ISSN: 2037-4445

Reversible Data Hiding in Medical Images Using Histogram Modification

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Abstract

Secrecy of information is very important which leads a way for data hiding through images. The special case of lossless recovery of data as well as cover media is known to be reversible data hiding. In this paper, we will present a method to hide data in medical images, with images being the cover media. It is implemented in the spatial domain utilizing histogram modification technique. The proposed method first employs creation of modified histogram based on adjacent pixel differences and then histogram modification algorithm is applied. Data embedding varies the pixel values based on neighbouring pixel values and on the correlation between adjacent pixels. Data extraction is performed as opposite to the embedding. We chose some common medical images like CT, MRI, Ultrasound, etc. We performed our proposed technique and obtained result and calculated using various statistical parameters like Mean, Median, SSIM, PSNR, BPP, etc. We have implemented our technique using MATLAB Graphical User Interface (GUI), thereby representing it as an application of telemedicine.

Keywords-Cover Media, Data Hiding, Histogram, Spatial Domain, Reversible Data.

I. INTRODUCTION

Many Data hiding methods have been developed [7] to improve the embedding capacity as well as security of information. Most of these techniques affect the cover media resulting in losses of data. In these cases, cover media content has not given importance [2]. But the areas like medical, military, etc. the cover media contents are important for further analysis. Hence, cover media contents must be recovered listlessly. Our proposed technique is based on the correlation of pixel values [8] in medical images. Instead of considering pixel values directly for data embedding [10], this technique considers adjacent pixel differences which results in reduced visual perceptions in cover media. Consideration of adjacent pixel differences increases the PSNR and embedding capacity. Since the embedded data should not affect the cover media, the main goal is to recover the cover media without distortion.

II. METHODOLOGY

We can begin our method by collecting information about various data hiding techniques, their advantages, and limitations [4][3]. And then we will get clear idea about the implementation of technique. In this technique, the main part is the histogram modification i.e.: collection of maximum pixels allowing data embedding at initial points. This helps in increasing embedding capacity. There are three steps in the implementation of this technique.

1) Histogram construction
2) Data embedding
3) Data extraction

1) Histogram construction

We are using gray scale medical image. The 2D pixel values of image are obtained and converted to 1D. Then, difference between adjacent pixel values must be calculated except first pixel. It should be kept for reference. Instead of constructing histogram using the pixel values, it must be constructed with the adjacent pixel differences. The data embedding capacity depends on the pixel correlation.

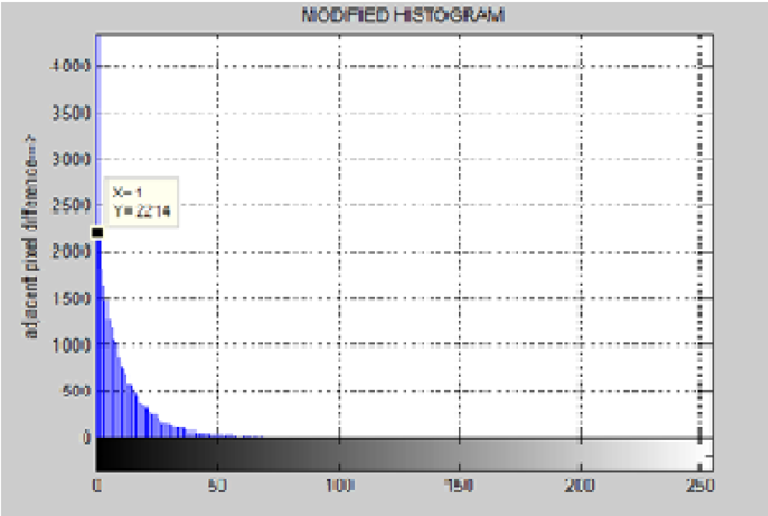

Fig. 1. Histogram of CT image

Fig. 1 indicated that the maximum pixel values are at 0,1 and 2 positions of histogram indicating the maximum embedding capacity.

2) Data Embedding

After performing histogram modification, we can analyse the correlation among pixels. To perform data embedding, the most frequent value must be considered after adjacent pixel difference. This element is treated as Deltamax and difference between each pixel is Delta. Deltamax is treated as reference for data embedding. If difference between adjacent pixels is equal to the reference and if the current pixel is less than the previous one, pixel value must be subtracted by the data bit to be embedded otherwise, if current pixel value is greater than the previous pixel, pixel value is added by the data bit. If the difference between adjacent pixels is less than reference, then the pixel value is retained as it is. But, if it is greater than reference, then pixel value is added by one or subtracted by one based on previous pixel value.

