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TWO-DIMENSIONAL DIFFERENCE-HISTOGRAM MODIFICATION BASED ON REVERSIBLE DATA HIDING

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ABSTRACT

Both information hiding and compression are very essential technologies in the field of image processing. It seems that there is no relationship between information hiding and compression mechanisms emphasize the compression ratio. Now a days the data security and data reliability are the two difficult areas for study. In this paper, present a novel lossless data hiding scheme based on histogram modification. This technique is based on differences of adjacent pixels for embedding data and has more hiding capacity compared to existing methods. The number of message bits that can be embedded into an image equals the number of pixels associated with peak point. The experiment conclusion and presentation comparison are presented to express the validity of the proposed algorithm.

INTRODUCTION

In recent era the use of information technology and internet had been growing rapidly, so the use of digital information such as image, audio, video and text are communicated and share very conveniently. Due to easy access of internet the data can be easily copied forged and modified. Therefore, information security is severe deficient and the forger tries to violet the content of the multimedia. Hence, for the protection of the originality and imperceptibility of the multimedia data, the secret message must be hidden in the image. Data hiding is a technique to conceal secret data into cover object, which plays a vital role in the protection of the information [1].

Mainly in the cases of data hiding, the cover object will affected by some distortion and cannot be reversed back to the original object, because of some stable distortion has been occurred to the cover object even after the extraction of hidden message. Reversible data hiding facilitates vast possibility of applications to link two sets of data, in that manner that the hidden message have been extracted out without effecting the cover object. Hence, provide an additional possibility for handling two different data sets.

Many reversible data hiding schemes have been proposed. Tian [2] proposed a difference expansion data hiding scheme, where the difference and average values of two neighboring pixels are calculated and the secret data to be embedded are appended to a difference value represented as a binary number. Alattar, Kim et al, and Weng further extended Tian's work. Ni et al. proposed a scheme of using peak/zero points in the histogram of spatial domain images. Fridrich et al [3] proposed several methods to embed data. The main idea of their work is to compress the selected image features for acquiring spare space. Hong et al. [3] [4] presented a scheme which performs a shift of the histogram of prediction errors. It use the median edge detector (MED) to predict pixel values. Barton developed a reversible data embedding algorithm that is based on data compression. In this method compressed data is to be embedded in an image.

This paper present a difference histogram modification reversible data hiding algorithm. In this proposed method the pixel pair context is convenient in projecting a local image region on two dimensional space for accomplishing a sequence that consist of difference pairs. Now by counting the difference pairs a two dimensional difference histogram is generated. As the DPM is an injective mapping technique which is defined on difference pairs and it is used in recent histogram based methods by natural extension of expansion embedding and shifting techniques [9]. So finally by difference pair mapping (DPM) technique reversible data embedding is implemented.

For enlightening the embedding performance the proposed method uses two-dimensional difference-histogram and its specific DPM, as compared with the conventional one dimensional histogram based methods which include more pixels for carrying the data and also we can reduce the number of shifted pixels [8]. In the previous literature studies of embedding position and selection techniques a new pixel pair selection strategy is proposed for locating the pixel pairs in smooth image regions to embed the data. Also, it is further used for enhancing the embedded performance.

In present paper reversible data hiding method by using a two-dimensional difference histogram are discussed for covert communication. In RDH algorithm original information can be completely recovered. In section 2 the proposed RDH scheme is introduced and discussed, section 3 discusses the experimental results of proposed method and previous methods. Finally section 4 presents brief conclusion of paper.

