

Efficient Reversible Watermarking Technique with Contrast Enhancement for Color Images

Jayshri Patel
MTech. scholar Digital Electronics
RCET Bhilai, India,
jayshri.ei@gmail.com

Nivedita Singh
Associate Prof. (ET&T)
RCET Bhilai, India,
nivedita.singhbit@gmail.com

Abstract- In this paper histogram bin shifting based reversible data hiding algorithm for color images has been proposed. In this technique binary bits are embedded directly by addition and subtraction in two highest bin chosen and this process is repeated in modified histogram. A location map is generated by pre -processing to prevent the unnecessary overflow and underflow. All other pixels except two highest bins are also manipulated for contrast enhancement. Embedding of binary secret data is done on the each color component (Red, Green, and Blue) of color images. Secret Binary data bits are embedded in random permutation manner to secure the data from unauthorized receiver. Extraction of embedded binary bits is done by inverse algorithm of embedding process and original image is recovered by reverse manipulation embedding process. This proposed algorithm provide high embedding capacity with low distortion of original quality of image which may be used in different medical, military and satellite application.

Keywords- *Reversible Watermarking, Visual Quality, Contrast, PSNR.*

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I. INTRODUCTION

Reversible watermarking algorithm (RWA) also referred as invertible watermarking or lossless watermarking is to embed the secret message bits in to the original image to generate the watermark. After generation of the watermark embedded information bits can be extracted and original image can be recovered efficiently. Reversible water marking algorithms are characterized in spatial domain and frequency domain. Spatial domain includes differential expansion [18][1], histogram shifting [12] [13][15], vector quantization and transform domain includes discrete wavelet transform, integer wavelet transform [2], and discrete cosine transform techniques. Watermarking is very important and useful in some applications like medical, military and satellite application.

In many sensitive applications like medical image watermarking small degradation of the image quality can also create problem. So in the literature many invisible watermarking techniques are surveyed. In reversible watermarking technique information bit embedding rate and quality of the watermarked image are important .matrices. Contrast of the watermarked image is also an important factor [13]. There is trade-off between embedding rate and image quality. To measure the quality of image mean squared error (MSE), Peak signal to noise ratio (PSNR) are calculated. Some image histogram modification technique [4] provides less payload capacity. Spatial domain technique [7] based on prediction error expansion is used in which correlation between the two adjacent pixels is used for generation of the prediction error.in such type of technique embedding can be done efficiently with lower degradation of image quality.

Although the watermarked generated by prediction error expansion technique operates moderately and gives high peak to signal ratio instead of these the visual quality of the watermark images degraded. So it is necessary to keep the peak signal to noise ratio high with respect to embedding capacity as well as contrast enhancement is also very important factor.so the aim of this paper to apply reversible watermarking algorithm on the color images with proper contrast enhancement, high payload capacity and high PSNR.

This proposed reversible watermarking algorithm is applied in to color images by histogram bin shifting technique. In this histogram modification Process highest two peak points in the histogram are selected in the original images for embedding and secret message bits are embedded in it. All other pixels are manipulated simultaneously for the enhancement in the contrast.in this process outer histogram is shifted outward. Embedding of binary bit is done by direct addition and subtraction in least significant bit of chosen peaks. Any compression technique is not applied in the embedding or extraction process. Extraction of embedded information bits and recover of original image is achieved by inverting embedding process. This algorithm is applied on the different test color images taken from USC-SIPI database. This technique enhances the contrast of watermarked images better than MATLAB enhancement functions.

Section II presents the details of implementation techniques of reversible watermarking by histogram bit shifting. Section III presents the experimental result with evaluated parameter. .Finally a conclusion and future scope is drawn in Section IV.

II. Reversible watermarking algorithm for color images

Original image is loaded. Histogram of the each component of color image is taken by excluding last 16 pixels in histogram. MATLAB shows pixels from 1 to 256 which is exactly from to 255 so all pixel values are deducted by one.

