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Smart Grid Monitoring using IoT with Renewable Integration

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ABSTRACT: A new blind authentication method based on the secret sharing technique with a data repair capability for color document images via the use of the Portable Network Graphics (PNG) image is proposed. An authentication signal is generated for each block of a color document image, which, together with the binarized block content, is transformed into several shares using the Shamir secret sharing scheme. The involved parameters are carefully chosen so that as many shares as possible are generated and embedded into an alpha channel plane. The alpha channel plane is then combined with the original color image to form a PNG image. During the embedding process, the computed share values are mapped into a range of alpha channel values near their maximum value of 255 to yield a transparent stego-image with a disguise effect. In the process of image authentication, an image block is marked as tampered if the authentication signal computed from the current block content does not match that extracted from the shares embedded in the alpha channel plane. Data repairing is then applied to each tampered block by a reverse Shamir scheme after collecting two shares from unmarked blocks. Measures for protecting the security of the data hidden in the alpha channel are also proposed.

KEYWORDS: Data hiding, data repair, grayscale document image, image authentication, Portable Network Graphics (PNG)image, secret sharing.

I. INTRODUCTION

Digital image is a form for preserving important information. However, with the fast advance of digital technologies, it is easy to make visually imperceptible modifications to the contents of digital images. How to ensure the integrity and the authenticity of a digital image is thus a challenge. It is desirable to design effective methods to solve this kind of imageauthentication problem, particularly for images of documents whose security must be protected. It is also hoped that, if part of a document image is verified to have been illicitly altered, the destroyed content can be repaired. Such image content authentication and self-repair capabilities are useful for the security protection of digital documents in many fields, such as important certificates, signed documents, scanned checks, circuit diagrams, art drawings, design drafts, last will and testaments, and so on.

Document images, which include texts, tables, line arts, etc., as main contents, are often digitized into gray scale images with two major gray values, one being of the background (including mainly blank spaces) and the other of the foreground (including mainly texts). It is noted that such images, although gray valued in nature, look like binary. The binary-like gray scale document images may be threshold into binary ones for later processing, but such a thresholding operation often destroys the smoothness of the boundaries of text characters, resulting in visually unpleasant stroke appearances with zigzag contours. Therefore, in practical applications, text documents are often digitized and kept as grayscale images for later visual inspection.

The image authentication crisis is difficult for a binary document image because of its simple binary nature which leads to perceptible changes after authentication signals are embedded in the image pixels. Such changes will arouse possible doubts from attackers. A good solution to such binary image authentication thus should take into account not only the security issue of preventing image tampering, but also the necessity of keeping the visual quality of the resulting image. Several methods for binary image authentication have been proposed in the past.C. S. Lu and H. Y. M. Liao[2] proposed a multipurpose watermarking scheme which can simultaneously achieve copyright protection and content authentication by hiding multipurpose watermarks at the same time.Wu and Liu [4] manipulated the so-called flippable pixels to create specific relationships to embed data for authentication and annotation of binary images. H. Y. Kim and A.[7] proposed a set of pseudorandom pixels in a binary or halftone image are chosen and cleared, and authentication

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codes are accordingly computed and inserted into selected random pixels.Yang and Kot [5] proposed a two-layer binary image authentication method in which one layer is used for checking the image fidelity and the other for checking image integrity. In the method, a connectivity-preserving transition criterion for determining the flippability of a pixel is used for embedding the cryptographic signature and the block identifier.Yang and Kot [6] proposed a pattern-based data hiding method for binary image authentication in which three transition criteria are used to determine the flippabilities of pixels in each block, and the watermark is adaptively embedded into embeddable blocks to deal with the uneven embed ability condition in the host image.Lee et al. [8] proposed a Hamming-code-based data embedding method that flips one pixel in each binary image block for embedding a watermark,yielding small distortions and low false negative rates. Here,an authentication method is proposed which deals with binary-like grayscaledocument images as a replacement for of pure binary ones, and solves concurrently the problems of image tampering detection and visual quality keeping. In this study, a method for authentication of document images with a supplementary self-repair capability for fixing tampered image data is proposed. The input cover image is assumed to be a binary-like grayscale image with 2 major gray values. After the proposed method is applied, the cover image is transformed into a stego-image in the PNG format with an supplementary alpha channel for transmission on networks or archiving in databases. The stego-image, when received or retrieved, may be verified by the proposed technique for its authenticity. Integrity modifications of the stegoimage can be detected by the method at the block level and repaired at the pixel level.

