Journal of Information Hiding and Multimedia Signal Processing ©2015 ISSN 2073-4212
Ubiquitous International Volume **6**, Number **2**, March **2015**

A Data Hiding Method which the Secret Image Exist After Cropping Style Image Resizing

Wen-Pinn Fang

Department of Computer Science and Information Engineering
Yuanpei University of Medical Technology
No.306, Yuanpei St., Hsinchu, Taiwan 30015
wpfang@mail.ypu.edu.tw

Received November, 2014; revised December, 2014

Abstract. *This paper proposed a procedure to preserve the authentication data in a image after it has been resized. Based on the fault tolerance property of secret sharing scheme, the goal of this paper is achieved. Recently, many different kinds of display devices are used. It is necessary to modify image size for fitting different display devices. Because the resizing methods include image cropping, image smoothing and pixel value interpolation, the hiding data may loss after the resizing process. By means of embedding data in many locations of the host image, the information will preserve after cropping procedure. The hiding data may not delete after the image has been resized. The result is suitable to extend for the video copyright protection between different devices. An experiment is also presented.*
Keywords: Data hiding, Image resizing, Secret sharing

1. **Introduction.** Recently, many commercial products are invented to show videos and images. These products include television, smart phone, tablet, and computer. The resolutions of these devices are different. Because cost consideration, there is only one version in the produce step for most videos. Although it is easy to resize the images by simple sampling process directly. People will not feel good when they watch the video which just been scale or crop. It is necessary to resize the video for many display devices. Furthermore, it is very important to protect the copyright for media holder. There are many approaches to protect the copyright. For example, digital signature, watermarking and data hiding, etc. However, the hiding data may disappear after image processing. This paper studies a method to overcome this problem especially focus on cropping type image resizing.
The rest of this paper is organized as follows: the background knowledge is show in Section 2; the method is proposed in Section 3; Experimental results are shown in Section 4. Finally, the discussion is represented in Section 5.

2. **Background knowledge.** Before describe the method, it is necessary to explain some basic knowledge. The basic knowledge include finite field, secret image sharing, image resizing and data hiding. The detail is shown as below:

2.1. **Finite Field.** A finite field is a field that contains a finite number of elements, called its order. A finite field is a set on which the operations of commutative multiplication, addition, subtraction and division have been defined. In general, finite fields are given by the integers modulo a prime. Finite fields only exist when the size is a prime power p^k

(where p is a prime number and k is a positive integer). For each prime power, there is a finite field with this size, and all fields of a given order are isomorphic. Finite fields are fundamental in a number of areas of mathematics and computer science, including number theory, algebraic geometry, Galois theory, finite geometry, cryptography and coding theory. In this paper, p is assigned as 2 and k is assigned as 8.

2.2. **Secret Image Sharing.** Secret sharing was first introduced by Shamir [1]. It is a reliable method for the protection of cryptographic key with many good properties. It also is a perfect threshold scheme, with the size of each share not exceeding the size of the secret and the security does not rely on unproven mathematical assumptions. It is presented below as mention in Ref [2], the algorithm is shown as below:

Algorithm 1 Secret Sharing Scheme

Initialization Phase

1. D choose w distinct, non-zero elements of $\mathbf{Z_p}$,$1 \leq i \leq w$ denoted x_i, (this is where we require $p \geq w + 1$). For $1 \leq i \leq w$, D gives the value x_i to P_i. The values x_i are public.

Share Distribution

2. Suppose D wants to share a key $K \in \mathbf{Z_p}$. D secretly chooses (independently at random) t-1 elements of Z_p, $a_1, \ldots a_{t-1}$.
3. For $1 \leq i \leq w$,D computes $y_i = a(x_i)$, where
$$a(x) = K + \sum_{j=1}^{t-1} a_j x^j \quad mod \quad p$$
4. For $1 \leq i \leq w$,D gives the share y_i to P_i

In 2002, Thien and Lin extend the scheme to image [3], named "Secret Image Sharing". They changed the values of a_j into a corresponding pixel value of a secret image. In an (r, n) image sharing system [1] [4] [5], n shares $L_1, L_2, ..., L_n$ are created for a given image, e.g., Lena. The image can be revealed when all n shares are received, while less than n shares reveal nothing about the image. Sharing is a safety process that is valuable in a company where no employee/investor alone should be trusted. Significantly, the original image can be discarded after the sharing; moreover, each of the n shares is $1/n$ of the size of the given image. Therefore, the sharing process does not waste storage space.