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A. Pre-processing

Location map is generated to prevent the unnecessary underflow and overflow. Location map generated by taking all the pixels of value 0 and 256 in to another same image of same size and all other pixels are taken as zero. And all the pixels with value 0 in the original image are increased by one and all the pixels with value 255 are decreased by one. And two pixel values which are appeared most of the times are selected for data embedding.

B. Secret message Embedding

Embedding is done on only some specific pixels. Highest two bins (highest two pixels which are appeared most of the time) in the histogram are selected for the data embedding. In between this two selected pixel values, highest index having pixel is denoted by P_L and second highest index having pixel is denoted by P_S.

C. Embedding algorithm

Now binary data are added and subtracted according to algorithm. First of all red component is used. P_L and P_S are selected as explained above in 4.7.2. All pixels present in the image with value P_L and P_S are added and subtracted respectively with the corresponding binary values of secrete message. All pixels present in the image with value lower than P_S are subtracted by corresponding binary one and all pixels with value greater than P_L are added by binary one .pixels between P_L and P_S value are not modified they are kept as it is.

Secret message is embedded only on P_L and P_S, all other modification applied is for contrast enhancement in watermarked image. Once all the P_L and P_S present in the red component are embedded, rest of secret message bits will be embed in Green component as per the algorithm explained above and then in blue component. Once the all selected pixels of these three components are embedded new modified histogram generated by red component is used for embedding.

New pair of P_L and P_S is selected in modified histogram and embedding process is repeated. Similarly new modified histogram of green and blue component is also selected for further embedding. This process is repeated until all the binary bit of secret message is embedded. When all secrete message bits are embedded then binary value then all other pairs of P_L and P_S except last one are converted in to binary and embedded sequentially in to the image, next to the secrete message. Then lastly selected pair of P_L and P_S are replaced by the LSB of 16 excluded pixels and these LSBs of excluded pixels are embedded next to the all pairs of P_L and P_S. Embedding algorithm is shown below in equation:

$$I' = \begin{cases} I-1, & \text{for } I > Ps \\ P_S - b_k, & \text{for } I = Ps \\ I, & \text{for } P_S < I < P_L \\ P_L + b_k, & \text{for } I = P_L \\ I+1, & \text{for } I > P_L \end{cases} \quad \text{.......................... (1)}$$

Where H – Histogram graph.
I' - Modified histogram graph.

P_S - Smaller pixel value selected from two highest bin in histogram.
P_L - Larger pixel value selected from two highest bin in histogram.
b_K - Binary bit to be embedded.

D. Extraction and recovery process

For extraction and recovery process, first of all the least significant bits of the excluded 16 pixels are extracted and replaced the LSBs of 16 excluded pixels. From these excluded pixels last embedding Pair of P_L and P_S are determined.

E. Secret message extraction

Because of all the information bit embedding has been done only on the P_L and P_S pixels, they are extracted first. Now secret message extraction algorithm has been applied. Every pixels with value P_L and P_S are contains binary 0's and pixels which less than P_L or P_S, contains binary 1's. All binary values are extracted and arranged according to the inverse process of random permutation. In this way secret data is constructed accordingly.

$$b_K' = \begin{cases} 1, & \text{if } I' = P_S - 1 \\ 0, & \text{if } I' = P_S \\ 0, & \text{if } I' = P_L \\ 1, & \text{if } I' = P_L + 1 \end{cases} \quad \text{.......................... (2)}$$