In case that the alpha channel is totally removed from the stego-image, the intact resulting image is regarded as inauthentic, meaning that the fidelity check of the image fails. The proposed method is based on the so-called (k,n)-threshold secret sharing scheme proposed by Shamir in which a secret message is transformed into n shares for keeping by n participants; and when k of the nshares, not necessarily all of them, are collected, the secret message can be recovered without any loss. Such a secret sharing scheme is useful for reducing the risk of incidental partial data loss.

II. PROPOSED SYTEM

The secured color document transfer using PNG image with data repair capability using alpha channel is the proposed system.

THE SHAMIR METHOD FOR SECRET SHARING

The proposed approach to secret image sharing is based on the (k,n)-threshold secret sharing method proposed.In this section we describe how to use the Shamir method for conventional secret sharing. By the Shamir method, to generate n shares for a group of nsecret sharing participants from a secret integer value y for the threshold k, we can use the following (k-1)-degree polynomial in the following way.

Algorithm 1: (k,n)-threshold secret sharing

Input: Secret d in the form of an integer, number of participants, and threshold.

Output : Shares in the form of integers for the participants to keep.

Step 1 :Choose randomly a prime number that is larger than d.

Step 2: Select k-1 integer values within the range of 0 through p-1.

Step 3 : Select n distinct real values $x_1, x_2, \ldots, x_n$.

Step 4 : Use the following (k-1)-degree polynomial to compute n function values,

$F(x_i)$ called partial shares for i=1,2,……,n, i.e.,

$$F(x_i) = (d + C_1 x_i + C_2 x_i^2 + \cdots + C_{k-1} x_i^{k-1})_{\text{mod } p} \qquad (1)$$

Step 5 : Deliver the 2-tuple $(x_i, F(x_i))$ as a share to the i th participant where i=1,2,……,n.

The k coefficients, namely d and c_k through c_{k-1}in Eqn. (1) above, it is necessary together at least shares from the n participants to form k equations of the form of Eqn.(1) to solve these k coefficients in order to recover secret d. This explains the term threshold for k and the name (k,n) -threshold for the Shamir method . Below is a description of the just-mentioned equation-solving process for secret recovery.

Algorithm 2: Secret recovery

Input :k shares collected from the n participants and the prime number p with both k and p being those used in Algorithm 1.

Output :Secret d hidden in the shares and coefficients ci used in Eqn. (1) in Algorithm 1, where i=1, 2 k-1.

Step1 : Use the k shares $(x_1, F(x_1))$, $(x_2, F(x_2))\ldots (x_k, F(x_k))$ to setup

$$F(x_j) = (d + C_1 x_j + C_2 x_j^2 + \cdots + C_{k-1} x_j^{k-1})_{\text{mod } p} \quad (2) \qquad \text{Where } j=1,2\ldots k.$$

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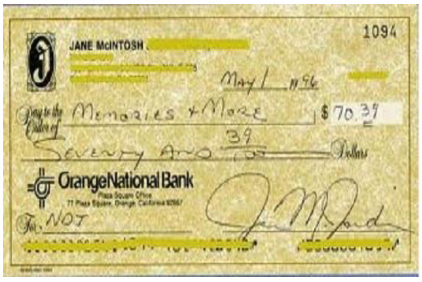
Step2: Solve the k equations above by Lagrange's interpolation to obtain d as Follows

$$d=(-1)^{k-1}[F(x_1)\frac{x_2x_3\ldots x_k}{(x_1-x_2)(x_1-x_3)\ldots(x_1-x_k)}+ F(x_2)\frac{x_1x_3\ldots x_k}{(x_2-x_1)(x_2-x_3)\ldots(x_2-x_k)}+\cdots+ F(x_k)\frac{x_1x_2\ldots x_{k-1}}{(x_k-x_1)(x_k-x_2)\ldots(x_k-x_{k-1})}]\bmod p$$

Step 3: Compute $c_1$through $c_{k-1}$by expanding the following equality and comparing the result with Eqn. (2) in Step 1 while regarding variable x in the equalitybelow to be xj in (2):

$$F(x)=[F(x_1)\frac{(x-x_2)(x-x_3)\ldots(x-x_k)}{(x_1-x_2)(x_1-x_3)\ldots(x_1-x_k)}+F(x_2)\frac{(x-x_1)(x-x_3)\ldots(x-x_k)}{(x_2-x_1)(x_2-x_3)\ldots(x_2-x_k)}+\cdots + F(x_k)\frac{(x-x_1)(x-x_2)\ldots(x-x_{k-1})}{(x_k-x_1)(x_k-x_2)\ldots(x_k-x_{k-1})}]\bmod p$$

In the above algorithm Step3 is in addition included for the purpose of computing the values of parameters $c_i$in the proposed method. In other applications, if only the secret value need be recovered, this step may be eliminated.If fewer than k secret shares are collected, the k unknowns cannot be solved and the desired y value cannot be reconstructed.



