Dual Image Watermarking Algorithm Based on Block Truncation Code

Minghui Shi[1], Bailiang Li[2]

[1]**School of Applied Technology, University of Soochow, Suzhou 215006, China**

[2]**School of Electronic Information, University of Soochow, Suzhou 215006, China**

Abstract

Dual image watermarking algorithm based on block truncation code is proposed. In the algorithm, after the origin image is performed block truncation code and quad tree segmentation, the area of HF image and LF image could be obtained. The HF and LF image are decomposed using DWT. Moreover, the dual watermarks are performed an m-sequence transformation. Select LH coefficients and use SVD method. Embed the watermark into V component of the SVD domain. The dual watermark image can be got after the inverse SVD and DWT transformed. The experimental results demonstrate that the watermarking algorithm has good robustness against the attacks such as rotation, image compression, noise addition, filtering and other image processing actions.

Keywords: *Image watermark, M-sequence, DWT, BTC.*

1. Introduction

Digital watermarking technology has been playing an important role in protecting copyrights in digital information such as images, audio, and video which can be accurately copied and arbitrarily distributed much more easily. In addition, the availability of powerful image processing tools has also provided opportunities to manipulate and tamper with digital images for the misuse of intellectual property. Therefore, how to protect the content of digital images for image authentication is an urgent issue.

Robust digital image watermarking can also be classified into two major categories spatial domain and transform domain watermarking. The most popular algorithm in spatial domain is least significant bit (LSB) [1]. And Algorithms based on the transform domain are more robust than the schemes based on spatial domain and hybrid domain. Watermarking algorithms based on DCT [2, 3], DWT [4, 5], discrete Hadamard transform [6, 7], singular value decomposition [8] and discrete Fourier transform [9] are some of the transform domain methods available in the literature.

There are three important issues in the watermark system. First, the embedded watermark should not degrade the quality of the image and should be perceptually invisible to maintain its protective secrecy. Second, the watermark must be robust enough to resist common image processing attacks and not be easily removable; only the owner of the image ought to be able to extract the watermark. Robust watermarking systems are expected to withstand different kind of attacks. Image compression, introduction of noise, low pass filtering, and image rescaling, cropping, rotation, JPEG compression are some but a few of types of attacks that often are not addressed in most literatures. And lastly, the viability of a watermarking may also be judged by how much data it can store into the host image.

Chunlin Song et al. [10] proposed a robust region-adaptive dual image watermarking technique. The technique utilities dual watermarking technologies and embed parts of the watermark images into selected regions in the host image. Watermark data is embedded on different regions of the host image using a combination of Discrete Wavelet Transform and Singular Value Decomposition techniques. Limitations of this method are not scrambling watermark, and the embedded region is randomly selected. This paper presents a robust dual watermark scheme in the transform domain. Scrambling watermark using m-sequence is proposed in order to enhance the robust. And choose the reliable region to embed watermark based on the mean of the region.

The rest of this paper is organized as follows. BTC is described in Section 2. Section 3 introduces the scrambling using m-sequence. The proposed algorithm is presented in Section 4. Experiments are given in Section 5. Finally, the conclusions are summarized in Section 6.

2. Block Truncation Code and Quad Tree

Block truncation coding (BTC) is a well-known image compression technique [11, 12]. In BTC, a gray scale image is divided into 4 × 4 or 8 × 8 no overlapping blocks of pixels, and each lock independently needs a two-level quantize. For each block with size 4 × 4, the mean value Mean can be calculated and defined as follows:

$$Mean=\frac{1}{k*k}\sum_{j=1}^{k}\sum_{j=1}^{k} a_{i,j} \qquad (1\text{-}1)$$

Where $a_{i,j}$ indicates the pixel value in the position (i, j) of the block, k is the size of block.

$BM_{i,j}$ is defined as two-level quantize, it is calculated as follows:

$$BM_{i,j}=\begin{cases}1, if a_{ij}>=Mean\\ 0, otherwise\end{cases} \qquad (1\text{-}2)$$

The two reconstruction levels Xh, Xl can be expressed by

$$Xh=\frac{1}{k*k-q}\sum_{BM_{i,j}=1} a_{i,j}$$
$$X1=\frac{1}{q}\sum_{BM_{i,j}=0} a_{i,j} \qquad (1\text{-}3)$$

where q denotes the number of value greater than mean value.

