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Contrast Enhancement Based Reversible Image Data Hiding

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ABSTRACT: Data hiding is a technique to hide secret data into images which is called as cover images. A set of the embedded data and another set of the cover media data are linked by data hiding process. Reversible Data Hiding (RDH) is used to embed a piece of data into an image to generate a marked image and after extracting process the original image can be recovered from the marked image. RDH is mainly used in signal processing field especially in applications of security, medical and military where no permanent changes are allowed for the hiding data. In this paper, RDH algorithms intensify the contrast of the host image to give a better visual quality rather than keeping the PSNR value high. For the data embedding, the highest two bins in the histogram are selected to perform the histogram equalization simultaneously. To increase the embedding capacity, the equalization process is repeated. Along with the message bits, the side information is also embedded in the host image for the complete recovery. By adding the considerable amount of data into the image, the brightness of the image is increased. Many RDH algorithms have been developed so far and each algorithm has its own merits and drawbacks, no methods are perfect. The visual quality of the contrast-enhanced images generated by this algorithm is better when compared with special MATLAB functions. Improving the algorithm on the color and video will be the future work.

KEYWORDS: Reversible Data Hiding, Histogram modification, Data embedding, Contrast enhancement.

I. INTRODUCTION

Data hiding are a group of technique to hide secret data into images which is called as cover images. Most hiding technique embeds the message into the cover image to obtain the marked image by modifying only the least significant part of the cover image. This embedding can cause some distortion to cover image and hence, unable to reconstruct the original image from the marked image.

In most applications, small distortions due to data embedding are allowed whereas in applications like medical, law forensics and military imagery, no distortions are allowed. For these cases, we require a special kind of data hiding method, which is called as reversible data hiding (RDH). Reversible Data Hiding (RDH) is used to embed a piece of data into an image to generate a marked image and after extracting process the original image can be recovered from the marked image. It is also called as invertible or lossless data hiding.

The hiding rate and quality of the marked image are important parameters for the measurement of the performance of the RDH algorithm as the increase in the hiding rate causes more distortion in the image content. The peak signal-to-noise ratio (PSNR) value of the marked image is calculated to measure the distortion. The PSNR of a marked image generated is usually kept high but the visual quality will be low. For the images obtained in poor illumination, the visual quality is more important than keeping the PSNR value high.

The traditional methods has many drawbacks like degradation of hidden data as well as original image and computational maybe costly. The conventional methods of RDH algorithm does not perform the task of contrast enhancement to improve the visual quality of the host image. So by using this RDH algorithm, the contrast enhancement is achieved instead of keeping the PSNR high.

Contrast enhancement of images can be obtained through histogram equalization. The data embedding and contrast enhancement can be done simultaneously in this algorithm by modifying the histogram of the pixel values. At first, the highest two bins are found and the bins between the peaks are unchanged. Each of the two peaks split into the adjacent

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bins by shifting outward the outer bins. The highest bins in the modified histogram can be further split until the sufficient contrast enhancement is obtained, which can also increase the embedding capacity.

The boundary pixel values are pre-processed to avoid the overflows and underflows because of the histogram modification and a location map is generated to remember their locations. The location map is hidden into the host image along with the message bits and other side information for the recovery of the original image. So that a complete data extraction and original image recovery is possible.

II. PROPOSED METHOD

This section describes the various steps in data embedding and recovery process. The data embedding is done by the histogram modification technique. Consider an 8-bit gray-level image I, by counting the pixels with a gray-level value j for j ∈ {0,1,....,254,255} the image histogram can be calculated. Let h_I denotes the image histogram then h_I(j) represent the number of pixels with a value j. Consider N different pixel values are present in I, hence there are N nonempty bins in h_I, from which the two peaks(i.e. the highest two bins) are selected. I_S and I_R represents the corresponding smaller and bigger values respectively. The data embedding is performed for a pixel counted in h_I with value i, by

