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Comparative Analysis of Reversible Data Hiding with Contrast Enhancement using Histogram Modification and Firefly Algorithm

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ABSTRACT

A novel reversible data hiding algorithms, which have ability to recover the original image without any distortion from the marked image after the hidden data has been extracted, is presented in this paper. This algorithm utilizes the histogram of an image and slightly modifies the pixel grayscale values to embed/hide the data into the image. It has ability to embed more data than many of the existing reversible data hiding algorithms today. It is proved analytically and shown experimentally that the peak signal-to-noise ratio (PSNR) of the marked image generated by firefly algorithm is better than histogram modification method in this paper. The computational complexity of our proposed technique is less and the execution time is short. The algorithm has been successfully applied to a wide Area of images including common images, medical images, texture images and aerial images. Experimental results and performance comparison of both reversible data hiding schemes (Histogram modification and Firefly algorithm) are presented in this paper to demonstrate the validity of the proposed algorithms.

Keywords-- RDH; PSNR; EMBEDDING; HISTOGRAM; FIREFLY

I. INTRODUCTION

Data hiding is referred to as a process to hide data (representing some useful information) into cover media [1]. That is, the data hiding process required two sets of data, a set of the embedded data (secret data) and another set of the cover media data. The relationships between these two sets of data possess different applications. For instance, in covert (secret) communications, the hidden data may sometimes be irrelevant to the cover media. In authentication, however, the embedded data are closely related to the cover media. Invisibility of hidden data (secret message) is an important requirement, in these two types of applications. The cover media will experience some distortion due to data hiding and cannot be recovered back to the original media in most of the cases of data hiding. Even after the hidden data has been recovered losslessly, there is some permanent distortion has been occurred to the cover media (original image). It is impossible to reverse the marked media back to the original cover media after the hidden data is recovered for some legal considerations in some applications such as medical diagnosis and law enforcement [8]. It is also desired that the original media (cover media) can be recovered because of the requirement of high-precision nature in other applications, such as remote sensing and high energy particle physical experimental investigation. The image data hiding techniques are referred to as lossless, reversible [6], distortion free or invertible data hiding techniques [5] if they satisfying these requirements. Reversible data hiding emphasize on enormous possibility of applications to bond two sets of data in such a way that the cover media can be losslessly recovered after the hidden data have been educe out and also providing an additional route of intendance two dissimilar sets of data [6]. The hiding rate and the marked image quality are important benchmark to determine the rendition of a RDH algorithm. There exists a trade-off between the data hiding rate and PSNR because increasing the hiding rate frequently causes more distortion in marked image quality and content [2]. The peak signal-to-noise ratio (PSNR) value of the marked image is repeatedly deliberated to expedient the distortion. In Generally speaking, direct revamping of image histogram provides less embedding capacity [7]. The most recent algorithms manipulate the more centrally distributed prediction errors by exploiting the correlations between neighboring pixels so that less distortion is caused by data hiding process in case of contrast [2],[9]. The optical quality can hardly be enhanced because more or less distortion has been introduced by the embedding operations although the PSNR of a marked image produced with a prediction error based algorithm is kept high [10]. For the images refined with poor illumination, improving the visual characteristic is further significant than keeping the PSNR value high. It is desired to show the details for optical (visual) examination for contrast enhancement of satellite and medical images [9]. The visibility of image information has been enhanced although the PSNR value of the upgraded image is often low. To our best cognizance, there is no subsist RDH algorithm that accomplish the assignment of contrast enhancement so as to enhance the visual characteristics of host images. So in this paper, we aim at fabricate a new RDH algorithm to attain the property of contrast enhancement instead of just maintaining the PSNR value high.