PROPOSED RDH SCHEME

The proposed RDH scheme is based on modification of two-dimensional difference-histogram by constructing a DPM which is an injective mapping defined on difference pairs. For a pixel pair (x, y), compute two difference values $d_1 = x-y$ and $d_2 = y-z$ to form a two dimensional difference histogram of (d_1, d_2), where z is a prediction of y. The pixel pair (x, y) has four choices: $(x-1, y)$, $(x+1, y)$, $(x, y-1)$, or $(x, y+1)$ (as discussed in fig. 1(a)). Based on these four modification directions, Lee et al.'s method can be improved by designing a new PPM [15].
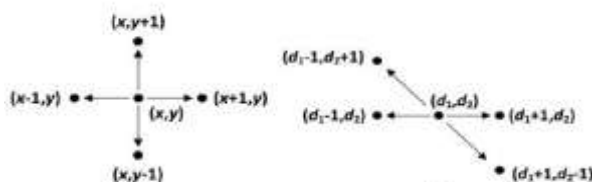

Fig. 1(a) By modifying either x or y by 1, (x, y) has four modification directions. (b) The corresponding difference pair also has four modifications.

Inspired by the above mentioned new PPM, either x or y is modified by 1. In the PPM, since (x, y) has four modification directions.

The difference pair also has four modifications directions: (d_1-1, d_2), (d_1+1, d_2), (d_1+1, d_2-1), (d_1-1, d_2-1), given in fig. 1(a) and 1(b). For example, by modifying to, the modification direction to (x, y) is "up" and the corresponding alteration direction to (d_1, d_2) is "upper-left", since d_1 changes to d_1-1 and d_2 changes to d_2+1. Based on these four modification directions, a new RDH method by designing a DPM is introduced. The idea of two-dimensional pixel intensity histogram of Lee et al., is complete to two dimensional difference histogram. Besides, for each (x, y), compute the prediction of y based on the context of (x, y) for an accurate estimation. Here, the gradient adjusted prediction (GAP) will be used in this scheme.

Here, in fig. 3 the blue pixels are taken for the computation of the GAP predictor for y, and remaining pixels $\{v_1, \ldots, v_{10}\}$ will use for the computation of the noisy level.

     j   j+1   j+2   j+3

I	X	Y	V_1	V_2
i+1	V_3	V_4	V_5	V_6
i+2	V_7	V_8	V_9	V_{10}

Fig. 2. Context of (x, y), where the location of pixel x is (i, j).

$$ Z = \begin{cases} v_1, & if\ d_v - d_h\ > 80 \\ \frac{(v_1+u)}{2}, & if\ d_v - d_h\ \epsilon\ (32,80] \\ \frac{(v_1+3u)}{4}, & if\ d_v - d_h\ \epsilon\ (8,32] \\ u, & if\ d_v - d_h\ \epsilon\ [-8,8] \\ \frac{(v_4+3u)}{4}, & if\ d_v - d_h\ \epsilon\ [-32,8) \\ \frac{(v_4+u)}{2}, & if\ d_v - d_h\ \epsilon\ [-80,-32) \\ v_4, & if\ d_v - d_h\ < -80 \end{cases} \tag{1} $$

Where $\{v_1,\ldots\ldots v_7, v_8\}$ are neighboring pixels of (x, y) (see fig. 2), $d_v = | v_1 - v_5| + | v_3 - v_7| + | v_4 - v_8|$ and $d_h = | v_1 - v_2| + | v_3 - v_4| + | v_4 - v_5|$ represent the vertical and horizontal gradients, and $u = (v_1 + v_4)/2 + (v_3 - v_5)/4$. Notice that z should be rounded to its nearest integer if it is not an integer. Then, compute the noisy level of (x, y) denoted as using its ten neighboring pixels as NL(x, y) using its ten neighboring pixels $\{v_1,\ldots\ldots v_7, v_8\}$ as

$$ NL = \int_{(i',j') \varepsilon v} | \nabla I(i',j')| \tag{2} $$

Where V represents the context of containing the ten pixels and ∇ stands for the gradient operator. Here, for discrete image, the noisy level is computed by summing both vertical and horizontal differences of every two consecutive pixels in V, and it is less than or equal to 13 x 255 = 3315. Clearly a pixel pair located in smooth regions may have a small noisy level. Finally for each pixel pair with noisy level less than a threshold T, compute the difference pair (d_1, d_2) and implement data embedding.

