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An Improvement in Data Hiding Rate on Color Images

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Abstract: In this paper, a novel reversible data hiding (RDH) algorithm is proposed for color images. The proposed algorithm mainly aims at maximizing the data hiding rate on images through various methods. This algorithm also enhances the contrast of the host image in order to improve its visual quality. Data are hidden into the three different layers of color images i.e. red, green and blue. This will help to increase the size of the data that can be hidden in the images which can be either binary values or images. In order to increase data hiding rate further, data can also be hidden into the least significant bits (LSBs) of all the bins with highest pixel value in the histogram. A location map is generated for memorizing the positions of these bins in the histogram. By applying all the above in data hiding will increase both data hiding rate as well as size of the data that can be embedded drastically. This paper also compares the time consumed for data hiding by different images. Data hiding can be extended to video images as future work.

Keywords: Contrast enhancement, histogram modification, location map, reversible data hiding, visual quality.

I. INTRODUCTION

Data hiding is the process of embedding some useful information into images. In most of the applications, the data that is embedded is related to authentication for which invisibility is a major requirement. Data hiding is mostly useful in the field of sensitive applications such as sending authentication data. Reversible data hiding (RDH) which is also referred as invertible or lossless data hiding, has been studied in depth in the field of signal processing. In RDH method, a piece of information is hidden in an image to generate a watermarked image, from which the original image can be recovered after extracting the data. In most of the cases, the image will experience some distortion as a result of data hiding and cannot be converted back to that of the original image. That is, some permanent distortion exists in the image even after the hidden data have been removed.

There are two main requirements for RDH techniques: the embedding capacity which has to be large; and that of distortion that must be less. However these two requirements conflict with one another. In general, higher embedding capacity results in higher degree of distortion. A new improved technique can embed the same capacity with lower distortion or vice versa. The goal of data hiding process is to embed as much data as possible into a host image without causing any kind of distortions, and that should be still robust enough to survive both benign and malicious attacks. That is, there are three conflicting requirements for a data hiding scheme. They are: 1) Transparency: The host signal should not undergo any perceptual degradation. 2) Robustness: The embedded signal should survive the effect of benign and malicious attacks. 3) Capacity: Embed as much information as possible into the host.

For evaluating the performance of a RDH algorithm, the hiding rate and the watermarked image quality are important factors. There exists a trade-off between these two factors because incrementing the hiding rate often causes more distortion in image content. For measuring the distortion caused, the peak signal-to-noise ratio (PSNR) value of the watermarked image is often calculated. Most of the algorithms used in this area try to improve visual quality of the image instead of PSNR value. However, the visual quality can hardly be improved because distortion has been already introduced into the images with the embedding operations. Hence for the images with poor illumination, improving the visual quality is more important than trying to keep the PSNR value high. Therefore this RDH algorithm aims at achieving the property of contrast enhancement instead of just keeping the PSNR value high.

The aim of the proposed method is to extend the data hiding operation to color image from gray-level images. This will increase the data hiding rate thrice than that can be done with gray-level images. Also data hiding rate can be further increased by embedding data in the least significant bits (LSBs) of bins with highest two values of the histogram.

Contrast enhancement in images can be achieved through histogram equalization. In order to perform data embedding and contrast enhancement simultaneously, the histogram of pixel values are modified. First, the three different layers in the color image i.e. red, green and blue are extracted. Then, the highest two bins in the histogram for each layer are found out. The bins between these two peaks are kept unchanged while that of the outer bins is shifted outwards in order to split the two peaks into two adjacent bins. This will enable in embedding bigger size data into the images. In order to increase the hiding rate further all bins with the highest two pixel values are found and data is hidden in the LSBs of those bins. For memorizing the positions of those bins in the histogram, a location map is also generated. For avoiding the problem

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of overflows and underflows due to histogram modification, the bounding pixel values are pre-processed and for memorizing their locations, a location map is also generated which will be embedded into the host image along with the message bits and other side information for recovering the original image. The experimental result shows that the data hiding rate is drastically increased compared to embedding done with gray-level images. A comparison of time consumed for performing data hiding and extraction for different images is also done.

