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

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Abstract— Reversible data embedding is also known as lossless data embedding in which invisible data (also known as payload) embeds into a digital image in a reversible fashion. This technique can be used for media notation, copyright security, integrity validation and covert communication etc. The present paper is discussed on various RDH methods in which PSNR has been calculated and it is used for covert communication. The present paper gives the comparison of different reversible data hiding techniques in terms of PSNR, which shows that the histogram modification scheme is one of the best methods of RDH.

Keywords: Pixel-Pair-Mapping (PPM), Reversible Data Hiding (RDH), Difference-Pair-Mapping (DPM), EC (Embedding Capacity).

I. INTRODUCTION

Data hiding are a set of techniques used to put a protected data in a host media with small deterioration in host and the means to extract the protected data afterwards. Data hiding is a protective technique for secret data transmission. Secret data can be embedded into digital images, audio, videos etc. Therefore, reversible data hiding techniques which can recover the hidden data without degrading the visual quality of original images as far as possible are necessary [4].

Now-a-days data hiding has become a well known method in security applications such as military, defense etc. Data hiding algorithms are either irreversible or reversible. In irreversible algorithm the host signal cannot be completely recovered, these technique are not suitable for medical and military applications. In reversible data hiding algorithm original information can be completely recovered [2].

Many RDH techniques have been proposed so far, e.g., the methods based on lossless compression, difference expansion, vector quantization, histogram modification, digital image watermarking, multimedia watermarking and prediction-error expansion etc. Among them, the histogram based methods are extensively used.. The histogram based methods transform the histogram in such a way that certain bins are shifted to generate empty space while some extra bins are utilized to hold data by filling the empty space. This type of technique can well manage the embedding distortion and provide a enough embedding capacity. The first histogram based RDH technique is the one proposed by Ni et al. in [5]. This technique uses peak and minimum points of the pixel intensity histogram to embed data. It changes each pixel value at most by 1, and thus a excellent marked image quality can be obtained. However, its EC is quite low and this technique does not work well if the cover image has a plane histogram. To lighten it, Lee et al. [6] proposed to utilize the difference histogram instead. This new technique exploits the connection among neighboring pixels and can embed better payload with reduced distortion compared with Ni et al.'s. Moreover, Lee et al.'s process works by modifying the two dimensional pixel intensity histogram by using pixel pair mapping (PPM). The PPM is a mapping procedure which is an injective mapping defined on pixel pair. Afterwards, fallahpour [6] introduce a process by modifying the histogram of prediction error. Apart from these above mentioned methods, a lot of additional works are also based on histogram by incorporating some strategies such as double layered embedding [9],[10] embedding position selection[10],[11],[12] adaptive embedding[11], context modification[5], etc.

The histogram based RDH methods generally contain two basic steps:

- Histogram generation
- Histogram modification

In the first step, simplify correlation of the local image to a one dimensional statistic. Clearly, by this simplification, the redundancy of the image cannot be completely exploited and it only contribute to the second step since a one-dimensional histogram used in earlier RDH methods and to better exploit the redundancy of the image, a novel reversible data concealing scheme with a two dimensional difference histogram is used. In this proposed method pixel pair and its 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.

The rest of the paper is organized as follows. The proposed RDH scheme introduced in section II. Section III presents experimental results of proposed method and previous methods. Conclusion is there in section IV.

II. 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) (see fig. 1(a)). Based on these four modification directions, Lee et al.'s method can be improved by designing a new PPM [15].

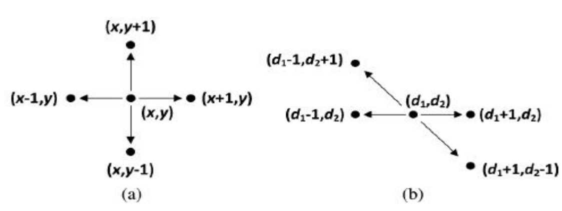

Fig. 1(a) By modifying either x or y by 1, (x, y) has four modification directions. (b) The corresponding difference pair also has four modification.

Inspired by the aforementioned 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 modification 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 scheme by designing a DPM is introduced. The idea of two-dimensional pixel intensity histogram of Lee et al., is extended to two dimensional difference histogram. Besides, for each (x,y), compute the prediction o y based on the context of (x,y) for an accurate estimation. Here, the gradient adjusted prediction (GAP) will be used in this scheme.

	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)

The brief introduction of the embedding method is given below. 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 arithmetic coding. By DPM method we can embed the secret data while by LSB replacement method auxiliary data is embedded. The smooth pixel pairs are used to embed the secret data in the embedding technique which can enhance the performance also. Both data extraction procedure and data 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 image restoration can be realized by extracting the LSB sequence.

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

(1)

Where {v_1,……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,……v_7,v_8} as

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

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.

The block diagram of data embedding are shown below :

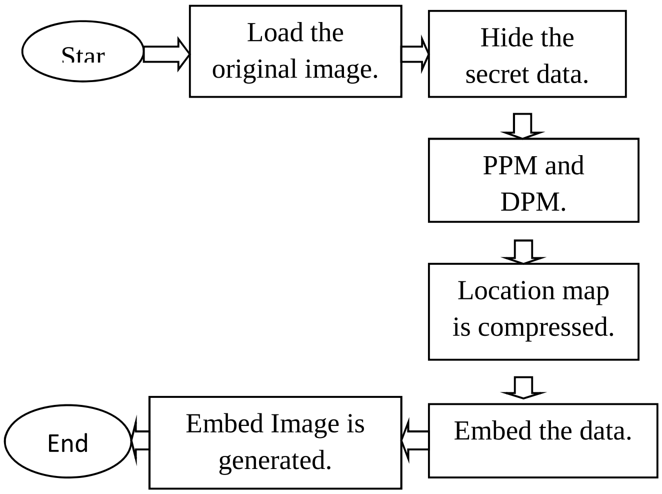

Figure. 3. Block diagram for embedding procedure

III. Experimental Results

Six 512X512 sized gray scale images including Lena, Baboon, Barbara, Gold hill, Peppers, and Cameraman 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) Goldhill (e) Cameraman (f) Pepper

Fig. 4. 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 PSNR (in db) between the proposed method and other method for an EC of 10,000 bits.

Image	Ni et al.'s method	Yeh et al.'s method	Proposed Method
Lena	48.739	48.817	49.106
Baboon	48.153	48.878	48.930
Barbara	48.16	48.79	48.917
Gold hill	48.547	48.802	48.918
Cameraman	48.447	48.73	48.806
Pepper	49.06	48.707	48.777
Average	**48.518**	**48.787**	**48.909**

IV. CONCLUSION

In this paper, a novel RDH scheme by using a two-dimensional difference histogram. An efficient extension of the histogram modification technique is presented by considering the differences between adjacent pixels rather than simple pixel values. The payload capacity is very high in the gray scale images when compared with the older methods. In this paper the data can be hiding in x-y plane. In future the data can be hiding in diagonally so that the EC can be increased and the quality of the image is also good.

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