Color Image

Input Image

PNG Image

Fig 1:convertion of color image to PNG image

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IMAGE AUTHENTICATION AND DATA REPAIRING

PNG image from a binary-type grayscale document image S with an alpha channel plane is created . The actual image S may be assumed as a grayscale channel plane of the PNG image. Then, S is converted to binary form with moment-preserving threshold, yielding a binary version of S, which we denote as S. Data image for authentication and repairing are then computed from Sb and taken as an input to Shamir's secret sharing scheme, to generate n secret shares of the data. The share values are mapped subsequently into a small range of alpha channel values near the maximum transparency value to create an imperceptibility effect. Lastly, the mapped secret shares are randomly entrenched into the alpha channel for the function of promoting the security, protection and data repair capability.

The alpha channel plane is used for carrying data for authentication and repairing, so no demolition will occur to the input image in the process of verification. On the contrary, traditional image authentication methods often sacrifice part of image contents, such as LSB's or pixels that can be flipped, to provide accommodation to data used for authentication.

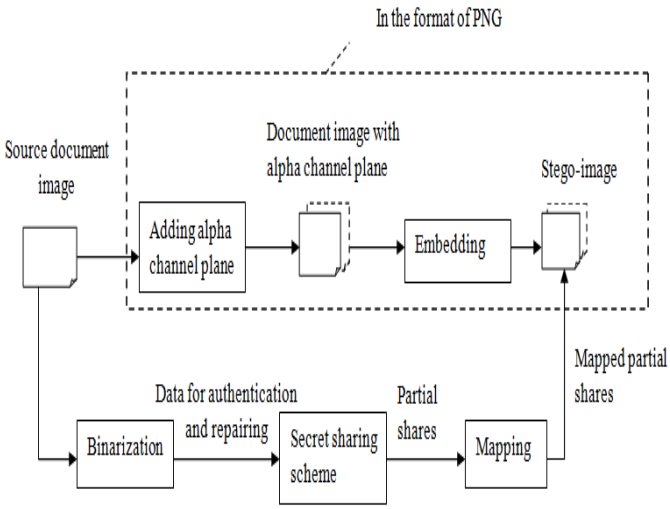

Fig 2:Creating a PNG image from color document image and an Alpha channel

Additionally, once stego-image generated from a conventional method like an LSB-based one is unintentionally compressed by a lossy compression method, the stego-image might cause fake positive alarms in the authentication system. In comparison, the anticipated method yields a stego-image in the PNG format which in usual cases will not be compressed further, reducing the opportunity of invalid authentication caused by imposing undesired compression operations on the stego-image.

GENERATING STEGO-IMAGE

A comprehensive algorithm for describing the generation of a stego-image in the PNG format of the anticipated method is presented as follows:

Algorithm 3:Generating a stego-image in PNG format from a given grayscale image.

Input :A image document in grayscale S with two major grayvalues, and a secret key K.

Output:A stego-image S′ in the PNG format with relevant data embedded, including the authentication signal and the data used for repairing

Step A: Generating authentication signals

(i) (Conversion of Input image to Binary form) Apply moment-preserving threshold [6] to S to obtaintwo representative gray values g1 and g2, compute **$T = (g_1 + g_2)/2$;** And use T as a threshold to convert S into binary form, yielding the binary version $S_b$with "0" representing g_1 and "1" representing g_2

(ii) (Convert the cover image into the PNG format) Convert S into a PNG image with an alpha channel plane$S_\alpha$by creating a new image layer with 100% opacity and no color as $S_\alpha$and combining it with S using an image processing software package.

(iii) Take in an unrefined raster-scan order a 2×3 block $B_b$of S_b with pixels $p_1,p_2\ldots p_6$.

(iv) (Creating authentication signals) Create a 2-bit authentication signal $Z=a_1a_2$with $a_1 = p_1$ XOR p_2XOR p_3 and $a_2= p_4$XOR p_4 XOR p_6. Step B: Design and Embedding of Shares

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(v) (Creating data for secret sharing) concatenate the 8 bits of a_1, a_2, and $p_1$through p_6 to form an 8-bit string, divide the string into two 4-bit segments, and convert the segments into 2 decimal numbers $m_1$and m_2, respectively.

