INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES
&
MANAGEMENT

Ijesm
Consulting, help, relaxation

Generic Lossless Visible watermarking

K.SUNDEEP PG STUDENT Nellore sundeepreddy2020@gmail.com
P.MUNA SWAMY , PROFESSOR,NEC,Nellore,sidduvamsi@gmail.com

Abstract— A novel method for generic visible watermarking with a capability of lossless image recovery is proposed. The method is based on the use of deterministic one-to-one compound mappings of image pixel values for overlaying a variety of visible watermarks of arbitrary sizes on cover images. The compound mappings are proved to be reversible, which allows for lossless recovery of original images from watermarked images. The mappings may be adjusted to yield pixel values close to those of desired visible watermarks. Different types of visible watermarks, including opaque
monochrome and translucent full color ones, are embedded as applications of the proposed generic approach. A two-fold monotonically increasing compound mapping is created and proved to yield more distinctive visible watermarks in the watermarked image. Security protection measures by parameter and mapping randomizations have also been proposed to deter attackers from illicit image recoveries. Experimental results demonstrating the effectiveness of the proposed approach are also included.

Index Terms—Lossless reversible visible watermarking, mapping randomization, one-to-one compound mapping, parameter randomization, translucent watermark, two-fold monotonically increasing.

I.INTRODUCTION

THE advance of computer technologies and the proliferation
of the Internet have made reproduction and distribution of digital information easier than ever before. Copyright protection of intellectual properties has, therefore, become an important topic. One way for copyright protection is *digital watermarking* [1]–[7], which means embedding of certain specific information about the copyright holder (company logos, ownership descriptions, etc.) into the media to be protected. Digital watermarking methods for images are usually categorized into two types: *invisible* and *visible*. The first type aims to embed copyright information imperceptibly into host media such that in cases of copyright infringements, the hidden information can be retrieved to identify the ownership of the protected host. It is important for the watermarked image to be resistant to common image operations to ensure that the hidden information is still retrievable after such alterations. Methods of the second type, on the other hand, yield visible watermarkswhich are generally clearly visible after common image operations are applied. In addition, visible watermarks convey ownership information directly on the media and can deter attempts of copyright violations.

Embedding ofwatermarks, either visible or invisible, degrade the quality of the host media in general. A group of techniques, named *reversible* watermarking [8]–[19], allow legitimate users to remove the embedded watermark and restore the original content as needed. However, not all reversible watermarking techniques guarantee *lossless image recovery*, which means that the recovered image is identical to the original, pixel by pixel. Lossless recovery is important in many applications where serious concerns about image quality arise. Some examples include forensics, medical image analysis, historical art imaging, or military applications. Compared with their invisible counterparts, there are relatively few mentions of lossless visible watermarking in the literature. Several lossless invisible watermarking techniques have
been proposed in the past. The most common approach is to compress a portion of the original host and then embed the compressed data together with the intended payload into the host [5],[13]–[15]. Another approach is to superimpose the spread-spectrum signal of the payload on the host so that the signal is detectable and removable [3]. A third approach is to manipulate a
group of pixels as a unit to embed a bit of information [16], [17]. Although one may use lossless invisible techniques to embed removable visible watermarks [11], [18], the low embedding capacities of these techniques hinder the possibility of implanting
large-sized visible watermarks into host media. As to lossless visible watermarking, the most common approach is to embed a monochrome watermark using deterministic and reversible mappings of pixel values or DCT coefficients in the watermark region [6], [9], [19]. Another approach is to rotate consecutive watermark pixels to embed a visible watermark [19]. One advantage of these approaches is that watermarks of arbitrary sizes can be embedded into any host image. However, only *binary* visible watermarks can be embedded using these approaches, which is too restrictive since most company logos are colorful.

In this paper, a new method for lossless visible watermarking is proposed by using appropriate *compound mappings* that allow mapped values to be controllable. The mappings are proved to be *reversible* for lossless recovery of the original image. The approach is *generic*, leading to the possibility of embedding different types of visible watermarks into cover images. Two applications of the proposed method are demonstrated, where opaque monochrome watermarks and nonuniformly translucent full-color ones are respectively embedded into color images.

II. PROPOSED NEW APPROACH TO LOSSLESS VISIBLE WATERMARKING

In this section, we describe the proposed approach to lossless reversible visible watermarking, based on which appropriate one-to-one compound mappings can be designed for embedding different types of visible watermarks into images. The original image can be recovered losslessly from a resulting watermarked image by using the corresponding reverse mappings.

