Histogram Shifting Based Reversible Data Hiding

[1]Anjali O, [2]Sreelakshmi K Shaji, [3]Beena M V
[1,2]M-tech student, [3]Assistant Professor
[1]Computer Science & Engineering,VAST,Thrissur,India
[2,3]CSE,VAST,Thrissur,India
[1]anjaliottoor@gmail.com,[2]chinnu.whiterose@gmail.com,[3]beena.m.v@vidyaacademy.ac.in

***Abstract*— Histogram shifting is a useful technique of reversible data hiding .With HS-based RDH, high capacity and low distortion can be achieved efficiently. In this paper, we revisit some of the existing reversible data hiding schemes their advantages and disadvantages and their usefulness to a particular situation. With the HS based technique one can get a RDH algorithm by simply designing the so-called shifting and embedding functions. Moreover, by taking specific shifting and embedding functions, we can show that several RDH algorithms reported in the literature are special cases of this general construction.**

***Index Terms*—Histogram Shifting (HS),Reversible Data Hiding (RDH)**

I. INTRODUCTION

For most image data hiding methods, the host image is permanently distorted and it cannot be restored from the marked content. But in some applications such as medical image sharing [1], and image trans-coding [2], any distortion due to data embedding is intolerable and the availability of the original image is in high demand. To this end, a solution called "reversible data hiding"(RDH) is proposed, in which the host image can be fully restored after data embedding [4]. RDH is a hybrid method which combines various techniques to ensure the reversibility. Its feasibility is mainly due to the lossless compressibility of natural images. Tian's DE algorithm [5] is an important work of RDH. In DE algorithm, the host image is divided into pixel pairs, and the difference value of two pixels in a pair is expanded to carry one data bit. This method can provide an embedding rate (ER) up to 0.5 bits per pixel (BPP) and it significantly out performs previous compression-based works. In particular, Tian employed a location map to record all expandable locations, and afterwards, the technique of location map is widely adopted by most RDH algorithms. Later on, Tian's work has been improved in many aspects. In [6], Hu et al. proposed a method by constructing a payload dependent location map. Another improvement of Hu et al.'s method is the work of Zhou and Au [7] by introducing a new capacity parameters determination strategy. Besides aforementioned works [1]-[4] many HS-based RDH algorithms have also been proposed so far. In general, HS-based RDH is implemented by modifying host image's histogram of a certain dimension. It has two major advantages. On one hand, the maximum modification to pixel values can be controlled and thus the embedding distortion can be well limited. On the other hand, the location map used to record underflow/overflow locations is usually small in size especially for low ER case.

II. DIFFERENT METHODS

In this section we consider different existing RDH methods one after another

A) Reversible watermarking for knowledge digest embedding and reliability control in medical images [1]

This method deals with the medical image sharing in applications such as e-learning and remote diagnosis. When watermarking the image with the digest the aim is to be used for retrieving similar images with either the same findings or differential diagnoses. Instead of modifying image file format by adding some extra header information, watermarking is used to embed the KD in the pixel gray level values of the corresponding images. This method deals with a description language in endoscopy in order to unify the representation of diseases and cases. The basic principle of this approach is to share a medical image with a knowledge digest. The proposed KD gives a synthetic medical description and interpretation of image content. To share medical images with some concomitant data one approach involves adding when allowed by the image file format some extra header information. Example, most of the data contained in the header of the digital imaging and communication in medicine (DICOM) image file will be lost after conversion in to another multimedia format like JPEG. The message that is watermarked also provides data integrity and authenticity control as it contains a digital signature computed on both image and its KD along with the date of creation and an authenticity code. This strategy also describes a method that is parameter free and minimizes image distortion. However the image and exact image recovery are possible only if the watermarked image has not been modified, since the watermark is fragile. This method can also be extended to JPEG compressed images. There are two popular standards for image compression that allows 2 compression modes. Lossless and lossy. First reduces the image file size through an entropic encoding, while the second authorizes some information loss according to an integer quality factor. As this factor decreases the compression file size ratio increases and the image quality is less well preserved. This method can be applied before lossy compression but after the information loss has occurred. Hence the embedding will be performed in the information preserved after compression. For JPEG this information is located in the frequency domain. Each time the image is recompressed with a different quality factor the watermark signal will have to be recomputed. Depending on the message length, the number of watermark coefficient planes may vary in order to reach the requirement in terms of capacity. As a consequence the watermark may become more or less visible depending on the number of planes. Hence the performance of this method depends on the size of the message, dimensions and the content of the image. Once the watermark is removed the image distortion observed is only due to compression information loss.