(vi) (Generation of Partial Share) Set p, c_i, and $x_i$in Eqn. (1) of Algorithm 1 to be the following values:

(a)p = 17(the smallest prime number larger than15);

(b) $d = m_1, c_1 = m_2$;

(c) $x_1 = 1$, $x_2 = 2$, …, $x_6 = 6$; and execute Algorithm 1 as a (2, 6)-threshold secret sharing scheme to generate six partial shares q_1 through q_6 using the following equations:

$$q_i = F(x_i) = (d + c_1 x_i) \bmod p \ldots\ldots \quad (3)$$

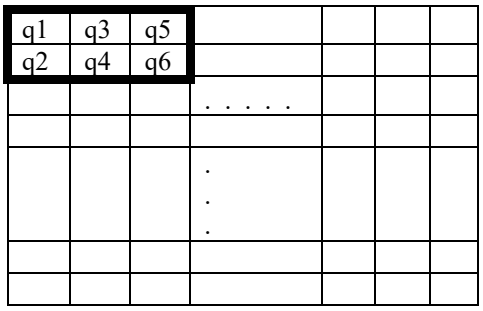
where i = 1, 2… 6.

(vii) (Map of the partial shares) Adding 238 to each of q_1 through q_6, resulting in the new values of q_1', through q_6', respectively, which fall in the nearly total transparency range of 238 through 254 in the alpha channel plane S_α.

(viii) (Embedding two fractional shares in the current block) receive the block $B_\alpha$in $S_\alpha$corresponding to $B_b$in S_b, select the first two pixels in B_α in the raster-scan order, and substitute their values by $q_1'$and q_2', respectively.

(ix) (Embedding remaining incomplete shares at random pixels) Use the key K to select randomly 4 pixels in but $S_\alpha$outside B_α, which are unselected yet in this step and not the first 2 pixels of any block, and in the raster scan order replace the four pixels values by the remaining four partial shares q_3' through q_6' generated above, respectively.

(x) If there exists any unprocessed block in S_b, then go to (iii), if not, take the final S in the PNG format as the preferred stego-image S′. The promising values of $q_1$through q_6 yield by Eqn. (3) above are between 0 and 16 because the prime number p used there is 17. After executing (vii) of the above algorithm, they become q_1' through q_6', respectively, which all fall into a small interval of integers ranging from 238 to 254 with a width of 17 (the value of the prime number). Consequent embedding of q_1' through q_6' in such a narrow interval into the alpha channel plane means that very alike values will appear everywhere in the plane, resulting in a nearly uniform transparency effect, which will not stimulate notice from an attacker.



The motivation why we choose the prime number to be 17 in the above algorithm is that if it was chosen instead to be larger than 17, then the above-mentioned interval will be enlarged and the values of q_1' through q_6' will become possibly lesser than 238, creating visually whiter stego-image. In contrast, the 8 bits mentioned in (v) and (vi) above are transformed into 2 decimal numbers m1 and m with their maximum values being 15 (notice (v) above), which are forced to lie in the range of 0 through p-1 (notice Step 2 in Algorithm 1). Therefore, p should not be chosen to be smaller than 16. In short, p = 17 is a best possible choice

6 shares created for a block

2 shares embedded at the current block and 4 at random pixels out of the block

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q1						
q2						
			. . . . .		q5	
	q6					
			. . .			
		q3				
						q4

Fig 3:Pictorial representation of embedding 6 shares generated for a block, 2 shares embedded in current block and other 4 in 4 randomly selected pixels outside the block, with each selected pixel not being the first 2 ones in any block.

Fig 4:stego image

STEGO-IMAGE AUTHENTICATION

Algorithm 4: Authentication of a given stego-image in the PNG format

Input : A stego-image S′, the representative gray values $g_1$and g_2, and the secret key K used in Algorithm 3.

Output : An image $S_r$with tampered blocks marked, and their data repaired if possible.

Part 1: Extraction of the embedded two representative gray values.

Step 1: (Conversion of the stego-image to Binary form) Compute **$T = (g_1 + g_2)/2$** And use it as a threshold to convert S′ into Binary Form, yielding the binary version Sb′ of S′ with "0" representing g_1 and "1" representing g_2**.**

Part 2: Authentication of the stego-image.

Step 2: (Start looping) Take in a raster-scan order an unprocessed block B_b' from S_b' with pixel values $p_1$through p_6, and find the 6 pixel values q_1' through q_6' of the corresponding block B_b' in the alpha channel plane S_α' of S′.