The rest of this paper is organized as follows. In Section II the related work is described briefly. Section III describes the details of the proposed method for RDH in color images with contrast enhancement. The experimental result is presented in Section IV. And finally a conclusion is drawn in Section V.

II. RELATED WORK

In the existing system, data hiding is performed on gray-level images. Here, data are embedded into bins with the highest two pixel values in the histogram of the image [1]. In order to extract data from the image these two pixel values are required. Therefore for memorizing the positions of highest two bins, last 16 bits of the image are excluded from histogram computing. With this method the amount of data that can be hidden is too small. Hence a new method is proposed for increasing both data hiding rate as well as size of data that can be embedded . This method is described in the following section. With this method data hiding rate is incremented by four times when compared to that of existing one. Data hiding capacity is also increased.

III. PROPOSED METHOD

This section describes various methods adopted for increasing data hiding rate in color images. Given an 8-bit color image I. Color images are composed of three different layers namely red, green and blue. In color images, data can be embedded into these three layers thereby increasing data hiding rate by thrice than that can be done with gray-level images. First, all the three layers are extracted from the color image. Then the following processes will be performed on each layer for data hiding. The image histogram is calculated by counting the pixel with value i for i ϵ {0,1,…,254,255}. The image histogram is denoted by h_I so that $h_I(i)$ represents the number of pixels with value i. Suppose I consists of N different pixel values, then there will be N non-empty bins in h_I out of which the two peaks i.e. the highest two bins, are chosen. The smaller value is denoted by I_1 and bigger value by I_2. For a pixel with value j in h_I, data embedding is performed as follows:

$$j' = \begin{cases} j-1, & \text{for } j < I_1 \\ I_1 - b_k & \text{for } j = I_1 \\ j & \text{for } I_1 < j < I_2 \\ I_2 + b_k & \text{for } j = I_2 \\ j+1 & \text{for } j > I_2 \end{cases} \qquad (1)$$

where j' is the modified pixel value and b_k is the k^{th} message bit (0 or 1) that is to be hidden into the image. When Eq. (1) is applied to every pixel in h_I, totally $h_I(I_1) + h_I(I_2)$ binary values are embedded into the image. Given, there is no bounding value (0 or 255) in I, hence there will be N + 2 bins in the modified histogram. That is, the bins between the two peaks are kept as such without any change while that of the outer ones is shifted outwards so that each of the peaks is split into two adjacent bins (i.e. I_1 -1 and I_1, I_2 and I_2 +1,respectively).

The peak values I_1 and I_2 are required for extracting the embedded data. Exclude 16 pixels in I from histogram computing to memorize this values. The least significant bits(LSBs) of these pixels are collected and are included with the binary values which is to be hidden. Once Eq.(1) is applied to each pixel counted in h_I for data embedding, the values of I_1 and I_2 (each with 8 bits) are used for replacing the LSBs of the 16 excluded pixels by using bitwise operation. The peak values are required to be obtained for extracting the embedded data and the histogram of the marked image I' is calculated excluding the 16 pixels that is mentioned before. Them the following operation is performed with any of the pixel counted in the histogram and with the values of $I_1 - 1$, I_1, I_2 or $I_2 + 1$:

$$b_k' = \begin{cases} j-1, & \text{if } j' = I_1 - 1 \\ 0, & \text{if } j' = I_1 \\ 0, & \text{if } j' = I_2 \\ 1, & \text{if } j' = I_2 + 1 \end{cases} \qquad (2)$$

where b_k' is the k^{th} binary value that is extracted from the marked image I'. Same as that of the embedding operation, the extraction operations are also performed. According to Eq.(1), on every pixel that is counted from the histogram the following operation is performed for recovering its original value:

$$j = \begin{cases} j' + 1, & \text{for } j' < I_1 - 1 \\ I_1, & \text{for } j' = I_1 - 1 \text{ or } j' = I_1 \\ I_2, & \text{for } j' = I_2 \text{ or } j' = I_2 + 1 \\ i' - 1, & \text{for } j' > I_2 + 1 \end{cases} \qquad (3)$$

From the extracted binary values it is possible to obtain the original LSBs of 16 excluded pixels. The excluded pixels can be restored by writing them back in order to recover the original image.