$$i' = \begin{cases} i-1, & for\ \ i < I_S \\ I_S - b_k, & for\ \ i = I_S \\ i, & for\ \ I_S < i < I_R \\ I_R + b_k, & for\ \ i = I_R \\ i+1, & for\ \ i > I_R \end{cases} \quad (1)$$

where i' is the modified pixel value, and b_k is the k-th message bit(0 or 1) to be hidden. By using the Eq.(1) to all the pixel counted in h_I, totally $h_I(I_S) + h_I(I_R)$ binary values can be embedded. The bins between the two peaks remain unchanged and the outer bins are moved outward. So each of the peaks can be divided into two adjacent bins, $I_S - 1$ and I_S, I_R and $I_R - 1$ respectively. For extracting the embedded data, the peak values I_S and I_R are needed. So to keep these values, first exclude 16 pixels in I from the histogram calculation. The least significant bits (LSB) of those pixels are collected and included in the binary message to be hidden. The bit- wise operation is performed for substituting the LSBs of the16 excluded pixels by values of the I_S and I_R.

In the extraction part, the peak values need to be recovered and the histogram is found excluding the 16 pixels. To extract data, the following operation is performed on any pixel counted with values of $I_S - 1, I_S, I_R\ or\ I_R - 1$ in the histogram:

$$b'_k = \begin{cases} 1, & if\ i' = I_S - 1 \\ 0, & if\ \ \ i' = I_S \\ 0, & if\ \ \ i' = I_R \\ 1, & if\ i' = I_R + 1 \end{cases} \quad (2)$$

where b'_k is the k-th binary value extracted from the marked image I'. To recover the original image, the following operation is performed on every pixel counted in the histogram:

$$i = \begin{cases} i'+1, & for\ i' < I_S - 1 \\ I_S, & for\ i' = I_S - 1\ or\ i' = I_S \\ I_R, & for\ i' = I_R\ or\ i' = I_S + 1 \\ i'-1, & for\ i' > I_R + 1 \end{cases} \quad (3)$$

The original LSBs of 16 excluded pixels are obtained from the extracted data. The excluded pixels can be restored back to recover the original image.

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In the original image, all the pixels counted in h_I are within the limit {1,...., 254}. The histogram shifting can cause overflow or underflow, if there is any bounding pixel value (0 or 255) . To avoid this, a pre-process need to be done prior to the histogram modification operations. The pixel values of 0 and 255 are modified to 1 and 254, respectively. So, no overflow or underflow will caused because the maximum pixel values change is + or **-** 1.

Each of the two peaks in the histogram is split into two adjacent bins with the same heights because the numbers of 0s and 1s must be equal in the message bits. The hiding rate can be increased by further splitting the highest bins in the modified histogram and the process repeats to achieve histogram equalization effect. So by this way, the data embedding and contrast enhancement are simultaneously performed. The value of L, the previous peak values are embedded with the last two peaks to be split. In the extraction process, the last split peak values are regained and the data embedded are obtained using Eq.(2) and the original image is recovered using Eq.(3).

III. METHODOLOGY OF THE PROPOSED ALGORITHM

The steps of the proposed algorithm are shown in the Fig. 1. Let the total number of pairs of histogram bins to be split for data embedding is L.