II.I. Reversible One-to-One Compound Mapping

First A generic one-to-one compound mapping f is proposed for converting a set of numerical values p= *to another set Q= such that the respective mapping from* p_i to q_i for all i=1,2,….M is reversible. Here, for the copyright protection all the values p_i and q_i are image pixel values(gray scale or color values). The compound mapping f is governed by a one-to-one function F_x with one parameter x=a or b in the following way:

$q=f(p)=F_b^{-1}(F_a(p)$ ………………………. (1)

where F_x^{-1} is the inverse of F_x which by the one-to-one property, leads to the fact that if $F_a(p)=p'$ then $F_a^{-1}(p')$ for all values of a and p. on the other hand, $F_a(p)$ and $F_b(p)$ generally are set to be unequal if a≠b.

The compound mapping described by (1) is indeed reversible, that is, p can be derived exactly from q using the following formula:

$p=f^{-1}(q)=F_a^{-1}(F_b(q))$ …………………………..(2)

as proved below.

Lemma 1(Reversibility of Compound Mapping): If $q=F_b^{-1}(F_a(p))$ for any one-to-one function F_x with a parameter x, then $p=F_a^{-1}(F_b(q))$ for any values of a,b,p and q.

Proof: Substituting (1) into $F_a^{-1}(F_b(q))$ we get

$$F_a^{-1}(F_b(q))=F_a^{-1}(F_b(F_b^{-1}(F_a(p)))).$$

By regarding $F_a(p)$ as a value c, the right-hand side becomes $F_a^{-1}(F_b(F_b^{-1}(c)))$, which, after F_b and F_b^{-1} are cancelled out, becomes $F_a^{-1}(c)$. But $F_a^{-1}(c)=F_a^{-1}(F_a(p))$, which is just p after F_a and F_a^{-1} are cancelled out. That is, we have proved $p=F_a^{-1}(F_b(q))$.

As an example, if $F_x(p)= xp+d$, then $F_x^{-1}(p')=(p'-d)/x$.

Thus

$$q=F_b^{-1}(F_a(p))=F_b^{-1}(ap+d)=(ap+d-d)/b=ap/b$$

And so, we have

$$F_a^{-1}(F_b(q)) =F_a^{-1}(b(ap/b)+d)=F_a^{-1}(ap+d)=[((ap+d)-d)/a]=(ap/a)=p$$

As expected by lemma 1.

II.2 Lossless Visible Watermarking Scheme

Based on lemma 1, we will now derive the proposed generic lossless visible watermarking scheme in the form of a class of one-to-one compound mappings, which can be used to embed a variety of visible watermarks into images. The embedding is reversible, that is, the watermark can be removed to recover the original image losslessly. For this aim, a preliminary lemma is first described as follows.

Lemma2 (preference of compound-mapped value q): It is possible to use the compound mapping $q=F_b^{-1}(F_a(p))$ to convert a numerical value p to another value close to a preferred value l.

Proof: Let $F_x(p)=p-x$ where x is the parameter for F. Then $F_x^{-1}(p^1)=p^1+x$. Also, let a=p-€ and b=l where € is a small value. Then, the compound mapping $F_b^{-1}(F_a(p))$ of p yields q as

$$q=F_b^{-1}(F_a(p))=F_b^{-1}(p-a)=F_b^{-1}(€)=€+b=€+l$$

which means that the value q is close to the preferred value l.

The above lemma relies on two assumptions. The first is that a is close to p, or equivalently, that a=p-€ instead of for a=p, is that in the reverse mapping we want to recover p from q without knowing p, which is a requirement in the applications of reversible visible watermarking investigated in this study. Although the value of p cannot be known in advance for such applications, it can usually be estimated.

The second assumption is that $F_x(p)$ yields a small value if x and p are close. Though the basic difference function $F_x(p)=p-x$ used in the above proof satisfies this requirement for most cases, there is a possible problem where the mapped value may exceed the range of valid pixel values for some values of a,b and p. For example, when a=255, b=255 and p=253, we have q=255-253+255=257>255. It is possible to use the standard modulo technique(i.e., taking $q=257_{mod256}=1$) to solve this issue; however, such a technique will make q far from the desired target value of b, which is 255.

By satisfying the above two requirements, the compound mapping yields a value q that is close to the desired value l. we now prove a theorem about the desired lossless reversible visible watermarking in the following.

Theorem 1 (Lossless Reversible Visible Watermarking): There exist one-to-one compound mappings for use to embed into a given image I a visible watermark Q whose pixel values are close to those of a given watermark L, such that the original image I can be recovered from Q losslessly.

