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A Survey Paper on Reversible Image Data Hiding

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Abstract: Reversible data hiding (RDH) has been intensively studied in the community of signal processing. Also referred as invertible or lossless data hiding, RDH is to embed a piece of information into a host signal to generate the marked one, from which the original signal can be exactly recovered after extracting the embedded data.The earlier algorithm enhances the contrast of a host image to improve its visual quality, instead of trying to keep the PSNR value high. The highest two bins in the histogram are selected for data embedding so that histogram equalization can be performed by repeating the process. The original image is completely recoverable; the side information is embedded along with the message bits into the host image.

Keywords:Contrast Enhancement, Histogram Modification, Reversible Data Hiding.

I. Introduction

In the community of signal processing, REVERSIBLE DATA HIDING (RDH) has been intensively studied. From which the original signal can be exactly recovered after extracting the embedded data, also referred as invertible or lossless data hiding, RDH is to embed a piece of information into a host signal to generate the marked one. The technique of RDH is useful in some sensitive applications where no permanent change is allowed on the host signal. In the literature, most of the proposed algorithms are for digital images to embed invisible data or a visible watermark [7]. The hiding rate and the marked image quality are important metrics, to evaluate the performance of a RDH algorithm. Increasing the hiding rate often causes more distortion in image content, there exists a trade-off between them. The peak signal-to-noise ratio (PSNR) value of the marked image is often calculated, to measure the distortion. By exploiting the correlations between neighboring pixels so that less distortion is caused by data hiding, in contrast, the more recent algorithms manipulate the more centrally distributed prediction errors. The visual quality can hardly be improved because more or less distortion has been introduced by the embedding operations, although the PSNR of a marked image generated with a prediction error based algorithm is kept high. Improving the visual quality is more important than keeping the PSNR value high,for the images acquired with poor illumination. To show the details for visual inspection, moreover, contrast enhancement of medical or satellite images is desired. The visibility of image details has been improved, although the PSNR value of the enhanced image is often low. To improve the visual quality of host images, there is no existing RDH algorithm that performs the task of contrast enhancement. Image contrast enhancement [17] can be achieved by histogram equalization. The earlier algorithm is performed by modifying the histogram of pixel values, to perform data embedding and contrast enhancement at the same time. Firstly, the two peaks in the histogram are found out. The bins between the peaks are unchanged while the outer bins are shifted outward so that each of the two peaks can be split into two adjacent bins. The highest two bins in the modified histogram can be further chosen to be split, and so on until satisfactory contrast enhancement effect is achieved, to increase the embedding capacity. The bounding pixel values are pre-processed and a location map is generated to memorize their locations, to avoid the overflows and underflows due to histogram modification. Together with the message bits and other side information, for the recovery of the original image, the location map is embedded into the host image.

II.Related Work

Howard, Paul G. et al. [1] proposed the new standard, informally referred to as JBIG2, will support model-based coding for text and halftones to permit compression ratios up to three times those of existing standards for lossless compression. JBIG2 will also permit lossy preprocessing without specifying how it is to be done, In this case, compression ratios up to eight times those of existing standards may be obtained with imperceptible loss of quality. It is expected that JBIG2 will become an international standard by 2000.

Stark, J. Alex [2] proposed a scheme for adaptive image-contrast enhancement based on a generalization of histogram equalization (HE). HE is a useful technique for improving image contrast, but its effect is too severe for many purposes. However, dramatically different results can be obtained with relatively minor modifications. A concise description of adaptive HE is set out, and this framework is used in a discussion of past suggestions for variations on HE. A key feature of this formalism is a "cumulation function," which is used to generate a grey level mapping from the local histogram. By choosing alternative forms of cumulation function one can achieve a wide variety of effects. A specific form is proposed. Through the variation of one or two parameters, the resulting process can produce a range of degrees of contrast enhancement, at one extreme leaving the image unchanged, at another yielding full adaptive equalization.

Tian, Jun [3] presented a novel reversible data embedding method for digital images. They explored the redundancy in digital images to achieve very high embedding capacity, and keep the distortion low.

Ni, Zhicheng et al. [4] presented a novel reversible data hiding algorithm, which can recover the original image without any distortion from the marked image after the hidden data have been extracted. This algorithm utilizes the zero or the minimum points of the histogram of an image and slightly modifies the pixel grayscale values to embed data into the image. It can embed more data than many of the existing reversible data hiding algorithms. It is proved analytically and shown experimentally that the peak signal-to-noise ratio (PSNR) of the marked image generated by this method versus the original image is guaranteed to be above 48 dB. This lower bound of PSNR is much higher than that of all reversible data hiding techniques reported in the literature. The computational complexity of their proposed technique is low and the execution time is short. The algorithm has been successfully applied to a wide range of images, including commonly used images, medical images, texture images, aerial images and all of the 1096 images in CorelDraw database. Experimental results and performance comparison with other reversible data hiding schemes are presented to demonstrate the validity of the proposed algorithm.