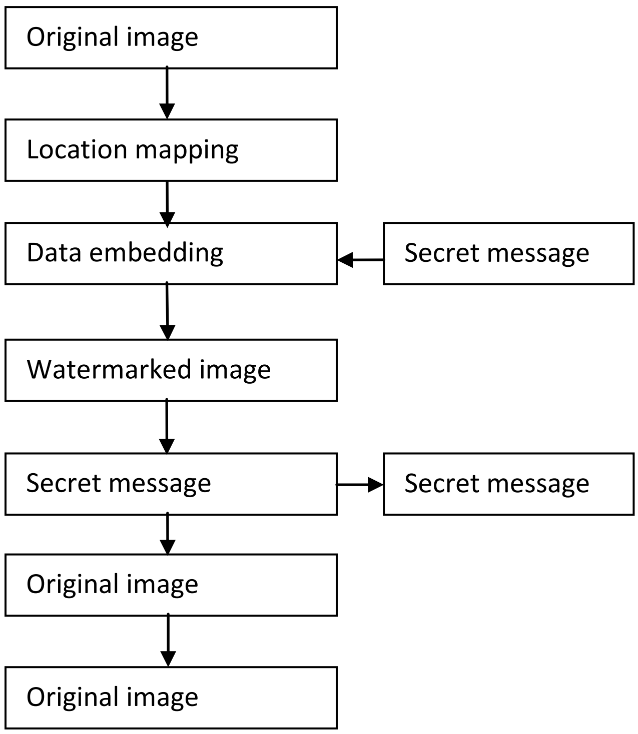


Fig.1. Procedure of the proposed algorithm.

E. Original image recovery

In this process 16 excluded LSBs and all P_S and P_L has been removed for form watermarked image For the recovery process inverse algorithm of embedding procedure, shown in equation 4.3 below, is applied. All pixels with value P_S or one less than P_S are constructed as P_S. All pixels with value P_L or one more than P_L are constructed as P_L. All pixels with value one less than P_S are added by binary one and pixels with value one more than P_L are subtracted by one. In this way all modified pixels are recovered back to their original position.

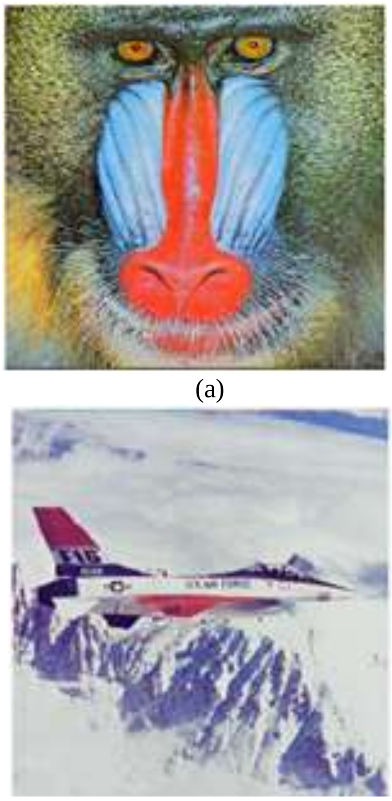
$$P = \begin{cases} I' + 1, & \text{for } I' < P_S - 1 \\ P_S, & \text{for } I' = P_S - 1 \text{ or } I' = P_S \\ P_L, & \text{for } I' = P_L + 1 \text{ or } I' = P_L \\ I' - 1, & \text{for } I' > P_L + 1 \end{cases} \quad \ldots\ldots\ldots\ldots (3)$$

III. EXPERIMENTAL RESULTS

In this algorithm, standard test images (color images) of size 512×512 are taken from USC_SIPI image database (http://sipi.usc.edu/database/). This algorithm is applied directly on color images. The secret information is converted into binary bit numbers of 0 and 1. For all of the color images taken are test different payload capacity. Mean Squared Error, Peak Signal to Noise Ratio are calculated for each image. The original image and watermarked images for different embedding capacity is shown in Fig. 2 and Fig. 3 respectively. The water marked images are obtained by splitting many pairs of histogram peaks for secret information bit embedding, respectively. It can be seen that the embedded information bits are invisible in the contrast-enhanced watermark images.

The more histogram peaks were used for message embedding, contrast of the images are enhanced more. As the PSNR decreases with secret data embedding the visual properties has been preserved as shown in Fig 2 and Fig 3. Table I shows the statistical results of watermarked "Baboon" color image, Table II shows the statistical results of recovered "Baboon" color image. Table III shows the statistical results of watermarked "F-16" color image, Table IV shows the statistical results of recovered "F-16" color image.