In the decoding procedure, the approximate image block can be reconstructed according to the binary bitmap BM and two quantization levels C1 and C2, and the decoded image can be obtained by collecting all the reconstructed image blocks. The reconstruction rule is defined as follows:

$$\overline{a_{i,j}}=\begin{cases}Xh, if a_{i,j} >= Mean\\ Xl, otherwise\end{cases} \qquad (1\text{-}4)$$

Where $\overline{a_{i,j}}$ denotes the reconstructed pixel value in position (i, j) of the current decoded block.

3. Block Truncation Code and Quad Tree

M sequence is the shortened form of longest linear back shift register sequence. It is produced by a shift register which has linear feedback, and has the longest periodic time. Generally, the longest periodic time produced by an n stage feedback (shift register can possibly be 2^n-1. Figure1 presents the constitution of a general linear feedback shift register. a_i presents the state of one-state shift register, a_i is 0 or 1, i=0, 1,…, n-1. The linking state of feedback line is present by ci. When ci is 0, the feedback line is broken; when ci is 1, the feedback line is linked.

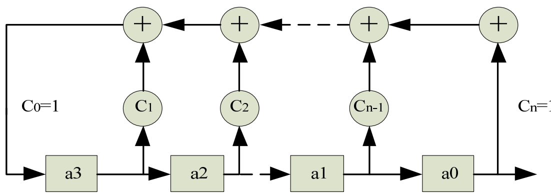

Figure1 m-sequence generation

Rearrangement based on m-sequence is a method of adjust the position of points in a set iteratively. Let F(x, y) denotes a two-dimensional set, x, y=0, 1,…, N-1, here N is the size of set. If k satisfies inequality (1), we choose a 2k-stage feedback shift register. The initial state is not all-zero state. Then x denotes the state of k-stage feedback shift register, and y is the state of the rest. x, y are calculated by the equation (1-5):

$$\begin{cases} x=\sum_{i=1}^{k} a_{k-i,r} \bullet 2^{k-i} \\ y=\sum_{i=1}^{k} a_{k-j,r} \bullet 2^{k-j} \end{cases} ,2^{k-1}<N \le 2^{k} \qquad (1\text{-}5)$$

Where r is the times of shifting from t=0, r=0, 1,…, 2^k-2. F(x’, y’) is supposed to the transformed set by m-sequence from F(x, y), x’, y’=0, 1,…, N-1. The proposed transformed algorithms based on m-sequence are listed below.

(1) The first point (0, 0) in F(x, y) is mapped to the point (x0’, y0’) in F(x’, y’) except (0, 0). Here x0’ denotes the initial state of the first k-stage feedback shift register, and y0’ is the rest k-state.

(2) m-sequence shifts once, and the new point (x1’, y1’) is calculated by the above equation (2).The new point replaces the point (x0’, y0’). Meanwhile, the next point in F(x, y) is also mapped to the point (x0’, y0’) in F(x’, y’).

(3) m-sequence continue shift. Go to the step (2), the other points in F(x, y) is mapped to the ones in F(x’, y’).

The restore of watermark is the inverse of scrambling process. The iteration and the origin status can be regards of key.

4. Dual Image Watermarking Algorithm Based on BTC

4.1 Embedding process

The proposed block truncation code watermark embedding is shown in Figure2.

F(x, y) is supposed to the origin image. The dual watermark is HF and LF. The proposed embedded algorithms based on block truncation code are listed below.

(1) The origin image is carried on block truncation code.

(2) The Quad Tree image partition technique splits the coding image into non-overlapping regions of different sizes [13]. These regions will then be marked in the origin image. Large regions represent mainly the LF region of interest (ROI) and small regions indicate HF ROI of origin image.

(3) Choose the HF and LF ROI of origin image to insert watermark. The non-edge region is selected. Sort the mean of LF and LF ROI. The larger mean will be used to embed the watermark. Decompose the HF and LF ROI into four subbands by DWT transformed. Apply SVD to LH subband of HF and LF region: $F^H = U^H*S^H*V^H$.

(4) Scrambling the HF and LF watermark by m-sequence. Segment the scrambling images. HF will be split 16*16 blocks, and LF will be organized 32*32 blocks. The SVD transformed is used to the HF and LF blocks: $W=U^W*S^W*V^W$.

(5) Using equation (1-6), obtain new singular values.

$$S^{WF} = S^{H} + \alpha * S^{w} \quad (1\text{-}6)$$

(6) Modify the HL coefficients: $F^{WH} = U^{H}*S^{WF}*V^{H}$. Using inverse DWT and obtain the watermark image.