Thodi, Dilith M., and Jeffrey J. Rodríguez [5] proposed a histogram shifting technique as an alternative to embedding the location map. The proposed technique improves the distortion performance at low embedding capacities and mitigates the capacity control problem. They also proposed a reversible data-embedding technique called prediction-error expansion. This new technique better exploits the correlation inherent in the neighborhood of a pixel than the difference-expansion scheme. Prediction-error expansion and histogram shifting combine to form an effective method for data embedding. The experimental results for many standard test images show that prediction-error expansion doubles the maximum embedding capacity when compared to difference expansion. There is also a significant improvement in the quality of the watermarked image, especially at moderate embedding capacities.

Coltuc, Dinu, and J-M. Chassery [6] discussed that Reversible contrast mapping (RCM) is a simple integer transform that applies to pairs of pixels. For some pairs of pixels, RCM is invertible, even if the least significant bits (LSBs) of the transformed pixels are lost. The data space occupied by the LSBs is suitable for data hiding. The embedded information bit-rates of the proposed spatial domain reversible watermarking scheme are close to the highest bit-rates reported so far. The scheme does not need additional data compression, and, in terms of mathematical complexity, it appears to be the lowest complexity one proposed up to now. A very fast lookup table implementation is proposed. Robustness against cropping can be ensured as well.

Yang, Ying et al. [7] proposed a reversible (also called lossless, distortion-free, or invertible) visible watermarking scheme to satisfy the applications, in which the visible watermark is expected to combat copyright piracy but can be removed to losslessly recover the original image. They transparently revealed the watermark image by overlapping it on a user-specified region of the host image through adaptively adjusting the pixel values beneath the watermark, depending on the human visual system-based scaling factors. In order to achieve reversibility, a reconstruction/recovery packet, which is utilized to restore the watermarked area, is reversibly inserted into non-visiblywatermarked region. The packet is established according to the difference image between the original image and its approximate version instead of its visibly watermarked version so as to alleviate its overhead. For the generation of the approximation, they developed a simple prediction technique that makes use of the unaltered neighboring pixels as auxiliary information. The recovery packet is uniquely encoded before hiding so that the original watermark pattern can be reconstructed based on the encoded packet. In this way, the image recovery process is carried out without needing the availability of the watermark. In addition, their method adopts data compression for further reduction in the recovery packet size and improvement in embedding capacity. The experimental results demonstrate the superiority of the proposed scheme compared to the existing methods.

Sachnev, Vasiliy et al. [8] presented a reversible or lossless watermarking algorithm for images without using a location map in most cases. This algorithm employs prediction errors to embed data into an image. A sorting technique is used to record the prediction errors based on magnitude of its local variance. Using sorted prediction errors and, if needed, though rarely, a reduced size location map allows us to embed more data into the image with less distortion. The results clearly indicate that the proposed scheme can embed more data with less distortion.

Li, Xiaolong et al. [9] proposed to adaptively embed 1 or 2 bits into expandable pixel according to the local complexity. This avoids expanding pixels with large prediction-errors, and thus, it reduces embedding impact by decreasing the maximum modification to pixel values. Meanwhile, adaptive PEE allows very large payload in a single embedding pass, and it improves the capacity limit of conventional PEE. They also proposed to select pixels of smooth area for data embedding and leave rough pixels unchanged. In this way, compared with conventional PEE, a more sharply distributed prediction-error histogram is obtained and a better visual quality of watermarked image is observed. With these improvements, their method outperforms conventional PEE. Its superiority over other state-of-the-art methods is also demonstrated experimentally.

Zhang, Xinpeng et al.[10] proposed a novel reversible data hiding scheme for encrypted image. After encrypting the entire data of an uncompressed image by a stream cipher, the additional data can be embedded into the image by modifying a small proportion of encrypted data. With an encrypted image containing additional data, one may firstly decrypt it using the encryption key, and the decrypted version is similar to the original image. According to the data-hiding key, with the aid of spatial correlation in natural image, the embedded data can be successfully extracted and the original image can be perfectly recovered.