2.3. **Image Resizing.** In the decade, many researchers discuss the method of video and image resizing. The methods include image cropping style [6][7][8][9], seam carving [10][11][12][13][14], wrapping [15][16] and hybrid approaches [15][16],[17]. The cropping method reserved the most important region directly. Avidn and Shamir [10] proposed a method to find out the seams first, remove the unimportant region, reserved significant regions. Many researchers extended the study. For example, Mansfield, etc al [8], Rubinstein and Shamir [12], Grundmann, etc. al [13] proposed some suggestions to improve the quality and eliminated errors. On the other hand Wan [16] and Li [17] discuss the deformation effect after an image has been retargeted. Rubinstein [18] combined cropping and zooming method to achieve resizing. Sun, etc al [19] proposed cyclic seam caving algorithm for the same purpose. Dong, etc al [20] discussed the relationship between reservation region and whole result. Pritch [21] study the deformation and cropping relationship by shift-map method, the paper get better image quality. Ding [22] designed specific filter and get better image quality after the image has been resized. In Fig. 1, an image resizing example is shown.

(a) (b)

FIGURE 1. An example of image resizing, (a) is the original image (b) is the image after resized

2.4. **Data Hiding.** In general, there are three types of data hiding: vector quantization, error expansion and reversible displacement. The advantages of vector quantization type hiding method are compress and information hiding. However it's capacity is less than most other methods and with low image quality. The Error expansion type data hiding method has high storage capacity but the image quality is much lower. The complexity of reversible displacement type data hiding method is small and the quality of image is high. However, the hiding rate is smaller than other methods.

3. **Proposed Method.** The goal of this paper is to design a data hiding method which the secret image will not disappear after the image has been resized. The symbols are shown as in Table 1.There are two phases in the method: (a) hiding phase (b) recovery phase.

In hiding phase, as shown in Fig.2, there are two steps:

Step 1 encode secret image into shares.

Using the (n,r) secret sharing scheme as shown in section 2.2.

Step 2 hide the shares and pivots (the sharing parametric) into the host image.

For example, if the size of host image is a gray scale image which the size is 512 by 512 pixels, the size of secret is a binary image which the size is 64 by 64. The sharing scheme is (2621441,4096) sharing. Here, the pivot means the location in the host image which store the relative coefficient of secret sharing scheme.

The hiding method is shown as below:

If the least two significant bits of pixel value of host image is l_1 and l_2. The hiding value of secret image is 1 if l_1 is equal to l_2, otherwise the value is 0 and it is the nearest number compare with original value. Before hide the secret image, the method hide the coefficient of secret sharing scheme in the left top most skin color pixel. Because the method never remove skin color pixel. Users can decode the shares. After hide the decode coefficients, scan the whole host image to hide share data pixel by pixel.

In recovery phase, there are three steps:

Step 1 retrieve the sharing coefficient from pivot.

Step 2 retrieve shares from stego image.

The value of shares is equal to s_i(x,y)

$$s_i(x, y) = P_{(x,y)}(l_1) xor P_{(x,y)}(l_2) \quad (1)$$

Step 3 recovery secret image.

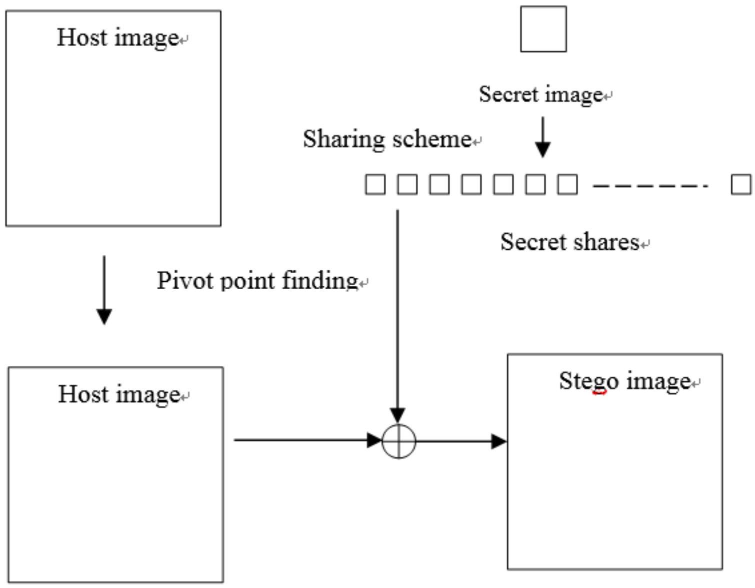

FIGURE 2. The proposed hiding method

Recover secret image by inverse matrix.