EVALUATION FOR DPM
For the histogram based RDH, if the maximum modification to pixel values is 1 in data embedding, the expected value of the modification (in $- l^2$ norm) to cover image is $\frac{N_{exp}}{2} + N_{shift}$ Where N_{exp} and N_{shift} are numbers of expanded and shifted pixels, respectively.

Table I Marked Value of Cover Pixel-Pair (x, y) According to the DPM

Condition on (d_1, d_2)	Operation in Data Embedding	Modification Direction to the Difference-Pair	Modification Direction to the Pixel-Pair	Marked Value
$d_1 = 1$ and $d_2 > 0$	Expansion embedding	Right	Right	(x + b, y -1)
$d_1 = -1$ and $d_2 < 0$	Expansion embedding	Left	Left	(x - b, y + 1)
$d_1 = -1$ and $d_2 < 0$	Expansion embedding	Upper – left	Up	(x - 1, y+ b)
$d_1 = -1$ and $d_2 < 0$				
$d_1 = -1$ and $d_2 < 0$	Expansion	Lower – right	Down	(x + 1, y- b)

$d_1 = -1$ and $d_2 < 0$	embedding			
$d_1 = -1$ and $d_2 < 0$				
$d_1 = -1$ and $d_2 < 0$	Shifting	Right	Right	$(x + 1, y)$
$d_1 = -1$ and $d_2 < 0$	Shifting	Left	Left	$(x +-1, y)$
$d_1 = -1$ and $d_2 < 0$	Shifting	Upper – left	Up	$(x, y+ 1)$
$d_1 = -1$ and $d_2 < 0$	Shifting	Lower – right	Down	$(x, y-1)$
$d_1 = -1$ and $d_2 < 0$				

Thus, the ratio of expanded pixels

$$\frac{N_{exp} + N_{shift}}{2} \qquad (3)$$

is a measure of the embedding performance. The larger the ratio is, the less modification to cover image and better performance is. Then (3) is used to demonstrate the superiority of the proposed DPM based scheme. For the proposed method, when the pixel pair selection threshold T is taken as its maximum noisy-level of all pixel pairs and 1.

$$1 + \max_{(x, y)} NL\ (x, y) \qquad (4)$$

It means that the pixel pair selection strategy is disabled and all pixel-pairs are used for data embedding.

Table II. Extracted Data Bit and Recovered Value from a marked Pixel-pair

Condition on (d_1^m, d_2^m)	Modification Direction to the Pixel-Pair	Marked Value
$d_1^m \ \varepsilon \ \{1, 2\}$ and $d_2^m > 0$	$d_1^m - 1$	$(x^m - b, y^m +1)$
$d_1^m \ \varepsilon \ \{-1, -2\}$ and $d_2^m < 0$	$-1 - d_1^m$	$(x^m + b, y^m -1)$
$(d_1^m = 0$ and $d_2^m \geq 0)$ or $(d_1^m = -1$ and $d_2^m \geq 1)$	$-d_1^m$	$(x^m + b, y^m - b)$
$(d_1^m < 0$ and $d_2^m = 0)$ or $(d_1^m < -1$ and $d_2^m = 1)$	d_2^m	
$(d_1^m = 0$ and $d_2^m < 0)$ or $(d_1^m = 1$ and $d_2^m < -1)$	d_1^m	$(x^m - 1, y^m + b)$
$(d_1^m > 0$ and $d_2^m = 0)$ or $(d_1^m > 1$ and $d_2^m = -1)$	$-d_2^m$	
$(d_1^m = 1$ and $d_2^m = -1)$ or $(d_1^m = 2$ and $d_2^m = -2)$	$d_1^m - 1$	
$d_1^m > 2$ and $d_2^m > 0$	No Embedded Data Bit	$(x^m - 1, y^m)$
$d_1^m < -2$ and $d_2^m < 0$	No Embedded Data Bit	$(x^m + 1, y^m)$
$d_1^m < -1$ and $d_2^m > 1$	No Embedded Data Bit	$(x^m , y^m - 1)$
$d_1^m > 2$ and $d_2^m < -1$	No Embedded Data Bit	$(x^m , y^m + 1)$
$d_1^m = 2$ and $d_2^m < -2$		