Fallahpour et al. [11] introduced a highly efficient reversible data hiding system. It is based on dividing the image into tiles and shifting the histograms of each image tile between its minimum and maximum frequency. Data are then inserted at the pixel level with the largest frequency to maximize data hiding capacity. It exploits the special properties of medical images, where the histogram of their non-overlapping image tiles mostly peak around some grey values and the rest of the spectrum is mainly empty. The zeros (or minima) and peaks (maxima) of the histograms of the image tiles are then relocated to embed the data. The grey values of some pixels are therefore modified. High capacity, high fidelity, reversibility and multiple data insertions are the key requirements of data hiding in medical images. The authors show how histograms of image tiles of medical images can be exploited to achieve these requirements. Compared to the data hiding method applied to the whole image, the authors' scheme can result in 30-200% capacity improvement and still with better image quality, depending on the medical image content. Additional advantages of the proposed method include hiding data in the regions of non-interest and better exploitation of spatial masking.

Zhao, Zhenfei et al. [12] proposed a reversible data hiding method for natural images. Due to the similarity of neighbor pixels' values, most differences between pairs of adjacent pixels are equal or close to zero. In this work, a histogram is constructed based on these difference statistics. In the data embedding stage, a multilevel histogram modification mechanism is employed. As more peak points are used for secret bits modulation, the hiding capacity is enhanced compared with those conventional methods based on one or two level histogram modification. Moreover, as the differences concentricity around zero is improved, the distortions on the host image introduced by secret content embedding is mitigated. In the data extraction and image recovery stage, the embedding level instead of the peak points and zero points is used. Accordingly the affiliated information is much smaller than in those methods of the kind. A sequential recovery strategy is exploited for each pixel is reconstructed with the aid of its previously recovered neighbor. Experimental results and comparisons with other methods demonstrated their method's effectiveness and superior performance.

Zhang, Xinpeng [13] proposed a novel scheme for separable reversible data hiding in encrypted images. In the first phase, a content owner encrypts the original uncompressed image using an encryption key. Then, a data-hider may compress the least significant bits of the encrypted image using a data-hiding key to create a sparse space to accommodate some additional data. With an encrypted image containing additional data, if a receiver has the data-hiding key, he can extract the additional data though he does not know the image content. If the receiver has the encryption key, he can decrypt the received data to obtain an image similar to the original one, but cannot extract the additional data. If the receiver has both the data-hiding key and the encryption key, he can extract the additional data and recover the original content without any error by exploiting the spatial correlation in natural image when the amount of additional data is not too large.

Wu, Hao-Tian, and Jiwu Huang [14] proposed a reversible data hiding algorithm, in which the efficiency of modifying a pair of histogram bins is considered. Multiple pairs of histogram bins can be further selected for data embedding in sequence, while pre-process of pixel values is performed to prevent the possible overflow and underflow. Embedding with the prediction errors is investigated with a new prediction scheme. In each of the four prediction modes, a large amount of prediction errors can be produced from the host image. Moreover, all combinations of the four modes to generate a number of histogram pairs are enumerated to obtain the best performance. Blind extraction and recovery are enabled by embedding a pre-computed location map and other overhead information into the watermarked image. Promising experimental results are obtained on a variety of test images. Compared with the existing algorithms, the image content is better preserved in high payload data hiding.

Gao, Ming-Zhi et al. [15] discussed the principle of image enhancement is based on increasing the contrast between adjacent pixels, enabling viewers to visually perceive images with greater detail in the textures and edges. Many contrast enhancement methods have been proposed to improve the quality of images and most of these methods are based histogram equalization (HE); however, the actual results remain uncertain due to the lack of an objective evaluation procedure with which to measure them. This paper proposes a quantitative analysis for the assessment of image quality based on several subjective and objective evaluation metrics. Furthermore, there are 11 different HE based contrast enhancement techniques are evaluated in this paper.

Jose, Rintu, and Gincy Abraham [16] proposed a novel scheme to reversibly hide data into encrypted grayscale image in a separable manner. During the first phase, the content owner encrypts the image by permuting the pixels using the encryption key. The data hider then hides some data into the encrypted image by histogram modification based data hiding, making use of data hiding key. At the receiver side, if the receiver has only encryption key, he can generate an image similar to the original one, but cannot read the hidden data. Peak Signal to Noise Ratio (PSNR) of this decrypted image is much higher than the existing methods. If the receiver has only data hiding key, he can extract the data, but cannot read the content of the image. If the receiver has both keys, he may first extract the data using data hiding key and then decrypt the image using encryption key. The method also has a higher data hiding capacity than the existing reversible data hiding techniques in encrypted image.