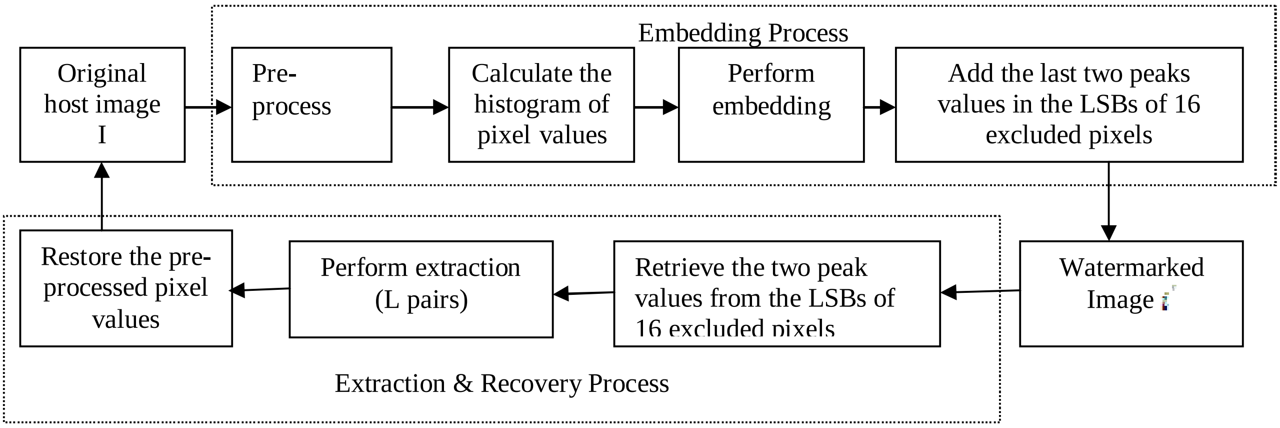

Fig.1: Procedure for the proposed algorithm

The embedding process includes the following steps:

1. Pre-Process: The pixels in the range of [0, L-1] and [256-L, 255] are processed. The pixel values in the range 0 to L-1 are added by L while the pixels in the range 256 –L to 255 are subtracted by L, excluding the first 16 pixels in the bottom row.
2. The histogram of the image is calculated excluding the first 16 pixels in the bottom row.
3. Embedding: The highest two bins in the image histogram are split for data embedding by using the eq.(1). Again the two peaks in the modified histogram are taken to be split and continue until L pairs are split. The value of L, LSBs of the 16 excluded pixels and the previous peak values are embedded along with the last two peaks to be split.
4. The LSBs of the 16 excluded pixels are replaced by last two peak values to form the marked image.

The extraction and recovery process includes the following steps:

1. The LSBs of the 16 excluded pixels are recovered to know the last two peak values.
2. The data embedded with the last two pixels are extracted by using the eq.(2) and by using the eq.(3) the recovery operations can be done on all the pixels except the 16 excluded ones. The process repeats until all the data are extracted.
3. The original image is recovered by updating back the original LSBs of 16 excluded pixels.

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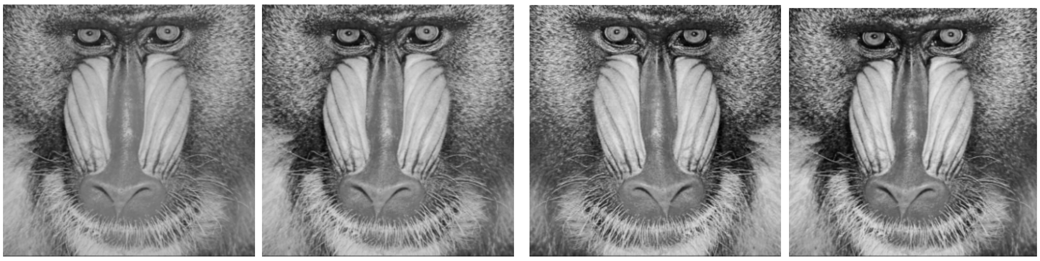
IV. RESULTS AND DISCUSSION

The only parameter in the parameter algorithm is L (the pair number of the histogram peaks to be split). The data bits to be hidden can be any string of binary values where the number of 0s and 1s are almost equal, or some extra bits can be added to make so. In this experiment the hiding rate generally increases by using more histogram peaks for data embedding.



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

Fig. 2: The original and contrast enhanced images of the "Baboon" by splitting 10, 15 and 20 pairs of histogram peaks in the proposed algorithm. (a) Original image (b) 10 pairs (c) 15 pairs (d) 20 pairs.

