Privacy Image Protection Using Fine-Grained Mosaic Technique

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Abstract—**Access control has been applied in multimedia database to preserve and protect the sensitive information. The past researches generate authorization rules to control the authorizations with fine-grained ability in social photos, meeting photos, promotional photos. However, it does not appropriate to use in some privacy scenarios (e.g., the increasing popularity of digital images being stored and managed by the service Google Street View). With low cost of maintenance, this paper integrates the data hiding technique into a fined-grained access control to mosaic the sensitive information as well as enable to recover the mosaic region if necessary. The experiments show the positive data to confirm the feasibility of the proposed scheme.**

Keywords:* *Image access control, fine-grained access control, privacy protection*, *mosaic technique

I. INTRODUCTION

Due to widespread use of network technologies, people can easily exchange and share information via the Internet. Internet is a public but insecure environment, which might make user's private information vulnerable to malicious intruders during data transmission. To ensure that no illegal users can access the contents, access control model is one of the ways used in privacy protection. Using the model, users can authorize people who have rights to access their own digitized contents. After that, users can grant or deny to resources after they log in the systems.

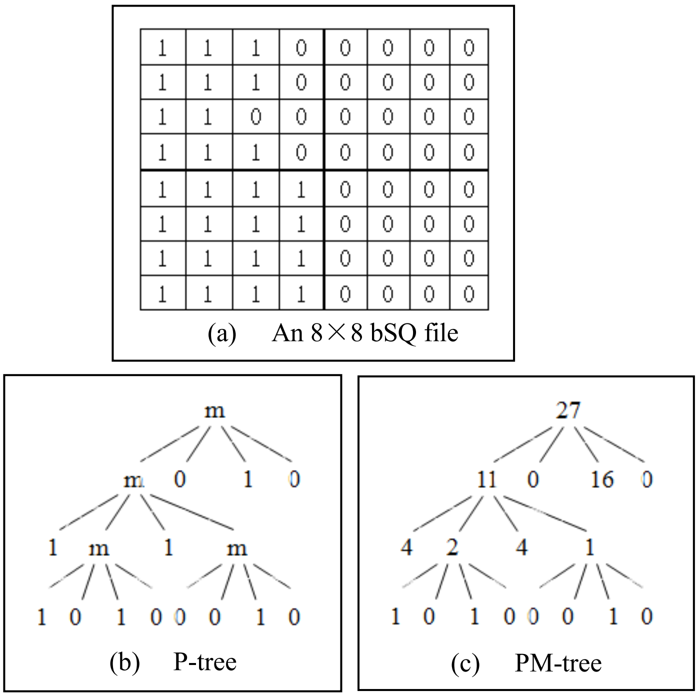
Nowadays, the access control model is widely applied in several kinds of digitized contents (text, web-based pages, multimedia, etc.). Among them, the massive use of multimedia causes several problems including privacy and confidentiality preserving. To resolve the problems, access control models for multimedia databases [1-7, 9-12] are proposed to provide safe browsing and publishing of multimedia. In 2003, Bertino et al. [7] proposed a hierarchical access control model for video database systems. Based on hierarchical concepts, Thuraninsigham et al. [9, 12] create a digest between the content of the video and the corresponding description to facilitate the specification of permissions. In [1], Nabil R. Adam et al. proposed an access control model dedicated to the protection of digital libraries' content. In [3], Atluri and Chun proposed an access control model for geospatial data. Bouna et al. [5] proposed a fine-grained image access control model, which enable owners to authorize the partial contents on image to users. The fine-grained access control model can specify the security rules based on the constraints, which provides a simple data representation model to properly describe the image description, and present the requirement of fine-grained control on image (e.g., one may prefer to apply a blurring function to partial contents of an image rather than to the whole one). Bouna et al. pointed out the control of partial contents in multimedia is an important issue in recent years (e.g., masking out objects with violent scenes for TV show, hiding the sensitive information in a picture).

