated for tamper recovery. Wand *et al*. [11] presented a tamper detection and self-recovery algorithm for colorimages based on the robust embedding of the dual visual watermarks that usediscrete wavelet transform and singular value decomposition.

Kuo-Cheng Liu is with the Information Educating Center, Taiwan Hospitality & Tourism College, Taiwan (e-mail: kcliu@zmail.tht.edu.tw).

In [12], a new method for tamperdetection and recovery of JPEG images by using a Reed-Solomon code was depicted.The proposedmethod embeds the check symbols correspondingto the reduced original image into the LSBs of thequantized DCT coefficients in a JPEG image directly. The method completely extracts the embedded data for recovery from watermarkedJPEG images. In [13], the color image is transformed into a grey image by color sampling in the form of Bayer patterns. Data of the grey image is embedded into the color image for authentication and recovery. However, the improvement of visual quality of the recovered color image is not discussed while most color image watermarking schemes concentrate on the efficiency of tamper detection.

In this paper, we propose a watermarking scheme for color images. The high quality of the recovered color image for the tampered image and the improvement in the proofing process are focused. Based on the thresholding technique, the tampered region of the color image can be recovered with two representative color vectors such that certain color moments of the block in the region can be preserved while the proofing result is obtained. We also present a dual-option parity check method.

II. Thresholding Method for Images

Thresholding technique is animage processing method that classifies the pixels of a given image into two groups and the pixels in each group are assigned to a certain gray value such that the moment of the image can be preserved. In this technique, a threshold is selected to group the pixels with the gray values above the threshold, and other pixels with gray values equal to and below thethreshold. The threshold selection method that can be used to preserve the moment of the image is incorporated into the proposed watermarking scheme such that the tampered region of the color image can be recovered with high quality while the proofing result is obtained.

In [14], the gray-level moments of theinput image are computed before thresholding.The thresholds are then selected in such a way that the moments of thethresholded image are maintained. The approach can select thresholds without iteration or search, while a representative gray valuecan also be obtained for each thresholded class. Herein, the thresholding approach to bi-level thresholding is described. The *z*-th moment of the image *K* is computed as follows.

$$m_z = \frac{\sum_{j=1}^{N} K^z(j)}{N} \qquad (1)$$

where $K(j)$ is the gray value of the pixel j in the image and N the total number of pixels in the image. By using the histogram, the z-th moment can also be defined as

$$m_z = \sum_n p_n (g_n)^z, \quad n = 1,2,3\ldots \tag{2}$$

where p_n is the fraction of the pixel with gray value g_n in the image. For the bi-level thresholding method, a threshold and tworepresentative gray values can be solved by sing Eq. (2). By using the threshold to classify the pixels in the image K, the thresholdedbi-level image $\widetilde{K}$ is obtained by replacing the pixels below the threshold and the pixels above the threshold in the image K with the two representative gray values, respectively.For the tampered block in the fragile watermarking scheme, the threshold and the two representative values given by the thresholding technique can be adequately used to recover the block with better quality.

III. Proposed Fragile Watermarking Scheme for Color Images

The framework of the embeddingprocessincludes block division and mapping, watermark generation, and watermark embedding.For the host image in the YC_bC_r color space, each color component is divided into non-overlapping blocks of size 4×4 to design the proposed watermarking scheme. By using the block mapping sequence [3], the feature informationofblock P and its corresponding authentication data are generated and embedded into its mapping block Q.The feature information of each block will be embedded into its mapping block. The processes are described as follows.

1. Calculatea threshold value g_t and two representative gray values, g_x and g_y, for block $P$by the thresholdingtechnique described in Section II.
2. Use g_t to generate the bit map of block P in which each bit assigned by 1 or 0 indicates whether the block pixel value will be assigned to g_x or g_y.
3. Generate the feature information:
   a.) c_i i=1, 2, 3, …, 16, for representing the bit map of block P.
   b.) $a_7a_6a_5a_4a_3a_{2(2)}$ and $b_7b_6b_5b_4b_3b_{2(2)}$, for representing the two representative values of block P by truncating the two LSBs of g_x and g_y, respectively (The notation suffix $_{(2)}$ means the binary form).
4. Set the two LSBs of each pixel within block P to zeroandcompute the average intensity of the block, denoted by η.
5. Generate the authentication data: parity-check bits, (α_1, β_1),for block P.

$$\alpha_1 = \begin{cases} \eta_7 \oplus \eta_5 \oplus \eta_3, & \text{if } \varphi_i \bmod 2 = 0 \\ \eta_6 \oplus \eta_4 \oplus \eta_2, & \text{if } \varphi_i \bmod 2 = 1 \end{cases} \tag{3}$$

$$\beta_1 = \begin{cases} 0, & \text{if } \alpha_1 = 1 \\ 1, & \text{if } \alpha_2 = 0 \end{cases} \tag{4}$$

   where $\oplus$ is the exclusive-or operation, $\eta_7\eta_6\eta_5\eta_4\eta_3\eta_2\eta_1\eta_{0(2)}$ is in binary form of η, $\{\varphi_i\}$ is a pseudorandomsequence generated by a random seed that is a key of 2 bits in the watermarking scheme.
6. Embed the watermark information given by Steps 3 and 5 into block Q.