BLOCK DIAGRAM FOR EMBEDDING AND EXTRACTION PROCEDURES

The brief introduction of the embedding method contain several basic steps. Initially the cover image is partitioned into non overlapping pixel-pairs. Then that secret message is embedded into a part of cover image represented as I'. For getting a binary sequence record the least significant bits (LSB) of some pixels which is represented as I'', and embed this sequence into the rest part of I, i.e., I-I'. At last to embed the auxiliary information and the compressed location map into I'' using LSB replacement is used. To overcome the overflow and underflow problems overflow location map is used and compression of location map is achieved by
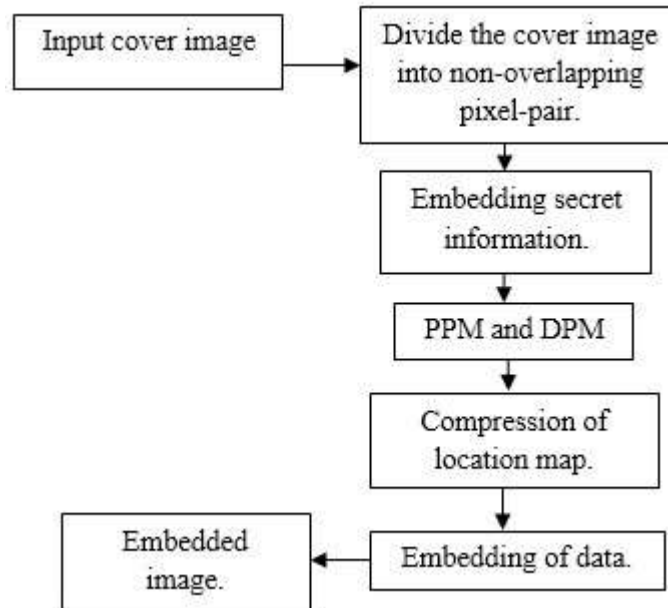
Fig. 3. Block Diagram for Embedding Procedure

arithmetic coding. By DPM method it can be embed the secret data while by LSB replacement method auxiliary data is embedded. The smooth pixels pairs are used to embed the secret data in the embedding technique which can enhance the embedding procedure are reverse in nature. In data extraction procedure, first the LSB replacement is performed to extract the compressed location map and then location map is generated by decompressing it. While decompression of the location map is done by blind decoding. The prediction and noisy level are computed according to the equation (1) and (2). The block diagrams of data embedding and data extraction are shown in figure 3 and 4.
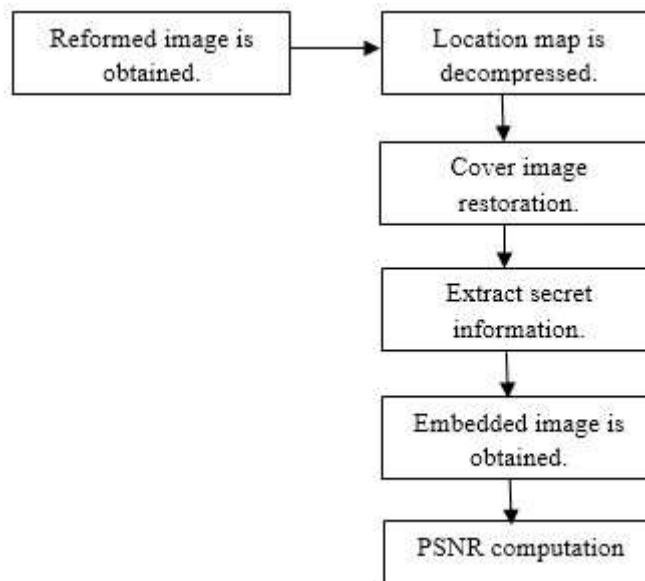