Privacy protection is also a main issue in some leading services recently (Google Street View, EveryScape, Mapjack, etc.). Google Street View provides users can see the street view after they look up the location in map; however, the service have a high probability of leaking one's private life without meaning to do so [2]. This has raised a need to de-identify individuals from the view of the street. For clarity, the region might leak out personal privacy information is called ROI (Region of Interest) region in this paper. As for the specific requirements, the ROI region can be recovered. For example, the ROI region of pictures could be a help for policeman to arrest the thief. To meet the requirement, it has a challenge that a significantly increasing number of pictures need maintaining. The past research provides good ways for fine-grained access control, but not at low cost of maintenance. In this paper, we proposed a low cost model with fine-grained access control for digital images. This paper blurs the ROI region with mosaics function. After that, the users can remedy back the ROI region if they own the mosaic factor. The mosaic factor is treated as a private key kept by owners. There is no extra data need to maintain or keep during de-mosaic process.

This paper is organized as follows: Related works are briefly described in section Ⅱ. In section Ⅲ, the details of the proposed scheme are presented, including the encoding procedure and decoding procedure. The experimental results are shown in section Ⅳ. Finally, conclusions and directions for future work are drawn in section Ⅴ.

II. RELATED WORKS

The proposed scheme adopts the P-tree (Peano Count Tree) structure [8] to encode the bSQ (Bit Sequential) file. P-tree structure is a representation used to losslessly compress the spatial data. This section briefly introduces the P-tree structure, PM-tree and its operations. As shown in Fig. 1, the amount of 1s in the image is 27, also called root count, to recode the root node of the P-tree, denoted as R_0, as the first level of the P-tree. After that, the image is divided into four parts with the same size, namely upper left, upper right, lower left, and lower right, and are the child notes of R_0 as the second level and denoted as R_1, R_2, R_3 and R_4, respectively. There is one condition to decide whether the current node (i.e., R_1, R_2, R_3 and R_4) needs dividing again. If all the values of the current regions are either 0 or 1, nothing needs to be processed; otherwise, divided again. As for the example of Fig. 1(a), the nodes R_2, R_3 and R_4 are keep intact, and R_1 needs dividing again. Also, the region for R_1 is divided into four equally parts, namely R_{11}, R_{12}, R_{13} and R_{14}, respectively. The number of 1s at R_{11}, R_{12}, R_{13} and R_{14} are 4, 2, 4 and 1, respectively. According to the rule, the nodes R_{12} and R_{14} need to detail the values of their child nodes. P-tree is shown in Fig. 1(b). If the node is not a leaf node and represented by notation *m*, called a PM-tree, as shown in Fig. 1(c).



(a) An 8×8 bSQ file

(b) P-tree

(c) PM-tree

Fig. 1 P-tree and PM-tree for an 8×8 bSQ file

The codes generated by Fig. 1(b) are "*mm*1*m*10101*m*00010010" while traversing order of the PM-tree is from top to down and left to right. If the value of node is 0 or 1, we add 0 before the value; otherwise, we add 1 before the "*m*". Therefore, the final compression codes are obtained as "1010011010100110001000010100".

III. Proposed Scheme

The proposed scheme details two procedures, namely encoding procedure and decoding procedure. The encoding procedure contains embedding phase and mosaic phase.

A. Encoding procedure

At first, the sensitive region and non-sensitive region in a given image *I* are marked as 1 and 0, respectively, to generate a like bSQ file. Next, we transform the bSQ file into a PM tree and finally extract the compression codes. After encoding, three type compression codes 00, 01 and 10 can be transformed into codes 0, 1, and 2, respectively. The transformed compression codes as hidden data *s* are embedded into the original image *I* with Equation (1), where p_x is the *x*-th pixels of *I*, λ is calculated with Equations (2), $|\lambda|$ is the absolute value of λ, and sign() is the function to get the value +1 or -1 if λ is a positive digit or negative one.

$$p'_x = p_x + sign(\lambda) \times ((|\lambda| \bmod 2) - \left\lfloor \frac{|\lambda|}{2} \right\rfloor . \quad (1)$$

$$\lambda = s - (p_x \bmod 3) . \quad (2)$$

After embedding, we make the ROI region as meaningless region by using mosaic function with Equation (3), which can be treated as an encryption process, where α is mosaic factors in a range of [a, b] and it is a private secret value used to control the mosaic strength of ROI region, and *a* is greater than 3. For example, if p'_x is 152 and α is 15, the value of p''_x will be 158.