TABLE 1. Symbolic table

Symbolic	description
H	Host image
S	Secret image
s_i	the i^{th} share
$p(x,y)$	The pixel value at location (x,y)

For example, assume that the size of host image is 512-by-512 pixels. The depth of host image is 8 bits. The size of secret image is 64-by-64 pixels. It is a binary image. In the first step, scan the secret image pixel by pixel. Splitting the pixels into 8 bits non-overlapped sectors. Combine every sector into an integer which the value range is from 0 to 255.

In the second step, design a polynomial if the numbers are p_0, p_1, p_2,., p_{511} .

$$f(x) = p_0 + p_1x + p_2x^2 + . + p_{511}x^{511} \tag{2}$$

In the third step, plug in x from 1 to 4096, there will be 4096 numbers, notice, all operator are in $\mathbf{GF}(2^8)$.

In the fourth step, split the 4096 number into 32768 bits by scanning the bit plane.

In the fifth step, replace the two least significant bits of host by equation (1).

4. **Experimental Result.** In this section, an experiment has been tested. There are three steps to test the proposed method. First at all, a secret image has been hidden into a host image by the proposed method. Secondly, the stego-image has been resized. In the third step, retrieve the secret image. Finally, compare the original secret image and the recovery secret image. Check the different between stego-image and host image. The test resizing method is a cropping method. There are three steps: (a) find the most important part of image. In this testing case, the important part is the location of human. (b) cut

the original image to fit the scale of display device. In this testing case is remove the background without people. The experimental result is shown in Fig.3. In this case, the secret image is the same as recovery image. After a series of experiments, The PSNR between host image and stego-image is more than 35 dB.

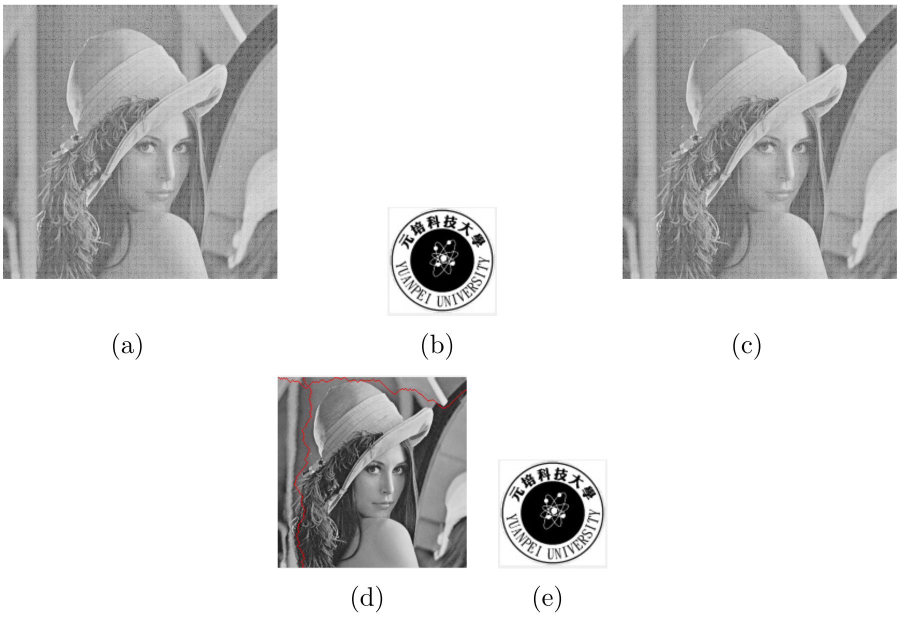

FIGURE 3. The experimental result, (a) is the original image (b) is the secret image (c) is the stego image (d) is the image after resizing (e) is the recovery image

5. **Conclusions and discussion.** Image resizing is a very important image processing method today. There are many display devices which the resolutions are different. To make user enjoy the multimedia, image resizing is necessary. However, it is difficult to preserve the hiding data after it has been resizing. This paper proposed a data hiding method to overcome the problem by cropping type resizing method. Moreover, the computation time is a very important issue in real application. There are some researchers study how to decrease the decoding time of secret image sharing. For example, Fang and Lin [23] [24] proposed a dynamic programming approach to improve the decoding procedure efficiently and parallel method to improve the encoding time. In the future, maybe use another hiding method to increase the hiding capacity.

Acknowledgment. This work is partially supported by Ministry of Education of Taiwan.