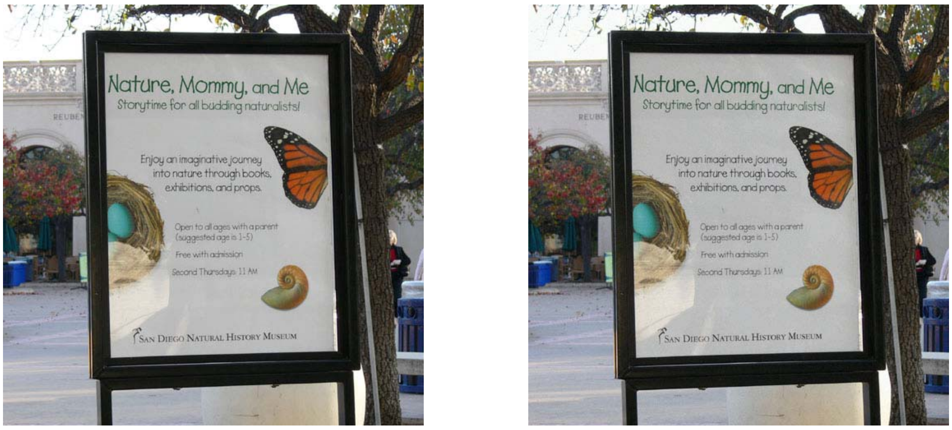
The tamper proofing process follows the watermark embedding process while the watermarked image is attacked. The watermarked color image is transformed to the YC_bC_r color space and each color component is then divided into non-overlapping blocks of size 4×4. The tamper proofing for block P^k is detailed as follows.

1. Extract the embedding authentication data (α_1^k, β_1^k)from the two LSBs of the pixelsin Q^k.
2. Compute the average intensity, η^c, of block P^k.
3. Compute the set parity check bitswith η^c.
4. Mark P^k invalid if the extracted authentication data in Step 1 and the computing authentication data in Step 3 are unequal; otherwise, mark it valid.
5. Generate a binary image, I_{bin}, to mark the location of valid and invalid blocks.

Finally, the recovery of the tampered image is achieved by using the extracted corresponding feature information after the tamper proofing process.

IV. Simulation Results

In this section, the experimental results are demonstrated to show the performance of the proposed scheme. The color images of size 512×512 are used in the experiments and the peaksignal to noise rate (PSNR) is adopted to measure the image quality of the watermarked color images and the recovered color images. To evaluate the validity of the proposed watermarking scheme, the results of tamper proofing and recovery for the watermarked color images are major concerned while the watermarked image is tampered by malicious attacks. The proposed scheme is also compared with the existing color image watermarking scheme to verify the proposed watermarking scheme. Figs. 1a and 1b illustrate the “Museum” image and its watermarked version obtained by the proposed watermarking scheme. The PSNR value of the watermarked “Museum” image is of 42.39dB. It can be seen that the watermark information is invisibly embedded into the color image by the proposed scheme without degrading the visual quality.



(a) (b)

Fig. 1Simulation results of the proposed watermarking scheme (a) original “Museum” image and (b) watermarked “Museum” image of 42.39dB

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

Fig. 2 Comparison of close-up view of the recovery results (a) part of the original “Museum” image, (b) tampered image of the same part, (c) recovery result of the tampered image by using the proposed watermarking scheme, and (d) recovery result of the tampered image by using the Lin’s scheme [3]

The performance of tamper proofing and recovery of the proposed watermarking scheme is assessed by inspecting the restored results while the watermarked color image is changed by malicious attacks. Meanwhile, we compare the performance of the considered watermarked schemes [3], [8] in terms of the PSNR values of the recovered color images at nearly the same high quality of the watermarked color images. The former is the representative method and the latter is the watermarking method for color images.Herein, a close-up view of the recovery results is compared with the Lin’s scheme [3] and is illustrated in Fig. 2. Fig. 2b depicts a close-up view of the tampered “Museum” image, while the same part of the original color image is shown in Fig. 2a. The recovery result (Fig. 2c) of the tampered “Museum” image is of 41.99dB and is obtained by using the proposed watermarking scheme. By using the Lin’s scheme, the resultof 40.20dB is shown in Fig. 2d.

The block artifact effects are given in the restored “Museum” image by the Lin’s scheme, since only the mean value of the block is used to carry out the recovery process. It can be obviously seen that the visual quality of the recovered image by the proposed watermarking scheme is better than that by the Lin’s scheme. The gain of1.79 dB is achieved by the proposed method in comparison with the Lin’s method. The proposed watermarking schemeeffectively utilizes thethresholding method to recoverthe edge and texture information in the tampered region with high quality.The comparison of PSNR values forvarious recovered color images obtained by the proposed scheme, the Lin’s scheme, and the Wang’s scheme [8] is shown in Table 1. For each tamper color image, the better recovery performance in terms of PSNRs is achieved by the proposed watermarking scheme.