Proof: This is a consequence of lemmas 1 and 2 after regarding the individual pixel values in I,L and Q respectively as those of p,l and q mentioned in lemma2. And it is clear by lemma 1 that the value p can be recovered losslessly from the mapped value q which is derived in lemma 2.

The above discussions are valid for embedding a watermark in a grayscale image. If color images are used both as the cover image and the watermark, we can apply the mappings to each of the color channels to get multiple independent results. The resulting visible watermark is the composite result of the color channels.

Based on the theorem 1, the proposed generic lossless reversible visible watermarking scheme with a given image I and a watermark L as input is described as an algorithm as follows

II.2.1 Algorithm 1: Generic Visible watermark Embedding

Input: an image I and a watermark L

Output: watermarked image W.

Steps:

1. Select a set P of pixels from I where L is to be embedded, and call P a watermarking area.
2. Denote the set of pixels corresponding to P in W by Q.
3. For each pixel X with value p in P, denote the corresponding pixel in Q as Z and the value of the corresponding pixel y in L as l, and conduct the following steps.
    a. Apply an estimation technique to derive a to be a value close to p, using the values of the neighboring pixels of X (excluding x itself).
    b. Set b to be the value l.
    c. Map p to a new value $q=F_b^{-1}(F_a(p))$.
    d. Set the value of Z to be q.
4. Set the value of each remaining pixel in W, which is outside the region P, to be equal to that of the corresponding pixel in I.

Note that we do not use the information of the original image pixel value of x itself for computing the parameters a and b for x. This ensures that identical parameter values can be calculated by the receiver of a watermarked image for the purpose of lossless image recovery.

As an example, the process performed by step3 of the above algorithm for a pixel is illustrated by Fig. 1, where the north and west pixels are used to estimate the color of the center pixel. The east and south pixels are not used because these pixels are covered by the watermark and unknown to the receiver. It is important to allow as many neighbors of a pixel as possible to be known by the receiver to ensure that a good estimate can be calculated for that pixel.

The corresponding watermark removal process for a watermarked image W generated by algorithm 1 is described as an algorithm as follows.

II.2.2 Algorithm 2: Generic Watermark Removal for Lossless Image Recovery

Input: a watermarked image W and a watermark L

Output: The original image R recovered from W

Steps:

1. Select the same watermarking area Q in W as that selected in algorithm 1
2. Set the value of each pixel in R, which is outside the region Q, to be equal to that of the corresponding pixel in W.
3. For each pixel Z with value q in Q, denote the corresponding pixel in the recovered image R as x and the value of the corresponding pixel Y in L as l, and conduct the following steps.
    a. Obtain the same value a as that derived in step 3a of algorithm 1 by applying the same estimation technique used there.
    b. Set b to be the value l.
    c. Restore p from q by setting $p=F_a^{-1}(F_b(q))$.
    d. Set the value of x to be p.

Fig:1:a:watermark image b:opaque watermark c:translucent watermark

II.3 Security Considerations

As mentioned previously, although we want legitimate users to be able to recover the original image from a watermarked one, we do not want an attacker to be able to do the same. Herein, we propose some security protection measures against illicit recoveries of original images.

First, we make the parameters a and b in the above algorithm to be dependent on certain secret keys that are known only by the creator of the watermarked image and the intended receivers. One simple technique to achieve this is to use a secret key to generate a pseudo-random sequence of numerical values and add them to either or both of a and b for the pixels in the watermarking area. This technique is hereinafter referred to as parameter randomization.

Another way of security protection is to make the choices of the positions for the pixels to be dependent on a secret key. Specifically, we propose to process two randomly chosen pixels (based on the security key) in P simultaneously as follows. Let the two pixels be denoted as X_1 and X_2 with values p_1 and p_2, respectively.

Fig.3.1. Illustration of mapping the center pixel of a 3x3 image using Algorithm 1. Only the mapping of the center pixel is shown for clarity; the east and south pixels are depicted as TBD (to be determined) in.

Fig.3.2. Illustration of pixels in a watermark. (a) A monochrome watermark. (b) Area of _ (yellow pixels). (c) Area of _ (yellow pixels).

The color estimates a_1 and a_2 corresponding to X_1 and X_2 respectively, are individually derived as before using their respective neighbors. The parameters b_1 and b_2 are set to be the values l1 and l2 of the respective watermark pixels Y_1 and Y_2. Then, instead of setting the values of the watermarked pixels Z_1 and Z_2 to be $q_1=F_{b1}^{-1}(F_{a1}(p_1))$ and $q_2=F_{b2}^{-1}(F_{a2}(p_2))$ as before, we swap the parameters and set

$$q_1=F_{b1}^{-1}(F_{a2}(p_2)) \quad \text{and} \quad q_2=F_{b2}^{-1}(F_{a1}(p_1)).$$

This parameter exchange does not affect the effectiveness of lossless recoverability, because we can now recover the original pixel values by the following compound mappings:

$$p_1=F_{a1}^{-1}(F_{b2}(q_2)) \text{ and } p_2=F_{a2}^{-1}(F_{b1}(q_1)).$$

We will refer to this technique in the sequel as mapping randomization. We may also combine this technique with the above mentioned parameter randomization technique to enhance the security further.