Step 3: (Drawing out of the secreted authentication signal) to extract the hidden 2-bit authentication signal $Z = a_1a_2$from Bα′ we will follow the steps:

(1) Subtract 238 from each of q1′ and q2′ to obtain the 2 respective partial shares $q_1$and q_2 of B_b'. With the shares (1, q_1) and (2, q_2) as input, perform Algorithm 2 to extract the 2 values d and c1 (the secret and the first coefficient value, respectively) as output. (2) Transform d and c1 into two 4-bit binary values, concatenate them to form an 8-bit string W, and take the first two bits a_1 and a_2 of W to compose the hidden authentication signal $Z = a_1a_2$.

(2) **Step 4**: (Computation of the authentication signal from the current block content) Compute a two-bit authentication signal $Z' = a_1'a_2'$ from the values p_1 through $p_6$of the six pixels of B_b' by $a_1' = p_1 XOR\ p_2\ XOR\ p_3$ and $a_2' = p_4 XOR\ p_5\ XOR\ p_6$.

(3) **Step 5:** (Harmonizing the hidden and computed authentication signals and marking of tampered blocks) Match Z &Z′ by checking if $a_1 = a_1'$ & $a_2 = a_2'$, and if any variance occurs, mark B_b', the corresponding block B′ in S′, and all the partial shares embedded in B'_αtampered.

(4) **Step 6:** (Close loop) if there exists any unprocessed block in S_b', then go to Step 2; otherwise, go on.

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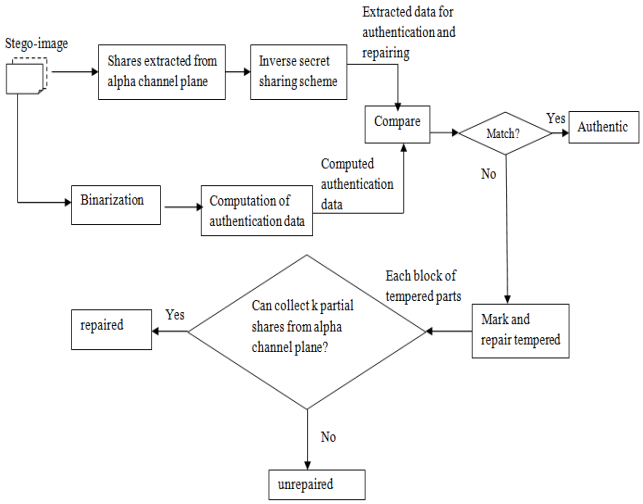

Fig 4:Verification and self-repairing of stego-image in PNG format for the process of image authentication

Part 3: Self-repairing the original image content

Step 7: (Drawing out of the remaining partial shares) For each block B'_{α} in S_{α}, execute the following steps to extract theremaining 4 partial shares q3 through q6 of thecorresponding block B_b' in S_b' from blocks in S_{α}'other thanB$'_{\alpha}$.

Step 8: (Repair the tampered regions) On behalf of each block B′ in S′ marked as tampered previously, execute the following steps to repair it if possible.

(1) From the 6 partial shares $q_1$through q_6 of the block B_b' in S_b' corresponding to B′(two computed in Step 3

(1) and four in Step 7(2) above), select 2 of them, say qk and ql, which are not marked as tampered, if possible.

(2) With the shares (k, q_k) and (l, q_1) as input, execute Algorithm 2 to mine the values of d and c_1(the secret and the first coefficient value) as output.

(3) Transform d and c_1 into two 4-bit binary values and concatenate them to form an 8-bit string W′.

(4) Take the last 6 bits b_1',b_2',… b_6' from W′ and check their binary values to repair the corresponding tampered pixel values y_1', y_2', …, y_6' of block B′ by the following way: if $b_i' = 0$, set $y_i' = g1$; otherwise, set $y_i' = g_2$; where i = 1, 2… 6.

Step 9: Take the final S′ as the desired self-repaired image S_r.

III. MERITS OF THE PROPOSED METHOD

- It provides pixel-level repairs of tampered image parts
- Enhancing data security by secret sharing
- Causing no distortion to the input image
- Use of a new type of image channel for data hiding

IV. CONCLUSION

We have proposed an image authentication method along with a data repair capability for color document images based on secret sharing. Both the generated authentication signal and the content of a block are transformed into partial shares by the Shamir method, which are then distributed in an elegant manner into an alpha channel plane to create a stego-image in the PNG format. For self-repairing the content of a tampered block, the reverse Shamir scheme is used to compute the original content of the block from any 2 un-tampered shares.A measure for enhancing the protection of the data embedded in the alpha channel plane is also proposed.

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