TABLE I
PSNRS OF THE RECOVERED IMAGES BY LIN'S SCHEME [3], WANG'S SCHEME [8], AND THE PROPOSED WATERMARKING SCHEME

	PSNRs of the recovered images		
Images	Lin's scheme [3]	Wang's scheme [8]	Proposed scheme
Museum	40.20dB	40.97dB	41.99dB
Resort	38.34dB	39.01dB	39.95dB
Baboon	38.13dB	39.24dB	40.68dB
House	39.64dB	40.58dB	41.41dB

V. CONCLUSIONS

A fragilewatermarking scheme based on the thresholdingtechnique has been proposedfor a wide variety of test color images. The proposed watermarking method can be applied to color images for tamper proofing and recovery. It improves the visual quality of the recovered color image while proofing the tampered region and provides an effective and low-complexity tamper proofing method. The contribution of this paper includes that a thresholding technique has been incorporated into the proposed watermarking scheme and a method of recovering the tampered image from the extracted watermark information has also been devised to achieve high quality of the restored color image. The proposed scheme outperforms the relevant existing scheme in deriving higher quality of the recovered color image while the watermarked image is nearly lossless with the original image. Our future work is to improve the proposed watermarking scheme for color videos in the communication applications.

ACKNOWLEDGEMENT

The work was supported by the National Science Council, R.O.C., under contract NSC100-2221-E-278-002, and Image& Video Processing Laboratory, National Dong Hwa University, Taiwan.

REFERENCES

[1] C.-T. Li and Huayin Si, "Wavelet-based fragile watermarking scheme for image authentication,"*Journal Electron. Imaging*, vol. 16, no. 1, 013009, 2007.

[2] H.-J. He, J.-S. Zhang, and F. Chen, "Adjacent-block based statistical detection method for self-embedding watermarking techniques," *Signal Processing*, vol. 89, no. 8, pp. 1557-1566, 2009.

[3] P.-L. Lin, C.-K. Hsieh, and P.-W. Huang, "A hierarchical digital watermarking method for image tamper detection and recovery," *Pattern Recognition*, vol. 38, pp. 2519–2529, 2005.

[4] S. D. Lin, Y.-C. Kuo, and M.-H. Yao, "An image watermarking scheme with tamper detection and recovery," *Int. Journal of Innovative Computing, Information and Control*, vol. 3, no. 6, pp. 1379-1387, 2007.

[5] C.-C. Chang, Y.-H. Fan, W.-L. Tai, "Four-scanning Attack on Hierarchical Digital Watermarking Method for Image Tamper Detection and Recovery," *Pattern Recognition*, Vol.41, No.2, pp. 654-661, 2008.

[6] T.-Y. Lee and S. D. Lin, "Dual watermark for tamper detection and recovery," *Pattern Recognition*, vol. 41, no. 11, pp. 3497-3506, 2008.

[7] H. He, F. Chen, H.-M. Tai, T. Kalker, and J. Zhang, "Performance analysis of a block-neighborhood-based self-recovery fragile watermarking scheme," *IEEE Trans. Information Forensics and Security*, vol. 7, no. 1, pp.185-196, 2012.

[8] M. S. Wang and W. C. Chen, "A majority-voting based watermarking scheme for color image tamper detection and recovery," *Computer Standards & Interfaces*, vol. 29, pp. 561-571, 2007.

[9] H. Mirza, H. Thai, and Z. Nakao, "Color image watermarking and self-recovery based on independent component analysis," *Lecture Notes in Computer Science*, vol. 5097, pp. 839-849, 2008.

[10] N. Wang and C.-H. Kim, "Color image of tamper detection and recovery using block-based watermarking,"in *Proc. Int. Conf. Embedded and Multimedia Computing*, 2009, pp. 1-6.

[11] N. Wang and C.-H. Kim, "Tamper detection and self-recovery algorithm of color image based on robust embedding of dual visual watermarks using DWT-SVD,"in *Proc. Int. Symp. Communications and Information Technology*, 2009, pp. 157-162.

[12] M. Iwata, T. Hori, A. Shiozaki, and A. Ogihara, "Digital watermarking method for tamper detection and recovery of JPEG images,"in *Proc. Int. Symp. Information Theory and its Applications*, 2010, pp. 309-314.

[13] Z. Qian, G. Feng, and Y. Ren, "Fragile watermarking for color image recovery based on color filter array interpolation,"*Lecture Notes in Computer Science*, vol. 6184, pp. 537-543, 2010.

[14] W.-H. Tsai, "Moment-preserving thresholding: A new approach,"*Computer Vision Graphics, and Image Processing*, vol. 29, pp. 377–393, 1985.

[15] S.-C. Pei and C.-M. Cheng, "Color image processing by using binary quaternion-moment-preserving thresholding technique," *IEEE Trans. Image Processing*, vol. 8, no. 5, pp.614-628, 1999.