Algorithm:

P_i, if $i=0$

P_i+b, if $\delta_i=\delta_{max}$ and $P_i>P_{i-1}$

$e_i = P_i-b$, if $\delta_i=\delta_{max}$ and $P_i<P_{i-1}$

P_i+1, if $\delta_i>\delta_{max}$ and $P_i>P_{i-1}$

P_i-1, if $\delta_i>\delta_{max}$ and $P_i<P_{i-1}$

Where, i = position of pixel, P = pixel value, b = data bit, e = embedding matrix, δ = difference between adjacent pixels, δmax = most frequent difference value

Example 1: The data need to be hidden is 10110110. The pixel values of a grey image be

20	10	20
10	30	40
30	40	10

After converting to 1D, it becomes 20,10,30,10,30,40,20,40,10.

20	10	19
10	31	40
31	40	11

Table above represents 5 bits embedded in 3*3 matrix.

3) Data Extraction

The data extraction is done in opposite manner to data embedding. The pixel values of image must be converted to 1D as did in embedding. The first pixel will remain same for reference. Calculating the adjacent pixel difference, the most frequent element must be obtained which is Deltamax and the data recovery is based on Deltamax and previous pixel values. If the difference between adjacent pixels is equal to Deltamax+1, then bit 1 is recovered. If difference is less than Deltamax, then the value is retained as is. If difference is equal to Deltamax, bit 0 is recovered. Suppose the difference is greater than Deltamax, and if previous pixel value is greater than present, current pixel value is added by one otherwise, it is subtracted by one.

Algorithm:

b =0, if δi=δmax
1, if δi=δmax+1
ei+1, if δi>δmax and ei<Pi-1
Pi =ei-1, if δi>δmax and ei>Pi-1
ei, else

Where, b = data bits recovered

Example1: The embedded matrix converted to 1D is 20,10,31,10,31,40,19,40,11

20	10	20
10	30	40
30	40	10

Data bits recovered are 1,0,1,1,0

4. Statistical Parameters

Statistics is a collection, organisation, analysis, and interpretation of data. There are two types in statistical parameters based on reference. They are no reference and full reference. Mean, Median, Standard Deviation and Mode are classified under no reference as they depend only on the current image [6]. SSIM (Structural Similarity Index Measure) and PSNR (Peak Signal to Noise Ratio) are classified under full reference as they depend on reference image. Mean calculates average of all pixels in image and is given by f(x,y)=(1/(m*n))∑g(r,c) where, r and c belongs to w(window of image), g is the noisy image, r represents rows of image, c represents columns of image and m*n gives size of image. Median is the measure of intensity level of pixel that separates high and low intensity pixel values and is given by the equation f(x,y)=median{g(r,c) | (r,c)∈W}. Standard deviation variations or dispersions exists from the average value. It is represented by the equation, f(x,y)=$\sqrt{(\frac{1}{mn-1}\sum_{(r,c)\in W}(g(r,c) - \frac{1}{mn-1}\sum_{(r,c)\in W} g(r,c))^{\wedge}2)}$. Mode specifies most frequent element. SSIM defines image quality degradation based on visible structures in image. PSNR measures quality of reconstruction of lossy compression codecs. PSNR is calculated by PSNR (dB) = 10*$\log_{10}(\frac{255*255}{MSE})$ where, MSE is the mean square error [10].

III. RESULTS AND DISCUSSION

To understand the performance parameters, statistical parameter analysis can be performed. It includes mean, median, standard deviation, SSIM and PSNR. This statistical analysis has performed on various types of medical images. The result of CT image is shown. The histogram of original CT image i.e.: Fig 3 depicts that there are 290 pixels at intensity of 150. Fig 4 is the modified histogram which species that the maximum data embedding capacity of the image is 2214 bits. Fig 5 indicates the presence of 355 pixels at the intensity of 150, whereas in Fig 7 there are 357 pixels at intensity 150 indicating histogram modification improves data embedding capacity. The PSNR value of X-Ray is 37.74 and maximum bits per pixel is 0.58 as per Table 1 and 2. By this, data can be embedded more in X-Ray images and least in ultrasound images. BPP(Bits Per Pixel) is the number of embedded bits per the total count of pixels. Max BPP designates the maximum number of embeddable bits per pixel for the specified image.