Wu, H., J. Dugelay, and Y. Shi [17] proposed a novel reversible data hiding (RDH) algorithm is proposed for digital images. Instead of trying to keep the PSNR value high, the proposed algorithm enhances the contrast of a host image to improve its visual quality. The highest two bins in the histogram are selected for data embedding so that histogram equalization can be performed by repeating the process. The side information is embedded along with the message bits into the host image so that the original image is completely recoverable. The proposed algorithm was implemented on two sets of images to demonstrate its efficiency. To best knowledge, it is the first algorithm that achieves image contrast enhancement by RDH. Furthermore, the evaluation results show that the visual quality can be preserved after a considerable amount of message bits have been embedded into the contrast-enhanced images, even better than three specific MATLAB functions used for image contrast enhancement.

III .Basic RDH Techniques

1. PWLC data hiding technique

To the best of our knowledge, the only proposed reversible data hiding technique for binary images is PWLC (Pair- Wise Logical Computation). However, it seems that sometimes PWLC does not correctly extract the hidden data, and fails to recover perfectly the original cover image.

PWLC uses neither the spread spectrum nor any compression technique. It uses XOR binary operations to store the payload in the host image. It scans the host image in some order (for example, in raster scanning order). Only sequences “000000” or “111111” that are located near to the image boundaries are chosen to hide data. The sequence “000000” becomes “001000” if bit 0 is inserted, and becomes “001100” if bit 1 is inserted. Similarly, the sequence “111111” becomes “110111” if bit 0 is inserted, and becomes “110011” if bit 1 is inserted.

However, the papers do not describe clearly how to identify the modified pixels in the extraction process. The image boundaries may change with the watermark insertion. Moreover, let us suppose that a sequence “001000” (located near to an image boundary) was found in the stego image. The papers do not describe how to discriminate between an unmarked “001000” sequence and an originally “000000” sequence that became “001000” with the insertion of the hidden bit 0.

2. DHTC data hiding technique

(RDHTC) is based on the non-reversible data hiding named DHTC (Data Hiding by Template ranking with symmetrical Central pixels) [10]. DHTC flips only low-visibility pixels to insert the hidden data and consequently images marked by DHTC have excellent visual quality and do not present salt-and-pepper noise.

Hatched pixels match either black or white pixels (note that all central pixels are hatched). The score of a given pattern is that of the matching template with the lowest impact. Mirrors, rotations and reverses of each pattern have the same score.

3. Reversible Image Data Hiding with Contrast Enhancement

The procedure of the proposed algorithm [17] is illustrated in next Fig.1. Given that totally pairs of histogram bins are to be split for data embedding, the **embedding** procedure includes the following steps:

1) Pre-process: The pixels in the range of [0,L-1] and [256-L, 255] are processed excluding the first 16 pixels in the bottom row. A location map is generated to record the locations of those pixels and compressed by the JBIG2 standard [11] to reduce its length.
2) The image histogram is calculated without counting the first 16 pixels in the bottom row.
3) Embedding: The two peaks (i.e. the highest two bins) in the histogram are split for data embedding by applying equation to every pixel counted in the histogram. Then the two peaks in the *modified* histogram are chosen to be split, and so on untilpairs are split. The bit stream of the compressed location map is embedded before the message bits (binary values). The value of the length of the compressed location map, the LSBs collected from the 16 excluded pixels, and the previous peak values are embedded with the last two peaks to be split.
4) The lastly split peak values are used to replace the LSBs of the 16 excluded pixels to form the marked image.

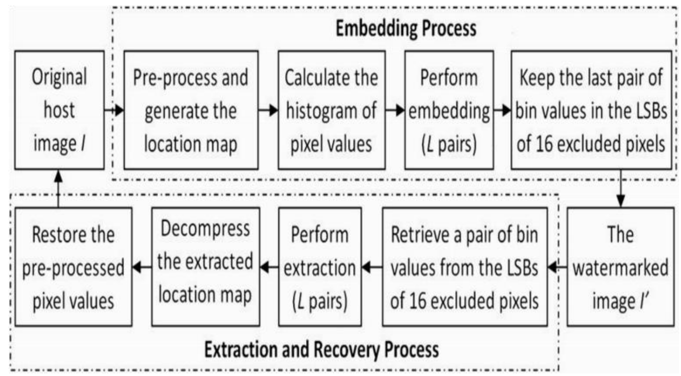

Fig. 1. Procedure of the proposed RDH algorithm

IV Limitations Of Earlier Techniques

The review on existing techniques has shown that the existing algorithms has neglected the following issues:-

1.The reversible data hiding algorithm has not considered the medical and satellite images for the better visibility.