4.2 Extract process

The proposed block truncation code watermark extract is shown in Figure3.

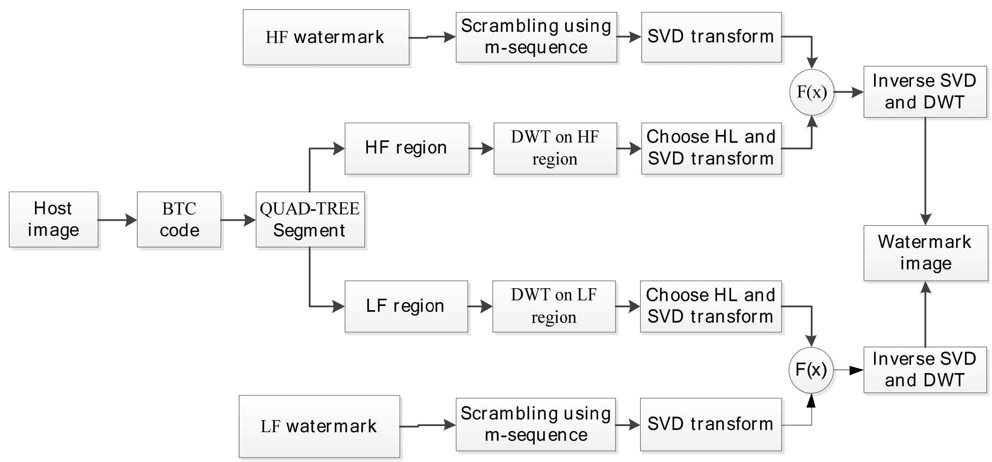

Figure2 Insert watermark

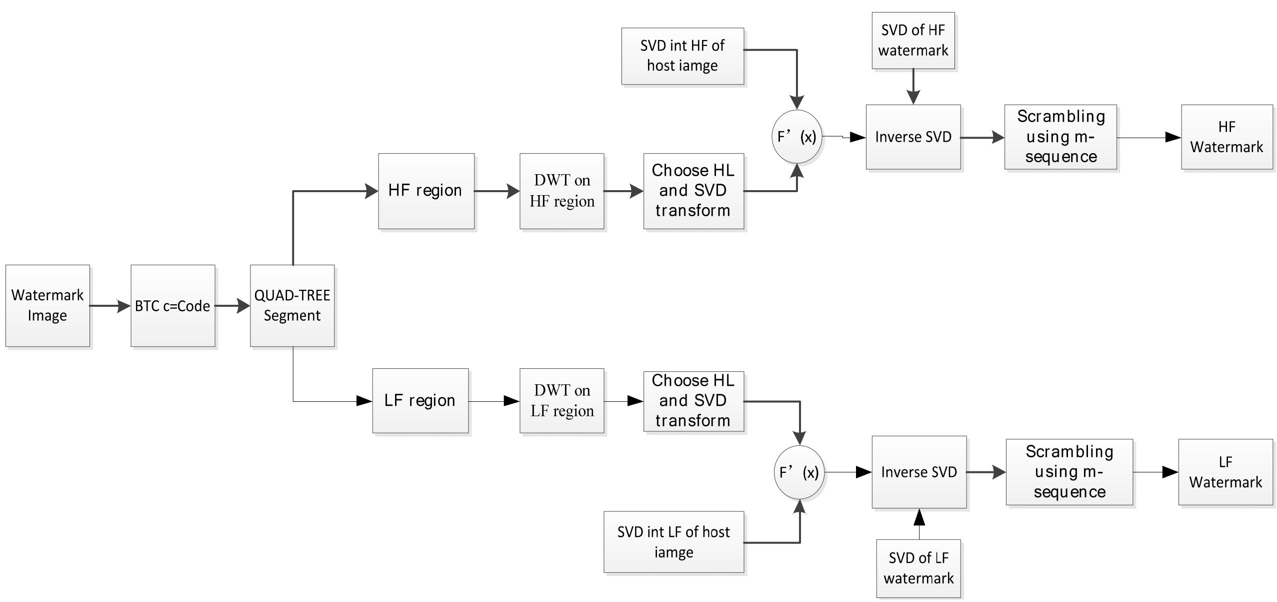

Figure3 Extract Watermark

F(x, y) is supposed to the origin image and F'(x, y) is regards as the watermark image. The dual watermark is HF and LF. The proposed extract algorithms based on block truncation code are listed below.