One of the requirement of the above mentioned method is that all pixels counted in h_I are within the range {1,…,254}. Overflow or underflow will be caused by histogram shifting if there is any bounding pixel value (0 or 255). To avoid this, the histogram is pre-processed prior to the histogram modification operation i.e. pixel values of 0 is modified to 1 and that of 255 is modified to 254. Therefore, there will be no overflow or underflow since all possible change in pixel value is either + or – 1.

Another method that can also be adopted to further increase the data hiding rate is to consider all the bins with the highest pixel value for embedding. In the above mentioned method, only two bins where selected for embedding. Here, all the bins with the highest pixel value in the histogram are found and data are embedded into their LSBs. A location map is then generated for memorizing the positions of these bins for extracting the data back from the image. By this the data that can be hidden into color images will be increased by four times with that compared to gray-level images.

By applying the above methods on color images results in increasing the data hiding rate drastically. This will also help to increase the amount of data that can be embedded into the images. Data that is embedded can be either of the form binary or image itself. The procedure for the above mentioned method is shown in Fig. 1.

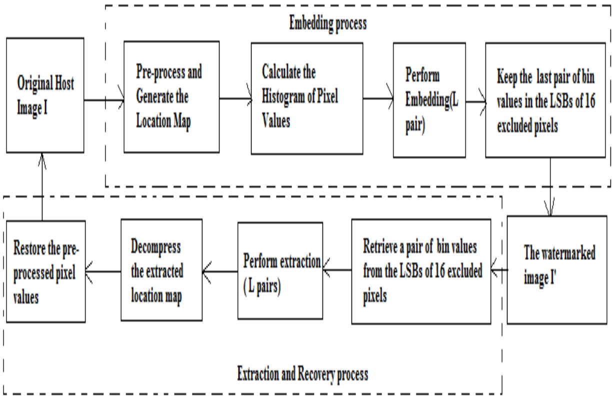
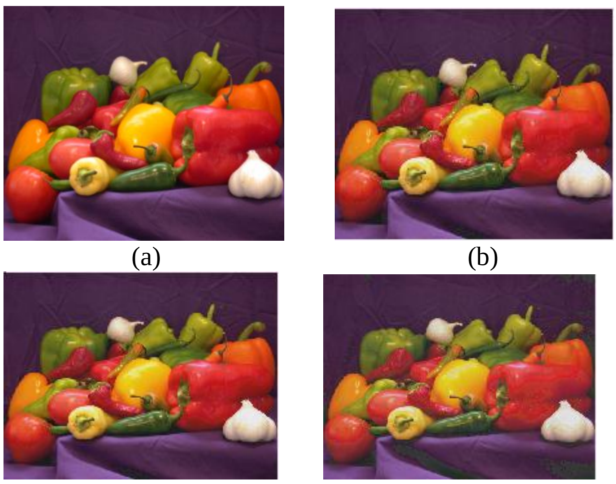


Fig. 1 Procedure of the proposed method

IV. Experimental Result

In the experiments, it can be seen that the data hiding rate of the proposed system is compared with that of the existing system. It is found that the data hiding rate has increased by four times when compared with that of the existing system. Thus more amount of data can be embedded in color images.



(a) (b) (c) (d)

Fig. 2 The original and recovered images of "peppers" by splitting 10, 20 and 30 pairs of histogram peaks in the proposed algorithm. (a) Original image of "peppers". (b) 10 pairs. (c) 20 pairs. (d) 30 pairs.