B) Enhanced image trans-coding using reversible data hiding[2]

A new transcoding system with the help of the technique of watermarking and data hiding is proposed. Here the focus is on the problem of resizing in thin edge region. The information of the thin edge region is generated and embedding in to the multimedia content in encoder. The lossy watermarking schemes causes the permanent distortion for the host images during the embedding process and results in peak-signal-to-noise ratio loss. Also the payload of the reversible watermarking is typically lower than that of lossy watermarking algorithms. Problem is that mobile devices such as mobile phones,PDAs ,handheld PCs usually come with a low display resolution and many interesting images are of higher resolution. Image transcoding is needed to convert high resolution images to fit in to the display size. However downsizing can introduces lots of problems. By using data hiding technique, we can embed a mask which contains the thin edge region information in to an image. In the trans coding system hidden data is extracted before the downsizing operation and used as side information for enhancement or post processing of the downsized image. Here the image quality is improved and the complexity is less than the real time detection of side information. In applications where image downsizing is required the side information is extracted and the experimental result shown that there is a great improvement in the visual quality of the downsized image.

C) Determining the capacity parameters in PEE based reversible image watermarking [3]

In all the existing schemes capacity parameters are determined in a recursive manner by gradually turning these parameters in to payload. And this method needs multiple rounds of embedding iterations, and is conceptually inefficient. And these methods are not capacity distortion optimized. Among the existing reversible watermarking schemes the prediction error expansion based approaches have received growing attention due to its excellent embedding capacity and good controllability of the distortion caused by watermarking embedding. PEE is actually a generalization of difference expansion (DE). PEE exploits the prediction error instead of difference of 2 adjacent pixels for expansion embedding. To reduce the overhead caused by location map we can use histogram shifting with expansion embedding. And also we can use payload dependent location map to achieve further compression of location map and hence achieve better capacity distortion performance. Upon getting prediction error we can obtain prediction error histogram. Then so called capacity parameters are determined to divide the histogram in to inner and outer region. For the pixels in the inner region expansion operation is conducted to embed 1 bit. For the pixels in the outer region shifting is applied to avoid ambiguity while no message bits are embedded. Hence the key issue is to determine capacity parameters which control the embedding capacity and influence the distortion caused by watermark embedding. This method can also be extended to handle multiple histograms where more capacity parameters are to be determined. This method shown that capacity parameters can be optimally determined under a capacity distortion optimization framework.If multiple histograms are needs to be handled the objective function and the constraint would become vector form and thus the capacity parameters for multiple histograms can be efficiently found.

D) Reversible image watermarking on prediction errors by efficient histogram modification [4]

This method deals with the generation of prediction errors in two phases. Data embedding is performed by modifying the histograms while the overflow and underflow of pixel values are prevented in the preprocess. Blind data extraction and exact recovery of the original image are both enabled by saving the overhead information in to the watermarked image. The distribution of prediction errors is more sharper than that of pixel values, less distortion may be introduced by modifying the prediction errors for data embedding. Although this scheme is accurate one drawback of the algorithm is that certain expandable cells cannot be used for data embedding to avoid ambiguity at the decoder. Instead of expanding the selected prediction data, embedding is performed by modifying the histogram of the generated errors. Besides the overflow/underflow of the pixel values are prevented by preprocess, in which the bounding pixel values are modified and a location map is computed accordingly. Binary location map can be compressed by the lossless JEPG 2 standard and needs to be embedded in to the host image as overhead information. In the case of multi pair embedding take L pairs for instance. In the preprocess L is added to pixel values in the range of [0 ,L-1] to prevent the underflow. While the pixel values in the range of [256-L, 255] are subtracted by L to prevent the overflow. The location map is generated by assigning 1 to modified pixels and 0 to others. This method differs from the previously explained methods in the following aspects.

- The embedding operation is not by histogram modification but by expansion.
- Prediction errors are sorted in according to location variance so as to be modified in sequence. While the prediction errors are not differentiated in this algorithm.
- Generation of location map is simpler.