(1) The origin image and watermark image are carried on block truncation code.

(2) The Quad Tree image partition technique splits the two coding images into non-overlapping regions of different sizes.

(3) Use the same method in origin image to obtain $F^{H} = U^{H}*S^{H}*V^{H}$. Similarly, $F^{H'}=U^{WF}*S^{WF}*V^{WF}$.

(4) Apply formula (1-7) , the singular values of watermark can be obtained.

$$S^{W'} = (S^{WF} - S^{H})/\alpha \qquad (1\text{-}7)$$

According to equation (1-8), the scrambling watermark could be obtained. Using the inverse m-sequence scrambling, the watermark could be reconstructed.

$$W' = UW * SW' * VW \qquad (1\text{-}8)$$

5. Experimental comparison

5.1 Watermark Embedded and Extract Process

The host gray image has dimension of 512*512 pixels and HF and LF gray watermark images have dimensions of 32*32 pixels and 64*64 pixels, respectively. HF will be split into four blocks with 16*16 pixels. HF will be decomposed into four blocks with 32*32 pixels. The origin status of m-sequence is 100000000000, and the times of iteration is one.

The host image and watermark show in Figure4. Figure5 illustrates the effect of scrambling watermark using m-sequence. The proposed embedded watermark process is shown in Figure7. In the figure, the HF and LF region are marked in (b). Note that the region is not edge of image in order to improve robust. (d) and (e) describe the effect of inserting HF and LF watermark. (f) is final watermark image.

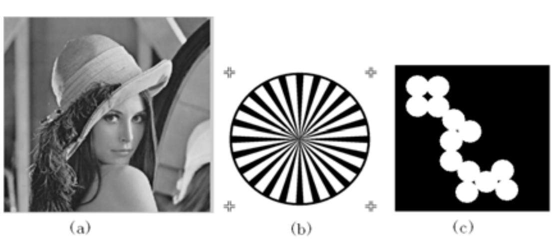

Figure4 (a) Host image, (b) HF watermark (32*32), (c) LF watermark (64*64)

Figure5 (a) Scrambling HF watermark, (b) Scrambling LF watermark.

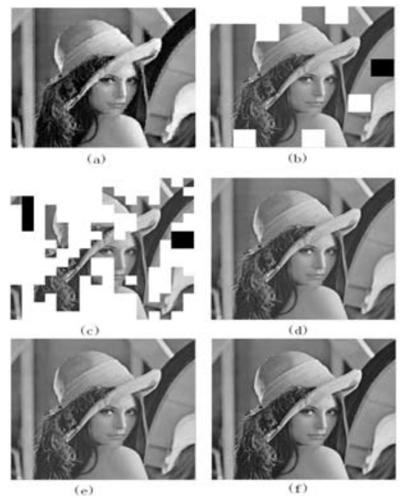

Figure6 (a) BTC image, (b) HF region. (c) LF region. (d) Insert HF watermark. (e) Insert LF watermark. (f) Watermark image.

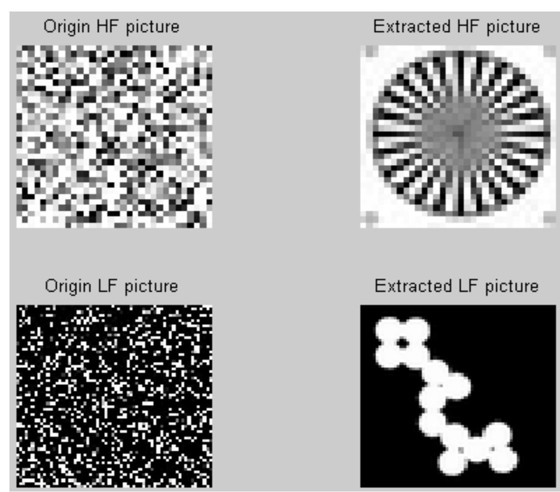

Figure7 Extract Watermark.

5.2 Performance Evaluation

In order to the similarity of the extract watermark and origin image, Normalized Cross-correlation (NC) is defined as follow:

$$NC = \frac{\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} w(x,y)\cdot w'(x,y)}{\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} w^2(x,y)} \quad (1\text{-}9)$$

Where w(x, y) is the origin watermark, and w'(x, y) is extract ones.