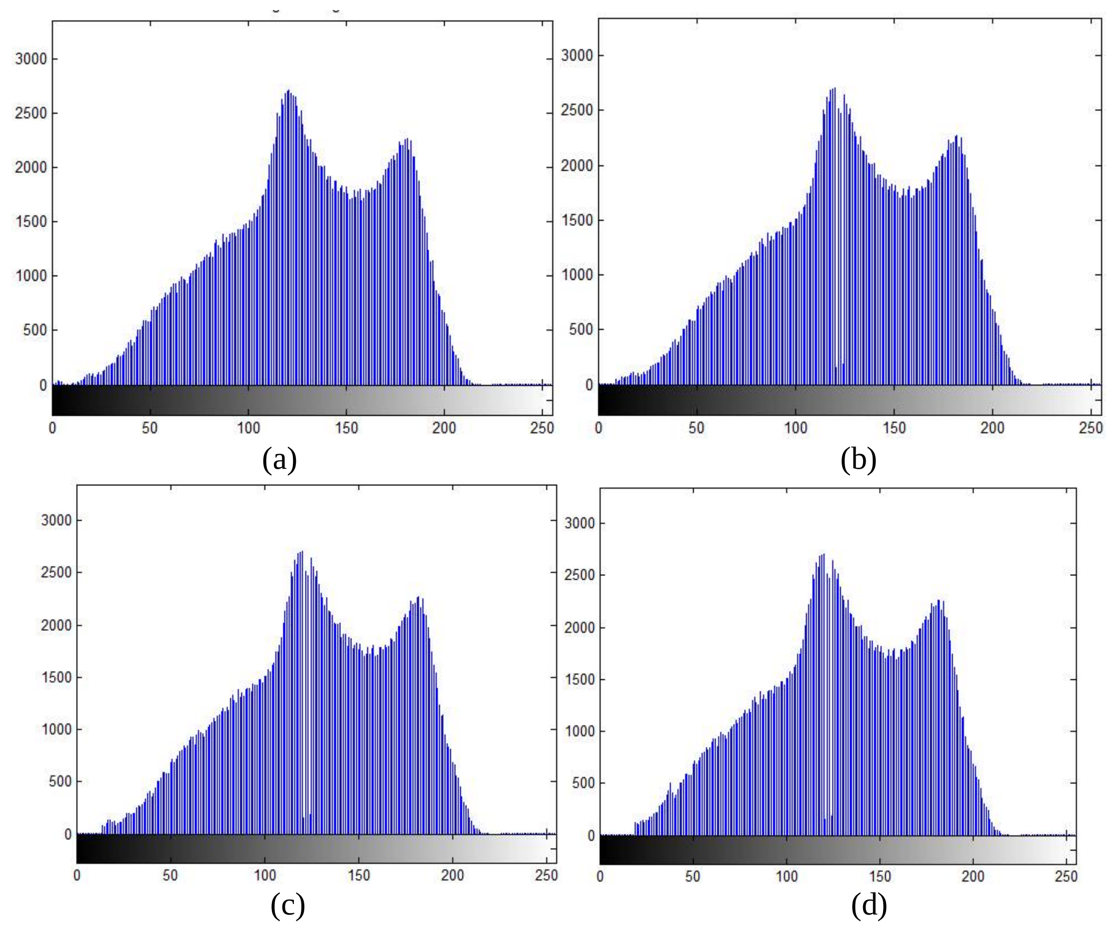


Fig. 3: The histogram of the above figure with L values 10, 15 and 20 pairs in the proposed algorithm. (a) Original image (b) 10 pairs (c) 15 pairs (d) 20 pairs.

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The hidden data is invisible in the contrast enhanced images. The more contrast enhancement is obtained, the more histogram peaks were split for data embedding. Also the PSNR values decreases with data hiding rate while the visual quality is maintained. RDH can be extended to video also.

V. CONCLUSION

The proposed RDH algorithm with the contrast enhancement property improves both the data hiding and data embedding capacity. The visual quality is better using this proposed method than the traditional methods. The original image can be extracted without any distortion after extracting the embedded data. Experimental results show that the contrast enhancement of the image occurs simultaneously with the data hiding by doing histogram equalization. This algorithm can be applied to medical and satellite images as well as in color images. This method can be extended to video also.

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