E) Reversible data embedding using a difference expansion [5]

In this method we need to calculate the differences of neighboring pixel values and select some difference `values for the difference expansion. The original content restoration information, a message authentication code and additional data will all be embedded in to the difference values. For color images there are several options. One can decor relate the dependence among different color components by reversible color conversion transform and then reversibly embed each color component individually. We explored the redundancy in digital content to achieve reversibility. Both the payload capacity limit and the visual quality of embedded images are the among the best in the literature

F) DE-based reversible data hiding with improved overflow location map[6]

For difference-expansion (DE)-based reversible data hiding, the embedded bit-stream mainly consists of two parts: one part that conveys the secret message and the other part that contains embedding information, including the 2-D binary (overflow) location map and the header file. The first part is the payload while the second part is the auxiliary information package for blind detection. To increase embedding capacity, we have to make the size of the second part as small as possible. Tian's [5] classical

DE method has a large auxiliary information package. The author mitigated the problem by using a payload-in- dependent overflow location map. However, the compressibility of the overflow location map is still undesirable in some image types. In this method, the authors focus on improving the overflow location map. We design a new embedding scheme that helps us construct an efficient payload-dependent overflow location map. Such an overflow location map has good compressibility. Accurate capacity control capability also reduces unnecessary alteration to the image. Under the same image quality, the proposed algorithm often has larger embedding capacity. It performs well in different types of images, including those where other algorithms often have difficulty in acquiring good embedding capacity and high image quality.

III. MAIN IDEA OF HISTOGRAM-SHIFTING-BASED REVERSIBLE DATA HIDING [7]

In this method, the host image is divided into non overlapping blocks such that each block contains n pixels Then, an n-dimensional histogram is generated by counting the frequency of the pixel-value-array sized n of each divided block. Finally, data embedding is implemented by modifying the resulting n-dimensional histogram. Notice that the pixel-value-array is an element of z^n we then needto divide z^n in to two disjointed sets, one set is used to carry hidden data by expansion embedding, and the other set is simply shifted to create vacant spaces to ensure the reversibility. We now present our new approach.

Let S and T be a partition of z^n: $S \cup T = z^n$ and $S \cap T = \emptyset$. Suppose that three functions $g : T \rightarrow z^n$
$f0 : S \rightarrow z^n$ and $f1 : S \rightarrow z^n$ satisfy the following conditions:
C1*:* The functions g, f0 and f1 are injective.

C2*:* The sets g(T), f0(S) and f1(S) are disjointed with each other. Here, g is called "shifting function" and will be used to shift pixel values, f0 and f1 are called "embedding functions" and will be used to embed data. More specifically, each block with value $\mathbf{x} \in T$ will be shifted to g(**x**), and the block with value $\mathbf{x} \in S$ will be expanded to either f0(**x**) or f1(**x**) to carry one data bit. The shifting and embedding functions will give a HS-based RDH algorithm where the reversibility can be guaranteed by the conditions C1 and C2.The underflow/overflow is an inevitable problem of RDH ,i.e., for gray-scale image, the shifted and expanded values should be restricted in the range of [0, 255]. To deal with this, the above defined sets T and S need be further processed. Let

$$An = \{\mathbf{x} = (x1, \ldots, xn) \in z^n : 0 \le xi \le 255\} \quad (1)$$

be the set of all pixel-value-arrays of length *n* of gray-scale image. We define

$$Ts = An \cap g^{-1}(An) \quad (2)$$

$$Se = An \cap f_0^{-1}(An) \cap f_1^{-1}(An) \quad (3)$$

$$Tu,o = An \cap T - Ts \quad (4)$$

$$Su,o = An \cap S - Se. \quad (5)$$

The sub-indices "s"," e" and "u, o" mean "shift", "embed" and "underflow/overflow", respectively. Obviously, the four sets Ts , Se, Tu,o and Su,o are disjointed with each other and constitute a partition of An,

$$\text{i.e.,} An = Ts \cup Se \cup Tu,o \cup Su,o. \quad (6)$$

Moreover, the sets g(Ts), f0(Se*)* and f1(Se) are contained in An and the condition *C2* ensures that they are also disjointed. Each block with value $\mathbf{x} \in Ts$ will be shifted, each block with value $\mathbf{x} \in Se$ will be expanded to carry one data bit, and the block with value $\mathbf{x} \in Tu,o \cup Su,o$ will remain unchanged since it cannot be shifted or expanded due to undeflow/overflow.