REFERENCES

[1] A. Shamir, How to share a secret, *Communications of the ACM*, vol.22, no.11, pp. 612-613, 1979.
[2] D.R. Stinson, *Cryptography Theory and Practice*, CRC Press, U.S.A. ,1995.
[3] C.C. Thien and J.C. Lin, Secret Image Sharing, *Computers and Graphics*, vol. 26, no. 5, pp. 765-770, 2002.
[4] C.C. Thien and J.C. Lin, An Image-Sharing Method with User-Friendly Shadow Images, *IEEE Trans. on Circuits and Systems for Video Technology*, vol. 13, no. 12, pp. 1161-1169, 2003.
[5] C.C. Thein, W.P. Fang and J.C. Lin, Sharing Secret Images by Using Base-transform and Small-size Host images,*International Journal of Computer Science and Network Security*, vol.6, no.7, pp. 219-225, 2006.

[6] L. Chen, X. Xie, X. Fan, W. Ma, H. Zhang and H. Zhou, A visual attention model for adapting images on small displays, *ACM Multimedia System Journal*, vol. 9, no. 4, pp. 353364, 2004.

[7] H. Liu, X. Xie, W.Y. Ma and H. Zhang, Automatic browsing of large pictures on mobile devices,*Proc. of ACM International Conference on Multimedia*, pp. 148-155, 2003.

[8] B. Suh, H. Ling, B. Bederson and D. Jacobs, Automatic browsing of large pictures on mobile devices, *Proceedings of UIST*, pp. 95104, 2003.

[9] A. Santella, M. Agrawala, D. Decarlo, D. Salesin and M. Cohen, Gaze-based interaction for semiautomatic photo cropping, *Proceedings of CHI*, pp. 771-780, 2006.

[10] S. Avidan and A. Shamir, Seam carving for content-aware image resizing, *ACM Trans. on Graphics* vol. 26, no.3, 2007.

[11] A. Mansfield, P. Gehler, L. V. Gool and C. Rother, Scene carving, Scene consistent image retargeting,*Proc. of European Conference on Computer Vision*, 2010.

[12] M. Rubinstein, A. Shamir and S. Avidan, Improved seam carving for video retargeting, *ACM Trans. on Graphics*, vol. 27, no.3, 2008.

[13] M. Grundmann, V. Kwatra, M. Han and I. Essa, Discontinuous seam carving for video retargeting, *Proc. of International Conference on Computer Vision*, 2010.

[14] Y. Liang, Z. Su and X. Luo, Patchwise scaling method for content-aware image resizing, *Signal Processing*, vol.92, no.5, pp. 12431257, 2012.

[15] R. Gal, O. Sorkine and D. Cohen-or, Feature-aware texturing, *Computer*, vol. 11, no. 5 pp. 17, 2006.

[16] Y. Wang, C. Tai, O. Sorkine and T. Lee, Optimized scale-and-stretch for image resizing,*ACM Trans. on Graphics*, vol. 27, no. 5, 2008.

[17] B. Li, Y. Chen, J. Wang, L. Duan and W. Gao, Fast retargeting with adaptive grid optimization, *Proc. of International Conference on Multimedia and Expo*, pp. 1-4, 2011.

[18] M. Rubinstein, A. Shamir and S. Avidan, Multi-operator media retargeting, *ACM Tran. on Graphics*, vol. 28, no. 3, 2009.

[19] J. Sun and H. Ling, Scale and object aware image retargeting for thumbnail browsing, *Proc. of International Conference on Computer Vision*, 2011.

[20] W. Dong, N. Zhou, J. Paul and X. Zhang, Optimized image resizing using seam carving and scaling, *Proc. of ACM SIGGRAPH Asia 2009*, vol. 28, 2009.

[21] Y. Pritch, E. Kav-Venaki and S. Peleg, Shift-map image editing,*Proc. of International Conference on Computer Vision* , pp. 151158, 2009.

[22] Y. Ding, J. Xiao and J. Yu, Importance filtering for image retargeting,*Proc. of IEEE Conference on Computer Vision and Pattern Recognition*, 2008.

[23] W.P. Fang and S.J Lin, Fast Secret Image Sharing in HPC. *Proc. on 10 th Internatioal Conference on High-Performance Computing in Asia Pacific Region join WorkShop on PC-Grid*, 2009.

[24] W.P. Fang, Parallel Processing for Secret Image Sharing,*International Symposium on Parallel and Distributed IEEE Proceeding on Processing with Application*, 2010.