II. HISTOGRAM MODIFICATION ALGORITHM

A. Procedure of the Proposed Algorithm

The procedure of the proposed algorithm is illustrated in Figure. 1. Given that totally L pairs of histogram bins are to be shatter for data embedding, the embedding protocol includes the following steps:

1. Pre process: The pixels in the range of [0,L-1]and [256, L-255] are processed as mentioned in Section II-B eliminating the first 16 pixels in the bottom row. A location map is induced to register the locations of those pixels and compressed by the JBIG2 standard to abridge its length.
2. The image histogram is measured without consider the first 16 pixels in the bottom row.
3. Embedding: The two peaks (i.e. the highest two bins) in the histogram are shatter for information embedding to every pixel numerate in the histogram. Then the two peaks in the *modified* histogram are selected to be shatter, and so on until L pairs are shatter (split). The bit stream of the compressed location map is embedded before the information bits (binary values). The value of L, the length of the compressed location map, the LSBs gathered from the 16 eliminated pixels, and the antecedent peak values are embedded with the last two peaks to be shatter.
4. The lastly shatter peak values are used to substitute the LSBs of the 16 eliminated pixels to form the marked image.

The **extraction** and **recovery** process include the following steps:

1. The LSBs of the 16 eliminated pixels are recovered so that the values of the last two shatter (split) peaks are known.
2. The data hidden (embedded) with the last two shatter peaks are educed so that the value of L, the length of the compressed location map, the original LSBs of 16 eliminated pixels, and the previously shatter peak values are known to us. Then the recovery procedure is carried out by processing all pixels except the 16 eliminated ones. The process of extraction and recovery is repeated until all of the shatter peaks are recovered and the data hidden with them are extracted.
3. The compressed location map is acquired from the extracted binary values and decompressed to the original size.
4. With the decompressed map, those pixels changed in pre-process are distinguished. Among them, a pixel value is subtracted by L if it is less than 128, or increased by L other-wise. To conform to this rule, the maximum value of L is 64 to scape uncertainty. At last, the original image is restored by writing back the original LSBs of 16 eliminated pixels.

B. Block diagram of the Histogram Modification Algorithm

Embedding

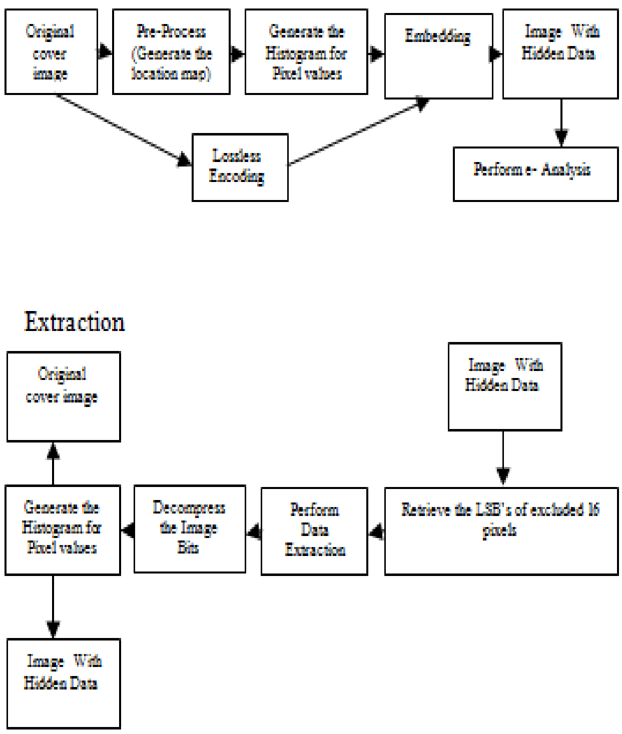

Figure.1

III. FIREFLY ALGORITHM

A. Embedding the secret data

The proposed method for hiding (embedding) confidential information in the cover image is shown in Figure 2. The firefly Algorithm (module) detects the optimum position using the above mentioned objective function [4]. These positions are then used for the confidential data embedding.

The steps to embed the secret data into cover image are presented below

Step 1: Get the original image C of size MxN and the confidential data S

Step 2: The confidential data is transformed into binary and then confidential word W is formed by concatenating the binary bits. The length of W be L.

Step 3: The original image (cover image) split into number of 8x8 size non overlapping blocks. It is denoted as B_l, where l= 1,2,.. n. The number of bits to be embedded in a block is represented as r = L/n.

Step 4: To find the best position in each block using firefly algorithm, we need to accomplish the following:

1. set the initial parameters:

nf (Number of fireflies),

its (Maximum number of iterations)

c1 and c2 (constants)

rand (random number)

Each firefly has the size of number bits to be hidden in each block r. If r is 5 then each firefly characterize the group of 5 bits which is chosen from 64 pixel block [3], [4].