A) Algorithm

For a 3 × 3 block **x** = (x1,…, x9*)* we take the following linear predictor with non-uniform weight

$$\grave{}x5 = 1 \div 16(x1 + x3 + x7 + x9) + 3 \div 16(x2 + x4 + x6 + x8) \quad (7)$$

to predict x5. The prediction-error is denoted as e5 = x5 −`x5. Here, unlike MED which uses only half-enclosing casual pixels to make estimation, full-enclosing pixels are exploited in the above predictor and a better prediction result can be expected. Utilizing smooth pixels for reversible data embedding whereas ignoring the noisy ones will significantly reduce the embedding distortion in RDH. Then we take the following function

$$C(\mathbf{x}) = \max\{x1, \ldots, x4, x6, \ldots, x9\} - \min\{x1, \ldots, x4, x6, \ldots, x9\} \quad (8)$$

to measure the local complexity of pixel *x*5 and we will use an integer-valued parameter s to select smooth pixels.
For an integer t >0, take $tl = \lfloor t \div 2 \rfloor$ and $tr = \lceil t \div 2 \rceil$ We then define

- S = {**x** Є z9: − tl≤ e5 < tr ,C(**x**) < s} and T = z9− S.
- For **x** Є T ,
  g(**x**) = (x1, . . . , x4, x5 + tr , x6, . . . , x9), if e5 ≥ tr and C(**x**) < s, or
  (x1, . . . , x4, x5 − tl , x6, . . . , **x**9), if e5 < − tl and C(**x**) < s, or
  x, if C(**x**) ≥ s. (9)
- For **x** Є S and m Є {0, 1},
  fm(**x**) = (x1, . . . , x4, x5 + └e5┘ + m, x6, . . . , x9).
  (10)

To minimize the embedding distortion, the parameter s is first fixed as its maximum 256 and the parameter t is taken as the smallest integer such that it is capable to embed the required payload. When t is determined, to take advantage of smooth pixels as much as possible, we vary the parameter s and then take it as the smallest integer such that it is capable to embed the required payload. Finally, we use multiple-pass embedding such that each pixel in the host image can be embedded.Using this method we can also embed auxiliary information. As is known, a RDH algorithm usually depends on some parameters and these para meters should be communicated to decoder. To this end, we may slightly modify the embedding and extraction procedures. Firstly, we divide host image into two parts to get I0 and I '.I0 contains a fixed number of pixels and I' is the rest pixels. Secondly, express the parameters in binary form to get a binary sequence and replace the LSBs of I0 by this sequence. Here, the original LSBs of I0 should be recorded and then embedded into host image as a part of hidden data. . Finally, consider I ' as an "image" and embed data into it. For decoder, it only needs to read LSBs of I0 to get the parameters, and then extract the hidden data from I'. In particular, I0 can be restored by overwriting its LSBs by a certain part of extracted hidden data. The security of this method can also be improved by
encrypting data before hiding in host image.

IV. Conclusion

In this paper, by revisiting existing algorithms, a general framework to construct HS-based RDH is proposed. According to this framework, to obtain a RDH algorithm, one just needs to define the shifting and embedding functions. This work will facilitate the design of RDH. Furthermore, by incorporating our framework with the PEE and pixel selection techniques, one novel RDH algorithm is also introduced. This algorithm can achieve a better performance compared with the state-of-the-art works. So the proposed framework has a potential to provide excellent RDH algorithms.

V. References

[1] A.G. Coatrieux, C. L. Guillou, J. M. Cauvin, and C. Roux, Reversible watermarking for knowledge digest embedding and reliability control in medical images, IEEE Trans. Inf. Technol. Biomed., vol. 13, no. 2, pp. 158–165, Mar. 2009.

[2] B.H.-T. Wu and J. Huang, Reversible image watermarking on prediction errors by efficient histogram modification, Signal Process., vol. 92,no. 12, pp. 3000–3009, Dec. 2012.

[3] C.J. Tian, Reversible data embedding using a difference expansion, IEEE Trans. Circuits Syst. Video Technol., vol. 13, no. 8, pp. 890–896,Aug.2003

[4] D.J. Zhou and O. C. Au, "Determining the capacity parameters in PEE based reversible image watermarking, IEEE Signal Process. Lett.,vol. 19, no. 5, pp. 287–290, May 2012.

[5] E.R. Li, O. C. Au, C. K. M. Yuk, S. Yip, and T. Chan, Enhanced image trans-coding using reversible data hiding, in Proc. IEEE Int. Symp.Circuits Syst., May 2007, pp. 1273–1276.

[6] F.Xiaolong Li, Bin Li, Bin Yang, and TieyongZeng General framework to histogram-shifting-based reversible data hiding.IEEE transaction on image processing vol 22 no 6 june 2013

[7] G.Y. Hu, H. K. Lee, and J. Li, DE-based reversible data hiding with improved overflow location map, IEEE Trans. Circuits Syst. Video Technol., vol. 19, no. 2, pp. 250–260, Feb. 2009