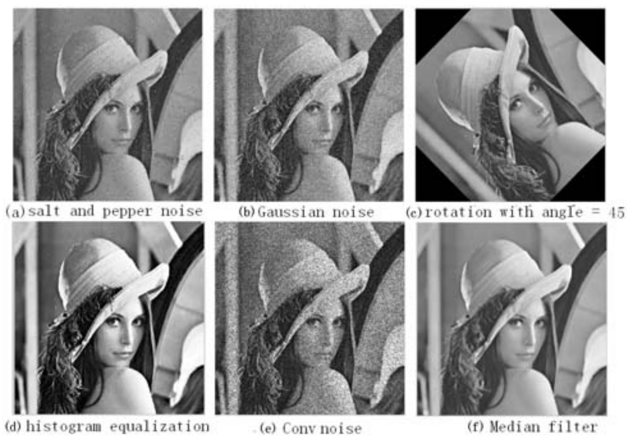

Figure8 Watermark image after attacked.

In literature [10], almost every attract could be analyzed, and proposed the robust region-adaptive dual image watermarking technique. It was not to deal with the LF and HF image. Moreover, the region was randomly selected. In Figure8-9, it can be seen that the proposed method could high-quality extract watermark especially salt noise and gauss noise compared with literature [10]. From table 1, the present algorithm obtains higher NC than literature [10].

Table 1 Numeric comparison of extracting watermark performance

Attack method	Our Method		literature [10]	
	HF	LF	HF	LF
salt	0.9737	1.0512	0.9830	0.9219
gauss	0.9794	1.0559	0.9854	0.9261
Rotate 45 degree	0.0030	0.3047	0.0050	0.2112
Histogram Equalization	1.1942	1.0579	1.1909	1.0556
Conv noise	0.9923	1.0574	1.0001	0.9468
median filtering	0.2116	0.1673	0.2349	0.4838
JPEG (90%)	0.9861	0.9017	0.9823	0.9823

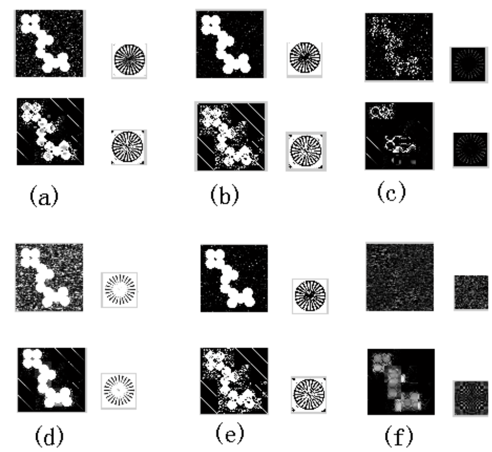

Figure9 Extract the attacked watermark image.

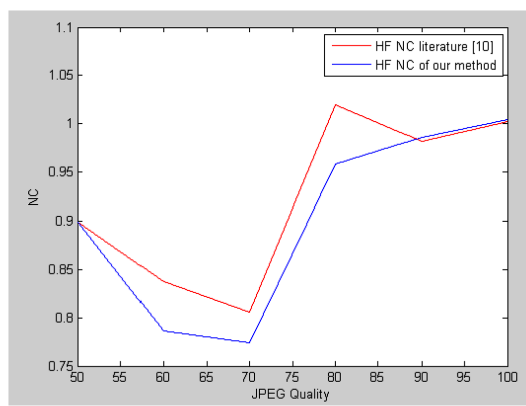

Figure10 the NC of HF image.

In Figure 10 and Figure 11, the NC of HF and LF are described, respectively. It is shown that the high NC of LF image could be obtained in our method. Moreover, if the quality of JPEG is greater than 90%, the high NC of HF could be reached.

Our method could also obtain high PSNR from Figure12. Thus, the algorithm can effectively improve the robustness of watermarking.

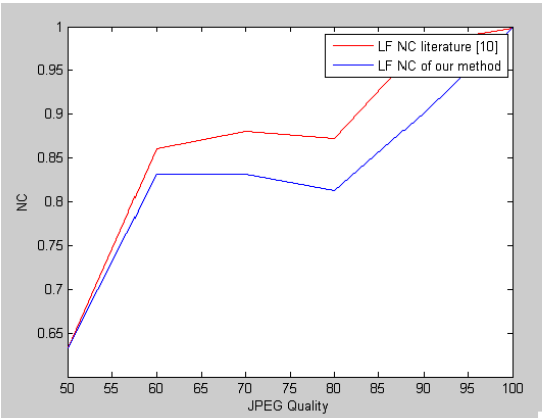

Figure11 the NC of LF image.