Fig. 4. Block Diagram for Extraction Procedure

EXPERIMENTAL RESULTS
Six 512X512 sized gray scale images including Lena, Boat, Airplane, Bird, and Rice are used, shown in fig 4. The proposed method is superior to aforementioned methods [14]. It experimentally demonstrates that the DPM based scheme can provide a much better performance than PPM.
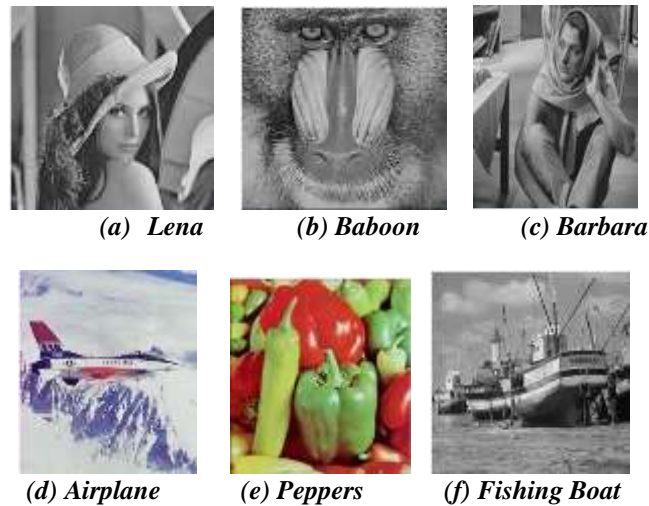

(a) Lena	*(b) Baboon*	*(c) Barbara*
(d) Airplane	*(e) Peppers*	*(f) Fishing Boat*

Fig. 5. The experimental grayscale image

The performance of the proposed data hiding scheme on different images has been evaluated. The PSNR value of Lena is good comparing for other images.

Table I. Comparison of proposed method and other method for an EC of 10,000 bits.

Image	[sachnev]	[li]	[hong]	[hong]	Proposed Scheme
Lena	55.03	54.82	54.92	54.97	55.46
Barbara	55.04	55.29	54.89	55.18	56.46
Airplane	57.34	56.84	58.58	58.67	59.74
Peppers	52.30	52.55	52.16	52.20	52.25
Fishing Boat	52.65	52.43	52.26	52.37	53.08
Average	54.47	54.39	54.56	54.68	55.398

Table II. Comparison of proposed method and other method for an EC of 20,000 bits.

Image	[sachnev]	[li]	[hong]	[hong]	Proposed Scheme
Lena	55.03	54.82	54.92	54.97	56.14
Barbara	55.04	55.29	54.89	55.18	55.78
Airplane	57.34	56.84	58.58	58.67	59.34
Peppers	52.30	52.55	52.16	52.20	53.46

Fishing Boat	52.65	52.43	52.26	52.37	53.01
Average	54.47	54.39	54.56	54.68	55.546

The performance comparisons of PSNR between the proposed method and other methods are shown in Table I and Table II. The EC of Table I is 10,000 bits and Table II is 20,000 bits. The hiding payload of the proposed method is higher than the other methods. The PSNR values are also higher than other method. The hiding payload and image quality of the proposed are significantly achieved to good performances.

CONCLUSION
This proposed work, focus on a new reversible data compression hiding scheme for hiding message in JPEG image. In this to location map will be compressed to increase in order to increase the embedding capacity. The location map depends on the payload or hidden message. Comparing with other RDH techniques and literature, this present work often has enhanced flexibility to different images and larger embedding capacity for the same image quality.

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