$$p''_x = p'_x + 3 \times (p'_x \bmod \alpha) . \quad (3)$$

B. Decoding procedure

During decoding, the first step is to extract the codes *s* hidden by the image with Equation (4). Next, the extracted codes are the compression codes used to reconstruct PM tree. The PM tree can be transformed into P-tree and then be the bQS file. Finally, the ROI region can be recognized.

$$s = p''_x \bmod 3 . \quad (4)$$

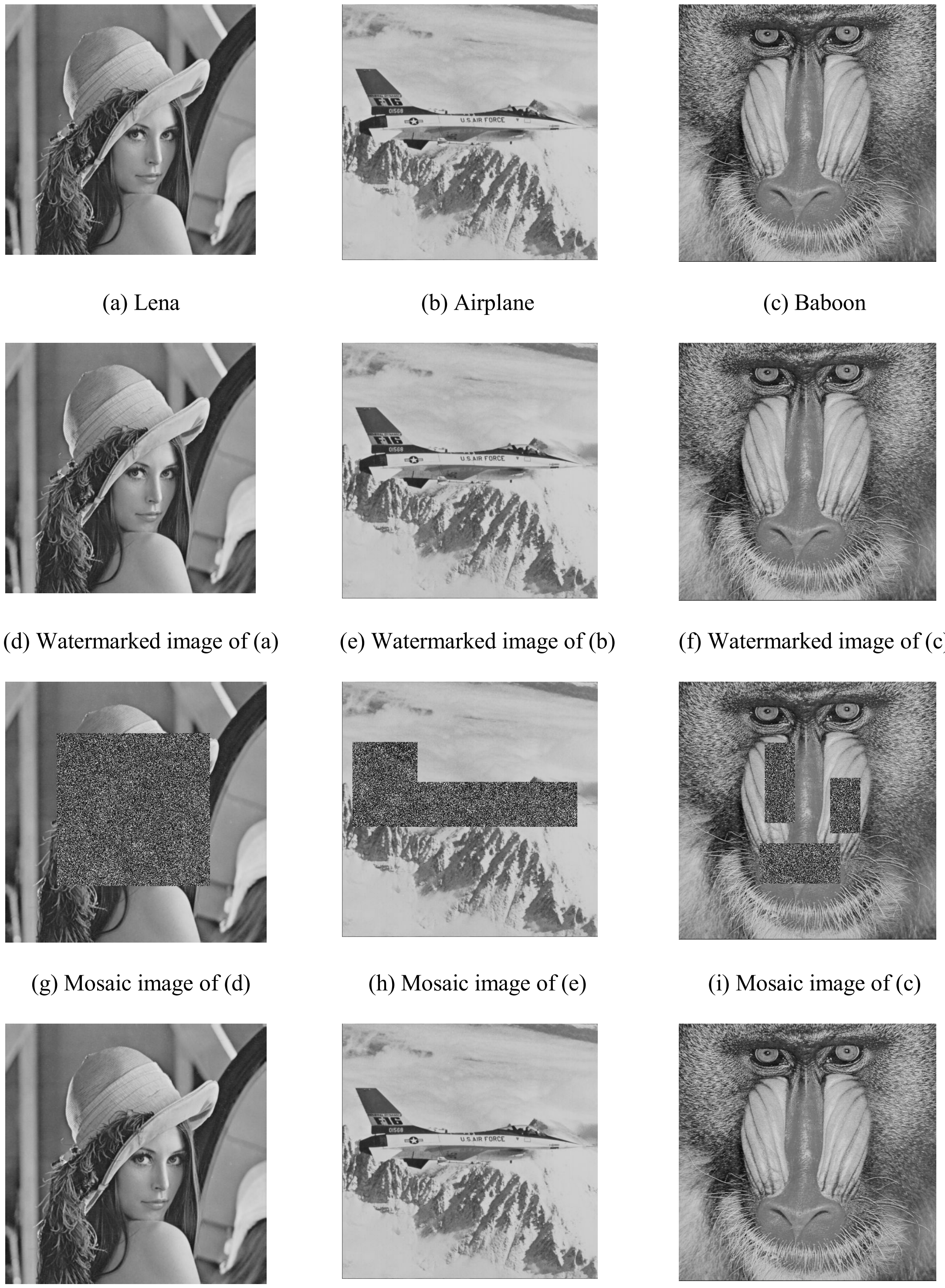
The user can recover the value of p'_x with Equation (5), and this process can be regarded as a decryption process, where β can be computed with Equation (6).