As the resolution of the images become higher more data can be stored in those images. But when the time consumption for performing data hiding is considered it can be seen that as resolution of the images become higher time required for performing hiding operation also get increased. Following figure shows that visual quality is preserved when the input image is pre-processed by splitting the histogram peaks with different values.

V. Conclusion

This paper has proposed a new method for improving both data hiding rate as well as data embedding capacity by extending the work to color images. In this method data are embedded into the three different layers of color images i.e. red, green and blue. For extracting the hidden data from the image, peak values of the highest two bins in the histogram into which the data is embedded are stored in the last 16 excluded bits in the image. In order to further increase data hiding rate, data can also be embedded into all the bins with highest peak value. Experimental results show that both rate as well as size of data that can be embedded got incremented by four times as compared with that of gray-level images. Data hiding can be extended to video as future work. Also improving the PSNR value of the extracted image can also be considered in the future works.

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References

[1] Hao- Tian Wu,Jean-Luc Dugelay and Yun-Qing Shi.," Reversible Image Data Hiding With Contrast Enhancement", IEEE Signal Processing Letters,VOL.22,No.1,Januvary 2015 .
[2] J. Tian, "Reversible data embedding using a difference expansion," IEEE Trans. Circuits Syst. Video Technol., vol. 13, no. 8, pp. 890–896, Aug. 2003.
[3] Z. Ni, Y. Q. Shi, N. Ansari, andW. Su, "Reversible data hiding," IEEE Trans. Circuits Syst. Video Technol., vol. 16, no. 3, pp. 354–362, Mar. 2006.
[4] D.M. Thodi and J. J. Rodriguez, "Expansion embedding techniques for reversible watermarking," IEEE Trans. Image Process., vol. 16, no. 3, pp. 721–730, Mar. 2007.
[5] V. Sachnev, H. J. Kim, J. Nam, S. Suresh, and Y. Q. Shi, "Reversible watermarking algorithm using sorting and prediction," IEEE Trans. Circuits Syst. Video Technol., vol. 19, no. 7, pp. 989–999, Jul. 2009.
[6] J.A. Stark, "Adaptive image contrast enhancement using generalizations of histogram equalization," IEEE Trans. Image Process., vol. 9, no. 5, pp. 889–896, May 2000.
[7] P. G. Howard, F. Kossentini, B. Martins, S. Forchhammer, and W. J. Rucklidge, "The emerging JBIG2 standard," IEEE Trans. Circuits Syst. Video Technol., vol. 8, no. 7, pp. 838–848, Jul. 1998.
[8] D. Coltuc and J.-M. Chassery, "Very fast watermarking by reversible contrast mapping," IEEE Signal Process. Lett., vol. 14, no. 4, pp. 255–258, Apr. 2007.
[9] A. Masmoudi, W. Puech, M.S. Bouhlel, "Efficient adaptive arithmetic coding based on updated probability distribution for lossless image compression", Journal of Electronic Imaging 19(2), 023014 (Apr–Jun 2010)
[10] X. Li, B. Yang, and T. Zeng, "Efficient reversible watermarking based on adaptive prediction-error expansion and pixel selection," IEEE Trans. Image Process., vol. 20, no. 12, pp. 3524–3533, Jan. 2011.
[11] H. T.Wu and J. Huang, "Reversible image watermarking on prediction error by efficient histogram modification," Signal

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Process., vol. 92, no. 12, pp. 3000–3009, Dec. 2012.
[12] Y. Yang, X. Sun, H. Yang, C.-T. Li, and R. Xiao, "A contrast-sensitive reversible visible image watermarking technique," IEEE Trans. Circuits Syst. Video Technol., vol. 19, no. 5, pp. 656–667, May 2009.
[13] M.-Z.Gao, Z.-G.Wu, and L.Wang, "Comprehensive evaluation forHE based contrast enhancement techniques," Adv. Intell. Syst. Applicat., vol. 2, pp. 331–338, 2013

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