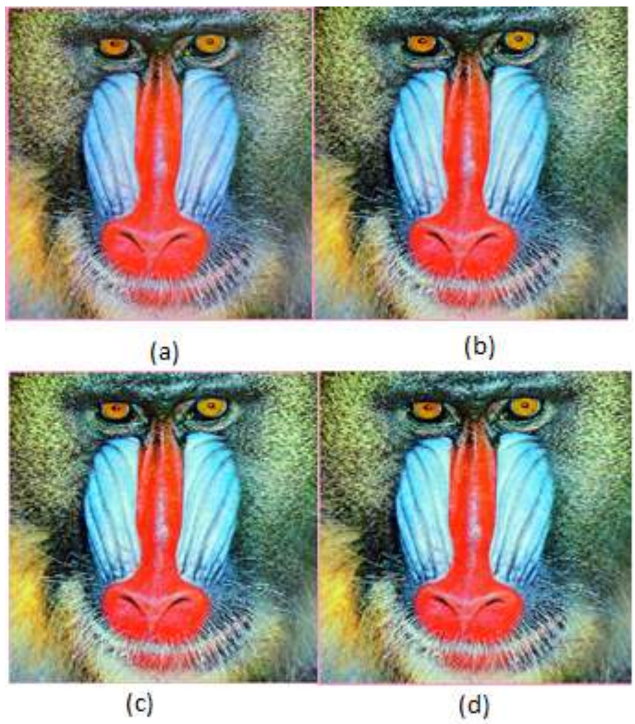
Mean squared error (MSE peak signal to noise ratio (PSNR) and structural similarity index matrices (SSIM) are calculated for watermarked images and recovered images respectively. Figure 5 shows the performance comparison of Interpolation technique [11] .Prediction Error Expansion (PEE) technique [18] and Proposed Reversible watermarking algorithm. Structural similarity index matrices has ideally value one. Which shows the original image quality is preserved. Original test images of "Baboon", and "F-16" are shown below in fig.1.



(a)

(b)

Fig 1. Original test color image (a)"Baboon", (b) "F-16".



(a) (b)

(c) (d)

Fig.2.Watermarked contrast enhanced images of "Baboon" at different payload (a) 0.2 bpp with PSNR 62. 7144db. (b) 0.4 bpp with PSNR 61.2780db (c) 0.6 bpp with PSNR 60.6221db (d) 0.8 bpp with PSNR 60.6207 db.

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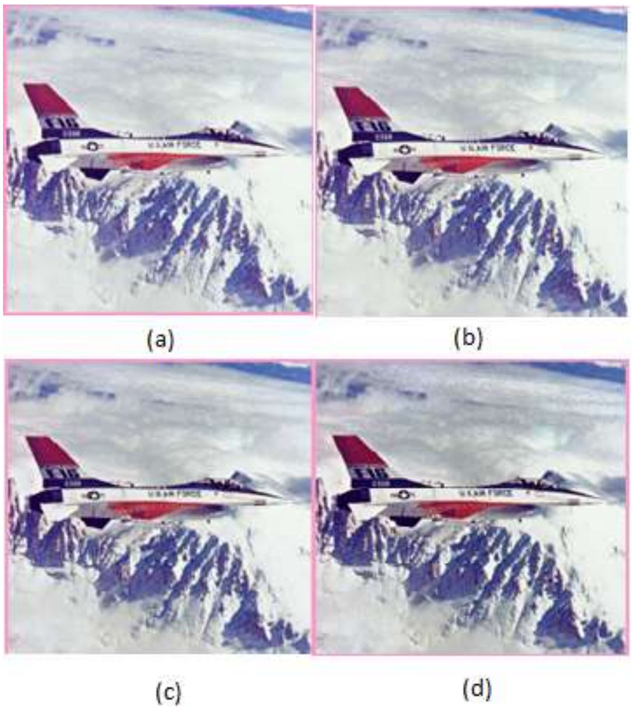


Fig. 3. Watermarked contrast enhanced images of "F-16" at different payload (a) 0.2 bpp with PSNR 65.1596db (b) 0.4 bpp with PSNR 61.9826db (c) 0.6 bpp with PSNR 59.7184db (d) 0.8 bpp with PSNR 58.4071db.

It is calculated that the contrast of test color images was gradually enhanced by splitting more histogram peaks in the proposed algorithm. Besides the higher PSNR values, with this proposed algorithm, from the generated contrast-enhanced image the original image can be directly recovered. So it is better than the three MATLAB functions for image contrast enhancement.