$$p'_x = p''_x - 3 \times \beta \text{ and } p'_x \bmod 3 = p''_x \bmod 3 \text{ and } 0 \le p'_x \le p''_x . \quad (5)$$

$$\beta = p'_x \bmod \alpha . \quad (6)$$

IV. Experiments and Results

In the experiments, three gray-scale images including Lena, Airplane, and Baboon shown in Figs. 2(a), 2(b), and 2(c) are of size 512×512 pixels used to evaluate the performances. The watermarked images of Figs. 2(a), 2(b), and 2(c) are shown in Fig. 2(d), 2(e), and 2(f). It is very difficult to recognize the differences between the original image and watermarked image with human vision system. After that, the ROI region is done by mosaic function as shown in Figs. 2 (g), 2(h), and 2(i) with different size of ROI regions, where α is a digit chosen with the secret key in the range of 3 to 50. Conversely, it is very difficult to realize the original content of the ROI region with naked eyes. After decoding, the de-mosaic image is the same as the watermarked image as shown in Figs. 2 (j), 2(k), and 2(l).



(a) Lena (b) Airplane (c) Baboon

(d) Watermarked image of (a) (e) Watermarked image of (b) (f) Watermarked image of (c)

(g) Mosaic image of (d) (h) Mosaic image of (e) (i) Mosaic image of (c)

(j) Decoded image of (g) (k) Decoded image of (h) (l) Decoded image of (i)

Fig. 2 Watermarked images, mosaic images, and decoded image applied to the original images

The size of ROI region of Figs. 2(g), 2(h), and 2(i) and their corresponding length of compression codes are listed in Table I . After embedding the compression codes into Fig. 2(a), 2(b), and 2(c), the evaluator, PSNR (Peak signal-to-noise ratio), is used to evaluate the visual quality as listed in Table 1. In summary, larger size of ROI region is, lower visual quality will be. The dispersed ROI region causes larger length of compression codes. That is, the size of compression codes is affected by the pixels in ROI region whether they are neighboring pixels. For example, the size of ROI region of Baboon is smallest, but largest length of compression codes because three ROI regions in Fig. 2(g) are dispersed. On average, the visual quality is higher than 65 dB. The visual quality of mosaic image is very bad such that users cannot realize what the original contents are. After decoding, the visual quality is the same as the watermarked image. That is, the visual quality of watermarked image keeps intact after decoding.

Table I. The visual qualities of test images based on different size of ROI region

Original Image	Lena	Airplan e	Babo on
Size of ROI region (bits)	90000	50900	2900 0
Length of compression codes (bits)	7210	7402	7546
PSNR of watermarked image (dB)	65.49	65.33	65.27
PSNR of mosaic image (dB)	13.40	14.38	17.67
PSNR of de-mosaic image (dB)	65.49	65.33	65.27

Table Ⅱ shows the strength of mosaic area controlled by the range of α value for Lena image. The higher α value makes higher strength of mosaic in ROI region. The visual quality of mosaic image is worst in that α value is fallen into a range with larger values of a and b than that of the others.

Table II. The strength of mosaic area based on different range of α value

Range of α value $[a, b]$	Visual quality of mosaic image (Lena for example)
α=[3, 20]	25.7468
α=[20, 30]	18.1220
α=[30, 40]	15.4882
α=[40, 50]	14.4168

V. Conclusions and Future Works

In this paper, a fine-grained access control model using mosaic technique for digital images is proposed. The model is appropriate to the privacy protection which needs low cost of maintenance. Due to images of Google Street View cannot be as the test image in our experiments because which involves personal privacy information. In the future, we shall try this way applying to other applications, such as personal image management. Some issues related to access control (e.g., delegation, federate cooperation, etc) would be concerned in the nearly future.

VI. Acknowledgement

I gratefully acknowledge financial support for this research provided by the National Science Council with No. NSC 102-2221-E-468-009.

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