2.The reversible data hiding algorithm has low robustness.

V Conclusion

From the review on techniques in this paper, it has been shown that important techniques implemented are PWLC, DHTC and so on. The original image can be exactly recovered without any additional information. Hence the proposed algorithm has made the image contrast enhancement reversible. Improving the algorithm robustness,And applying it to the medical and satellite images for the better visibility, will be our future work. A new robust reversible data hiding algorithm can be proposed to overcome these issues.

References

i. *Howard, Paul G., FaouziKossentini, Bo Martins, SørenForchhammer, and William J. Rucklidge. "The emerging JBIG2 standard." Circuits and Systems for Video Technology, IEEE Transactions on 8, no. 7 (1998): 838-848.*

ii. *Stark, J. Alex. "Adaptive image contrast enhancement using generalizations of histogram equalization." Image Processing, IEEE Transactions on 9, no. 5 (2000): 889-896.*

iii. *Tian, Jun. "Reversible data embedding using a difference expansion." IEEE Trans. Circuits Syst. Video Techn. 13, no. 8 (2003): 890-896.*

iv. *Ni, Zhicheng, Yun-Qing Shi, Nirwan Ansari, and Wei Su. "Reversible data hiding." Circuits and Systems for Video Technology, IEEE Transactions on 16, no. 3 (2006): 354-362.*

v. *Thodi, Diljith M., and Jeffrey J. Rodríguez. "Expansion embedding techniques for reversible watermarking." Image Processing, IEEE Transactions on 16, no. 3 (2007): 721-730.*

vi. *Coltuc, Dinu, and J-M. Chassery. "Very fast watermarking by reversible contrast mapping." Signal Processing Letters, IEEE 14, no. 4 (2007): 255-258.*

vii. *Yang, Ying, Xingming Sun, Hengfu Yang, Chang-Tsun Li, and Rong Xiao. "A contrast-sensitive reversible visible image watermarking technique." Circuits and Systems for Video Technology, IEEE Transactions on 19, no. 5 (2009): 656-667.*

viii. *Sachnev, Vasiliy, HyoungJoong Kim, Jeho Nam, Sundaram Suresh, and Yun Qing Shi. "Reversible watermarking algorithm using sorting and prediction."Circuits and Systems for Video Technology, IEEE Transactions on 19, no. 7 (2009): 989-999.*

ix. *Li, Xiaolong, Bin Yang, and Tieyong Zeng. "Efficient reversible watermarking based on adaptive prediction-error expansion and pixel selection." Image Processing, IEEE Transactions on 20, no. 12 (2011): 3524-3533.*

x. *Zhang, Xinpeng. "Reversible data hiding in encrypted image." Signal Processing Letters, IEEE 18, no. 4 (2011): 255-258.*

xi. *Fallahpour, Mehdi, D. Megias, and Mohammed Ghanbari. "Reversible and high-capacity data hiding in medical images." IET image processing 5, no. 2 (2011): 190-197.*

xii. *Zhao, Zhenfei, HaoLuo, Zhe-Ming Lu, and Jeng-Shyang Pan. "Reversible data hiding based on multilevel histogram modification and sequential recovery."AEU-International Journal of Electronics and Communications 65, no. 10 (2011): 814-826.*

xiii. *Zhang, Xinpeng. "Separable reversible data hiding in encrypted image."Information Forensics and Security, IEEE Transactions on 7, no. 2 (2012): 826-832.*

xiv. *Wu, Hao-Tian, and Jiwu Huang. "Reversible image watermarking on prediction errors by efficient histogram modification." Signal Processing 92, no. 12 (2012): 3000-3009.*

xv. *Gao, Ming-Zhi, Zhi-Gang Wu, and Lei Wang. "Comprehensive Evaluation for HE Based Contrast Enhancement Techniques." In Advances in Intelligent Systems and Applications-Volume 2, pp. 331-338. Springer Berlin Heidelberg, 2013.*

xvi. *Jose, Rintu, and Gincy Abraham. "A separable reversible data hiding in encrypted image with improved performance." In Emerging Research Areas and 2013 International Conference on Microelectronics, Communications and Renewable Energy (AICERA/ICMiCR), 2013 Annual International Conference on, pp. 1-5. IEEE, 2013.*

xvii. *Wu, H., J. Dugelay, and Y. Shi. "Reversible Image Data Hiding with Contrast Enhancement." (2015).*