The firefly algorithm (FA) is an iterative algorithm. In each replication, the stego image block for each firefly is acquired by hiding r bits of confidential data in that firefly location. Once this procedure is finalized then cover and stego image is calculated. Then the PSNR is calculated by extracting the secret bits from stego image block. Then each firefly's location is updated.

The best position is found when the following conditions occur:

- Number of iteration exceeds maximum number of iterations
- No improvement is obtained in the successive iterations
- An acceptable result has been found

Step 5: Data hiding Process: The r bits from confidential word W is hide in the best pixel of each block. For this intention the histogram shifting algorithm is used.

1. For a gray scale image the pixel intensity value x € [0, 255]. The histogram H(x) is produced based on the formula:

$$H(x) = p_x, 1 \le x \le 255$$

2. The maximum intensity pixel (peak point) and minimum intensity pixel (zero point) are found in the histogram H(x).

3. If the maximum intensity pixel (peak point) is greater than the minimum intensity pixel (zero point), then all the pixel values in the histogram are decremented by 1. It signifies that the entire histogram is shifted towards the left by 1 unit.

4. The image is scanned in the sequential order. Once the maximum intensity pixel (peak point) is finding, then the secret bit is verified. If secret bit is 1 then the maximum intensity pixel value is incremented by 1. If secret bit is 0 then there is no change in the maximum intensity pixel value.

B. Extracting the secret data

Step 1: The stego image is scanned in the same order which is used in the data hiding procedure. If the maximum intensity pixel value is greater than peak point then bit 1 is recovered and if the maximum intensity pixel value is equal to peak point then bit 0 is recovered.

Step 2: The value of maximum intensity pixel is decremented by 1 whenever the bit 1 is recovered.

Step 3: After extracting all the bits, the entire value of the histogram is incremented by 1. So that the blank place which is induced during data hiding process is removed.

C. Block diagram of the Firefly Algorithm

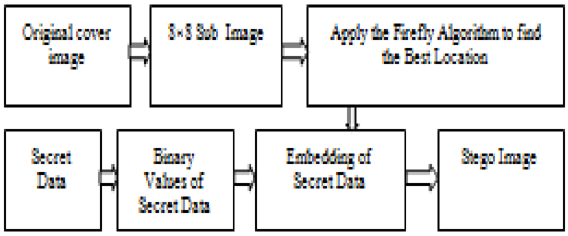

Figure.2

IV. EXPERIMENTAL RESULTS

In the experiments, 8 USC-SIPI test images [11] with the size of 512×512 were engaged and converted into grey-level images [12].

The only characteristic in the suggested algorithm is L, i.e. the pair number of histogram peaks to be shatter. The secret message bits to be hidden can be any string of binary values in which the numbers of 0s and 1s are nearly equal, or some extra bits can be attached to make so. As shown in Figure. 1, the absolute data hiding rates were generally increased by using more histogram peaks for image data embedding.

When 10 pairs of histogram peaks were split using Histogram Modification, the PSNR was 48db for Lena, 40db for Baboon and it increased to 57db for Lena, 45.5db for Baboon using Firefly Algorithm for hiding rate 0.2 bit per pixel (bpp).

The original images and marked images of "Lena" and "Baboon" are shown in Figure. 3. The data hidden (marked images) were obtained by splitting 10, 15 and 20 pairs of histogram peaks for data hiding, respectively. It can be seen that the hiding data were invisible in the contrast enhanced images. The more histogram peaks were shatter (split) for data hiding (embedding), the more contrast enhancement effect was acquired [2]. Although the PSNR value of the contrast-enhanced images decrease with increasing the data hiding rate (embedding rate), the visual characteristic has been maintained, as shown in Figure. 3.

Table I and Table II show the statistical results of two sets of test images (Lena and Baboon respectively). Each particular listed in the two tables is the value of single test images. The suggested algorithm using 10, 15 and 20 pairs of histogram peaks are denoted by *10 pairs*, *15 pairs* and *20 pairs*, respectively. It can be noticed that the contrast of test images was step-by-step enhanced by splitting more histogram bins in the suggested algorithm but more differences were inserted in brightness and structural similitude.