Table I

Statistical Evaluation of test image "Baboon"

Bit per pixel	MSE	PSNR	SSIM
0.23502	0.035078	62.7144	0.96714
0.44824	0.488290	61.2780	0.93824
0.65918	0.056790	60.6221	0.92487
0.84375	0.056808	60.6207	0.92483

Table II

Statistical Evaluation of test image "Baboon"

Bit per pixel	MSE	PSNR	SSIM
0.23502	0.010482	67.9603	0.099994
0.44824	0.010571	67.9236	0.099965
0.65918	0.010487	67.9305	0.099965
0.84375	0.010554	67.9305	0.099965

Table III

Statistical Evaluation of test image "F-16"

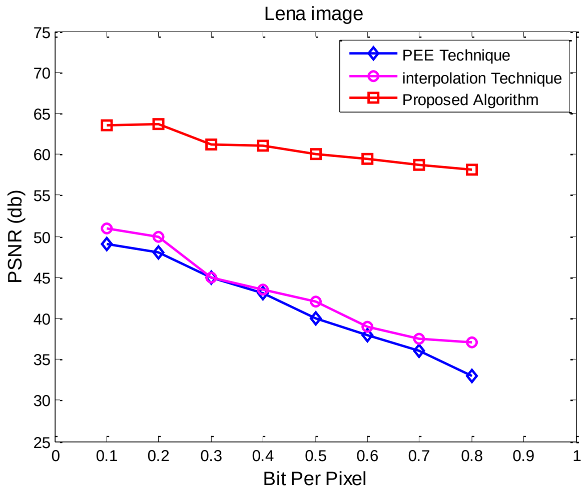
Bit per pixel	MSE	PSNR	SSIM
0.23502	0.019976	65.1596	0.98699
0.44824	0.041516	61.9826	0.96809
0.65918	0.069927	59.7184	0.92935
0.84375	0.094574	58.4071	0.89016

Table IV

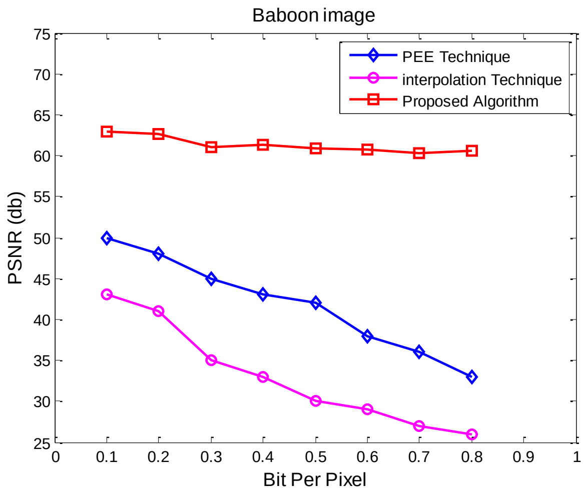
Statistical Evaluation of test image "F-16"

Bit per pixel	MSE	PSNR	SSIM
0.23502	0.038621	72.2966	1
0.44824	0.008879	68.6812	0.099999
0.65918	0.015186	66.3505	0.099997
0.84375	0.019385	65.2902	0.099987

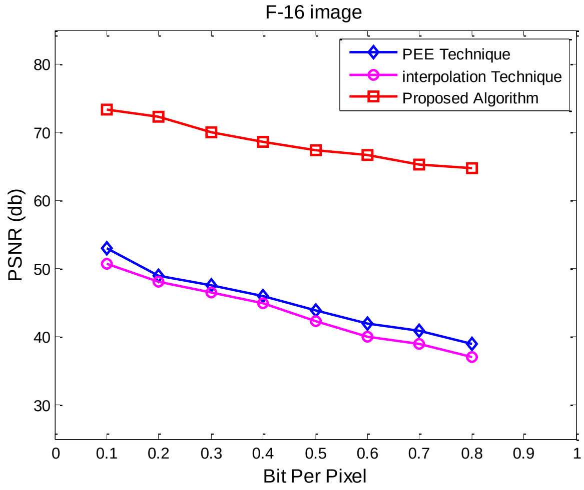
This proposed algorithm is compared with different spatial domain techniques shown below:



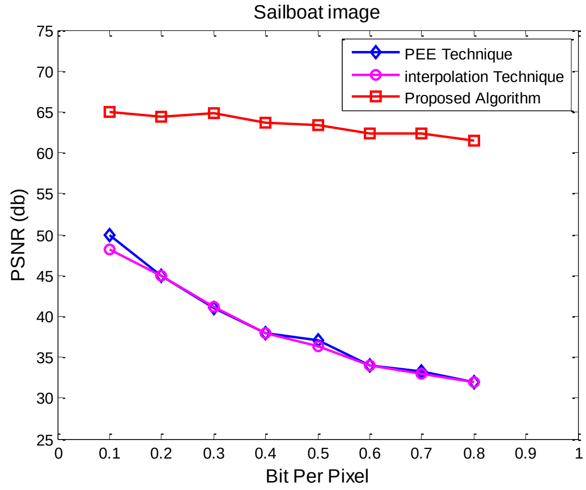
(a)



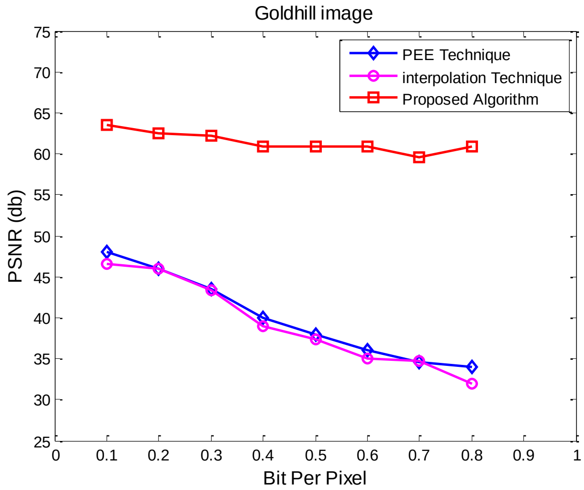
(b)



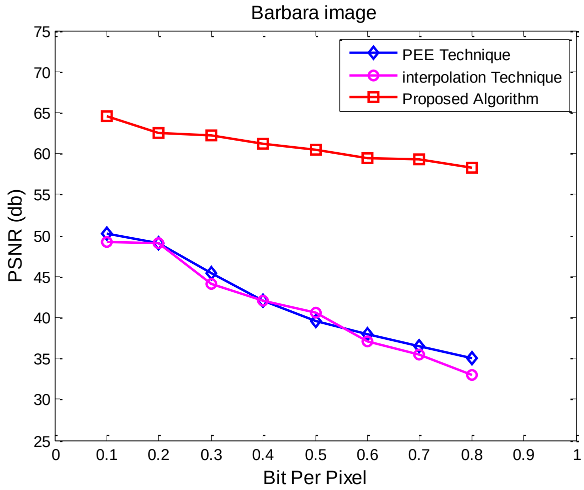
(c)



(f)



(d)



(e)

Fig.5. Performance comparison Payload with regard to PSNR with algorithm [11, 16] and proposed : (a) on “Lena”, (b) on “Baboon ”, (c) on “ F-16”, (d) on “Barbara”, (e)on “ Gold hill”, (f) on "Sailboat”.

IV. CONCLUSION AND FUTURE SCOPE

In this paper, a new reversible watermarking algorithm has been proposed with contrast enhancement technique. Two highest bins are selected for the data bit embedding process and this process is repeated in modified histogram. Three color components is used for embedding which increases the data hiding capacity. All pixels are manipulated simultaneously to enhance the contrast of watermarked image. Compared with the three special MATLAB functions i.e. imdjust, histeq, and adapthisteq. By this algorithm the visual quality of the contrast-enhanced images is preserved. This is a reversible process in which embedded data can be extracted and original image can be recovered efficiently. This technique improves the visual quality and robustness and can be efficiently applied in medical, military and satellite applications. This algorithm can be extended up to audio, video application also.

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