Last, the position in the image where a watermark is embedded affects the resilience of the watermarked image against illicit image recovery attempts. In more detail, if the watermark is embedded in a smooth region of the image, an attacker can simply fill the region with the background color to remove the watermark irrespective of the watermarking technique used. To counter this problem, an appropriate position should be chosen, using, the adaptive positioning technique when embedding a watermark. However, for ease of discussions and comparisons, we always embed a watermark in the lower right-hand corner of an image in this study.

III.RESULTS&DISCUSSION

To quantitatively measure the effectiveness of the proposed method, we define a set of performance metrics here. First, the quality of a watermarked image W is measured by the peak signal-to-noise ratio (PSNR) of W with respect to the nonrecoverable watermarked image B in the following way:

$$\mathrm{PSNR}_W = 20 \times \log_{10}\left(255 \Big/ \sqrt{\frac{1}{w \times h}\sum_{y=1}^{h}\sum_{x=1}^{w}[W(x,y)-B(x,y)]^2}\right)$$

Also, the quality of a recovered image R is measured by the PSNR of R with respect to the original image I in a similar way.

$$\mathrm{PSNR}_R = 20 \times \log_{10}\left(255 \Big/ \sqrt{\frac{1}{w \times h}\sum_{y=1}^{h}\sum_{x=1}^{w}[R(x,y)-I(x,y)]^2}\right)$$

It is desired to have the value of the PSNR_W to be as high as possible, so that the watermarked image can be visually as close to the benchmark image as possible. For illicit recoveries, the PSNR_R should be as low as possible to make the recovered image visually intolerable (e.g., very noisy). In particular, we want the region obscured by the watermark to be as noisy as possible in an illicitly recovered image. For this purpose, we introduce an additional quality metric for an illicitly recovered image that only takes into account the region Q covered by the watermark. Specifically, we measure the quality of the recovered image R by the following PSNR measure:

$$\mathrm{PSNR}_Q = 20 \times \log_{10}\left(255 \Big/ \sqrt{\frac{1}{|Q|}\sum_{y=1}^{h}\sum_{x=1}^{w} SE_Q(x,y)}\right)$$

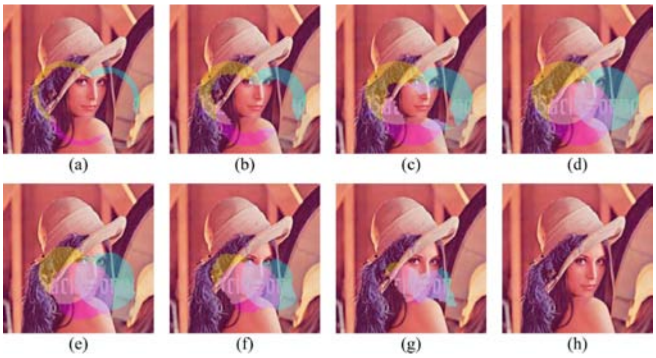

Fig. 2. Illustration of pixel processing order in watermark embedding and removal. (a)–(d) Intermediate results of image watermarking when 25%, 50%, 75%, and 100% of the watermark pixels have been processed, respectively. (e)–(h) Intermediate results of image recovery when 25%, 50%, 75%, and 100% of the watermark pixels have been recovered, respectively.

IV. CONCLUSION

In this paper, a new method for reversible visible watermarking with lossless image recovery capability has been proposed. The method uses one-to-one compound mappings that can map image pixel values to those of the desired visible watermarks. Relevant lemmas and theorems are described and proved to demonstrate the reversibility of the compound mappings for lossless reversible visible watermarking. The compound mappings allow different types of visible watermarks to be embedded, and two applications have been described for embedding opaque monochrome watermarks as well as translucent full-color ones. A translucent watermark is clearly visible and visually appealing, thus more appropriate than traditional transparent binary watermarks in terms of advertising effect and copyright declaration. The two-fold monotonically increasing property of compound mappings was defined and an implementation proposed that can provably allow mapped values to always be close to the desired watermark if color estimates are accurate. Also described are parameter randomization and mapping randomization techniques, which can prevent illicit recoveries of original images without correct input keys. Experimental results have demonstrated the feasibility of the proposed method and the effectiveness of the proposed security protection measures.