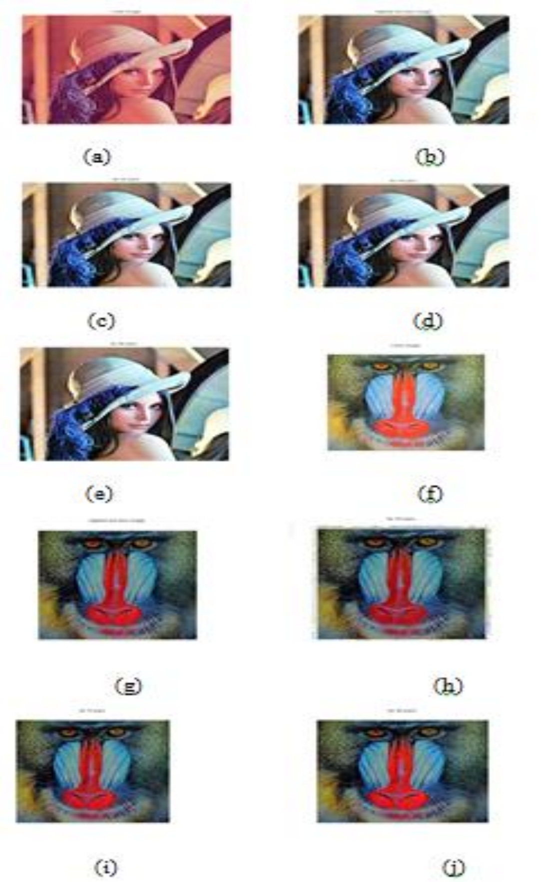

Figure.3. The original and contrast enhanced images of "Lena" and "Baboon" by splitting 10, 15 and 20 pairs of histogram peaks in the proposed algorithm. (a) Original image of "Lena" (b) Highest two bins (c) 10 pairs (d) 15 pairs (e) 20 pairs (f) Original image of "Baboon" (g) Highest two bins (h) 10 pairs (i) 15 pair (j) 20 pair

TABLE 1
Comparison of PSNR for Lena obtained from Histogram Modification method and Firefly Method

Contrast Enhanced Image	PSNR(db) (Using Histogram Modification Algorithm)	PSNR(db) (Using Firefly Algorithm)	Embedding Rate(bpp)
Highest Two Peaks Image of Lena	54	58	0.1
10 Pairs Image of Lena	48	57	0.2
15 Pairs Image of Lena	41	45	0.4
20 Pairs Image of Lena	32	35.5	0.7

TABLE 2
Comparison of PSNR for Baboon obtained from Histogram Modification method and Firefly Method

Contrast Enhanced Image	PSNR(db) (Using Histogram Modification Algorithm)	PSNR(db) (Using Firefly Algorithm)	Embedding Rate(bpp)
Highest Two Peaks Image of Baboon	46	52	0.1
10 Pairs Image of Baboon	40	45.5	0.2
15 Pairs Image of Baboon	27.5	37	0.4
20 Pairs Image of Baboon	21.5	29.5	0.7

V. CONCLUSION

In this Journal, a reversible image data hiding (embedding) algorithm has been suggested with the property of contrast enhancement. Basically, the two highest bins (peaks) in the histogram are picked for data hiding so that histogram equalization can be simultaneously executed by repeating the operation. The experimental results have shown that the image contrast can be enhanced by shatter a number of histogram bins pair by pair. The visual quality of the contrast enhanced images produced by our algorithm is better maintained when Compared with the special MATLAB functions. Moreover, the original image can be entirely recovered without any further information. Hence the suggested algorithm has made the image contrast enhancement reversible. Reversible Data embedding finds application in image authentication, military communication, and such communication frequently takes place over especially noisy communication channels [8]. We present a category of reversible Data Hiding schemes for digital images, and then a simulation based comparison of their peak Signal to noise ratio (PSNR) characteristics when motive to high Embedding Rate (data Hiding rate). If we increase embedding rate, the Signal to noise ratio of the Data hidden image will be reduced. Improving the algorithm robustness, and applying it to the medical, geological and satellite images for the better visibility, will be our future work.

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