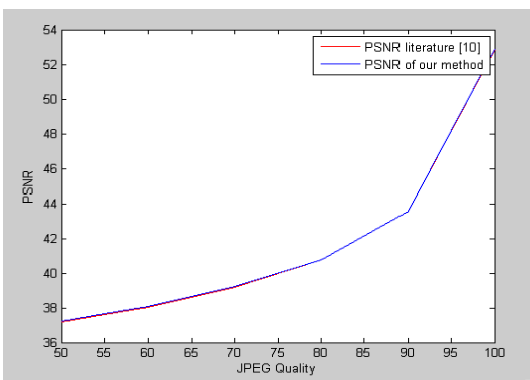

Figure12 the PSNR of image.

6. Conclusion

Dual image watermarking algorithm based on block truncation code could improve robust. It could efficiently protect the watermark information.

Experiment results showed that the proposed algorithm was more robust to attacks. But it has high complexity. Therefore, in the future work, we should reduce the complexity and speed the embedded and extract watermark.

Appendix

The authors were supported by Natural Science Foundation of Jiangsu Province, China (NO.BK2011375).

References

[1] Hong Shen, Bo Chen. From single watermark to dual watermark: A new approach for image watermarking. Computers and Electrical Engineering, 2011:1-15.

[2] Chu,W.C. DCT based image watermarking using sub sampling, IEEE Trans. Multimedia, 2005, 5, (1), pp. 34–38.

[3] Wang, Y., Pearmain, A. Blind image data hiding based on self reference, Pattern Recognit. Lett., 2004, 25, pp. 1681–1689.

[4] Lin, W.-H., Horng, S.-J., Kao, T.-W., Fan, P., Lee, C.-L., Pan, Y. An efficient watermarking method based on significant difference of wavelet coefficient quantization, IEEE Trans. Multimedia, 2008, 10, (5), pp. 746–757.

[5] Lin, W.H., Wang, Y.R., Horng, S.J., Kao, T.W., Pan, Y. A blind watermarking method using maximum wavelet coefficient quantization, Expert Syst. Appl., 2009, 36, (9), pp. 11509–11516.

[6] Ramanjaneyulu, K., Rajarajeswari, K. An oblivious image watermarking scheme using multiple description coding and genetic algorithm, IJCSNS, Int. J. Comput. Sci. Netw. Secur., 2010, 10, (5), pp. 167–174.

[7] Ramanjaneyulu, K., Rajarajeswari, K. An oblivious and robust multiple image watermarking scheme using genetic algorithm, Int. J. Multimedia Appl. (IJMA), 2010, 2, (3), pp. 19–38.

[8] Yongdong, Wu. On the security of an SVD based ownership watermarking, IEEE Trans. Multimedia, 2005, 7, (4), pp. 624–627.

[9] Solachidis, V., Pitas, V. Circularly symmetric watermark embedding in 2-D DFT domain, IEEE Trans. Image Process., 2001, 10, pp. 1741–1753.

[10] Chunlin Song, Sud Sudirman, Madjid Merabti. A robust region-adaptive dual image watermarking technique[J]. J. Vis. Commun. Image R., 2012: 549-568.

[11] Shu-Chien Huang and Ching-Fen Jiang. A color image authentication and recovery method using block truncation

code embedding [J]. Journal of Marine Science and Technology, 2012, 49-55.

[12] Chun-Ning Yang, Zhe-Ming Lu. A Blind Image Watermarking Scheme Utilizing BTC Bitplanes. International Journal of Digital Crime and Forensics, 2011, 3(4):42-53.

[13] Yih-Chuan Lin, Tzung-Shian Li. Reversible Image Data Hiding Using Quad-tree Segmentation and Histogram Shifting [J]. Journal of Multimedia, 2011, 6(4): 349-358.

Minghui Shi Received Bachelor's degree from Northwest Normal University of China. Her current research interest is signal and information processing.

Bailiang Li Received his M.S. degree in Electronic Science and Technology from Soochow University, Suzhou, China in 2009. He is currently working for the M.S. degree in School of Electronic Information at Soochow University. His research focus is image processing.