BIBLIOGRAPHY:

1. F. A. P. Petitcolas, R. J. Anderson, and M. G. Kuhn, "Information hiding—A survey," Proc. IEEE, vol. 87, no. 7, pp. 1062–1078, Jul. 1999.
2. N. F. Johnson, Z. Duric, and S. Jajodia, Information Hiding. Steganographyand Watermarking—Attacks and Countermeasures. Boston, MA: Kluwer, 2001.
3. I. J. Cox, J. Kilian, F. T. Leighton, and T. Shamoon, "Secure spread spectrum watermarking for multimedia," IEEE Trans. Image Process., vol. 6, no. 12, pp. 1673–1687, Jun. 1997.
4. M. S. Kankanhalli, Rajmohan, and K. R. Ramakrishnan, "Adaptive visible watermarking of images," in Proc. IEEE Int. Conf. Multimedia Computing and Systems, 1999, vol. 1, pp. 568–573.
5. Y. Hu and S.Kwong,"Wavelet domain adaptive visiblewatermarking," Electron. Lett., vol. 37, no. 20, pp. 1219–1220, Sep. 2001.
6. S. P. Mohanty, K. R. Ramakrishnan, and M. S. Kankanhalli, "A DCT domain visible watermarking technique for images," in Proc. IEEE Int. Conf. Multimedia and Expo, Jul. 2000, vol. 2, pp. 1029–1032.
7. G.Braudaway, K. A. Magerlein, and F. Mintzer, "Protecting publiclyavailable images with a visible image watermark," in Proc. SPIE Int.Conf. Electronic Imaging, Feb. 1996, vol. 2659, pp. 126–133.
8. Y.J. Cheng and W. H. Tsai, "A new method for copyright and integrityprotection for bitmap images by removable visible watermarksand irremovable invisible watermarks," presented at the Int. ComputerSymp.—Workshop on Cryptology and Information Security, Hualien,Taiwan, R.O.C., Dec. 2002.
9. P. M. Huang and W. H. Tsai, "Copyright protection and authenticationof grayscale images by removable visible watermarking and invisiblesignal embedding techniques: A new approach," presented at the Conf.Computer Vision, Graphics and Image Processing, Kinmen, Taiwan,R.O.C., Aug. 2003.
10. Y. Hu, S. Kwong, and J. Huang, "An algorithm for removable visiblewatermarking," IEEE Trans. Circuits Syst. Video Technol., vol. 16, no.1, pp. 129–133, Jan. 2006.
11. Y. Hu and B. Jeon, "Reversible visible watermarking and lossless recoveryof original images," IEEE Trans. Circuits Syst. Video Technol.,vol. 16, no. 11, pp. 1423–1429, Nov. 2006.
12. B. Macq, "Lossless multiresolution transform for image authenticatingwatermarking," presented at the European Signal Processing Conf.,Tampere, Finland, Sep. 2000.
13. J. Fridrich, M. Goljan, and R. Du, "Lossless data embedding—Newparadigm in digital watermarking," J. Appl. Signal Process., vol. 2002,no. 2, pp. 185–196, Feb. 002.
14. M. Awrangjeb and M. S. Kankanhalli, "Lossless watermarking considering the human visual system," presented at the Int. Workshop on Digital Watermarking, Seoul, Korea, Oct. 2003.
15. M. Awrangjeb and M. S. Kankanhalli, "Reversible watermarking using a perceptual model," *J. Electron. Imag.*, vol. 14, no. 013014, Mar. 2005.
16. C. de Vleeschouwer, J. F. Delaigle, and B. Macq, "Circular interpretation of bijective transformations in lossless watermarking for media asset management," *IEEE Trans. Multimedia*, vol. 5, no. 1, pp. 97–105, Mar. 2003.
17. J. Tian, "Reversible data embedding using a difference expansion," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, no. 8, pp. 890–896, Aug. 2003.
18. H. M. Tsai and L. W. Chang, "A high secure reversible visible watermarking scheme," in *Proc. IEEE Int. Conf. Multimedia and Expo*, Beijing, China, Jul. 2007, pp. 2106–2109.
19. S. K. Yip, O. C. Au, C. W. Ho, and H. M. Wong, "Lossless visible watermarking," in *Proc. IEEE Int. Conf. Multimedia and Expo*, Jul. 2006, pp. 853–856.
20. A. Lumini and D. Maio, "Adaptive positioning of a visible watermark in a digital image," in *Proc. Int.*