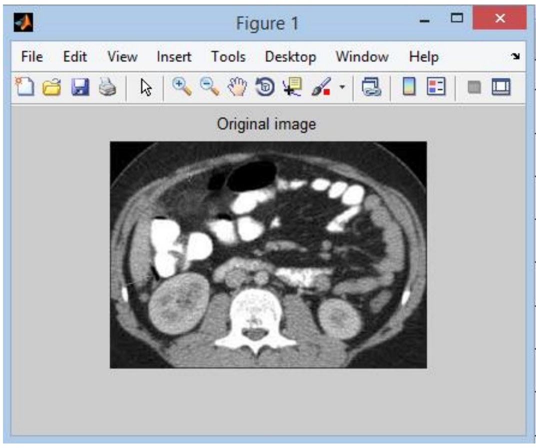

Fig 2: Original CT image

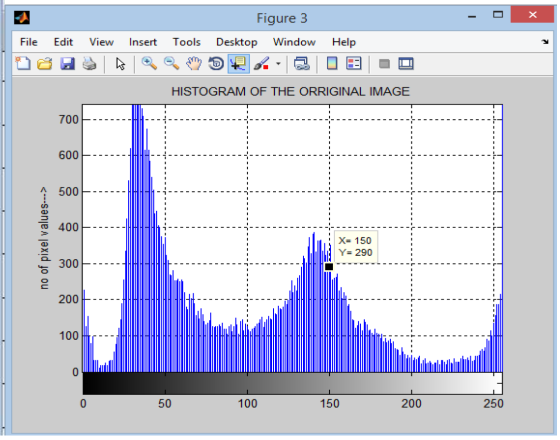

Fig 3: Histogram of CT image

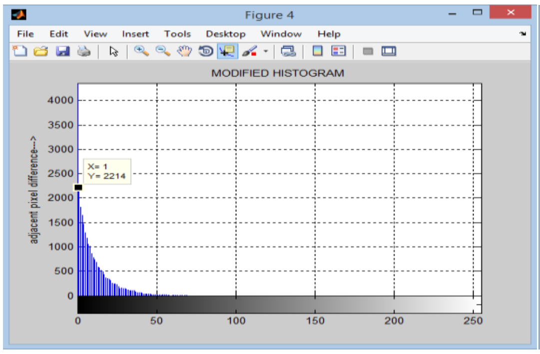

Fig 4: Modified histogram of CT image

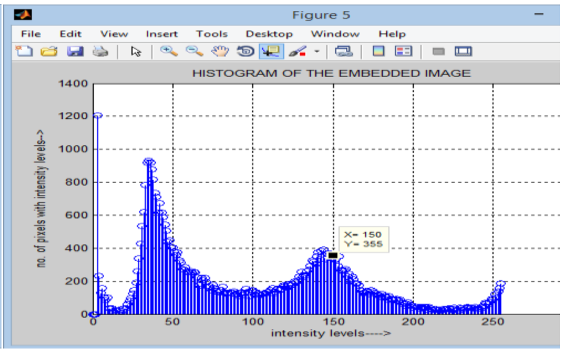

Fig 5: Histogram of Embedded image without histogram modification

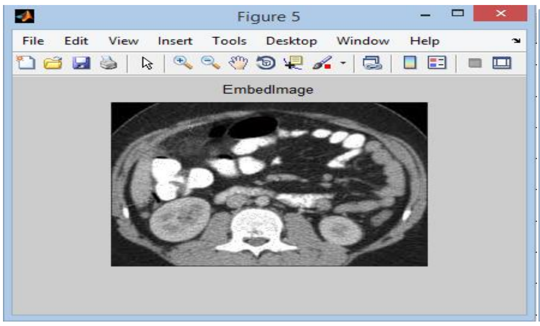

Fig 6: Embedded CT image

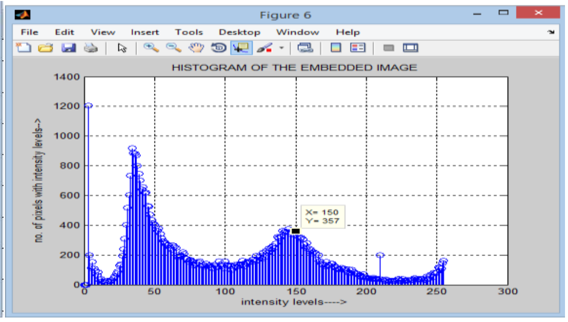

Fig 6: Histogram of embedded CT image

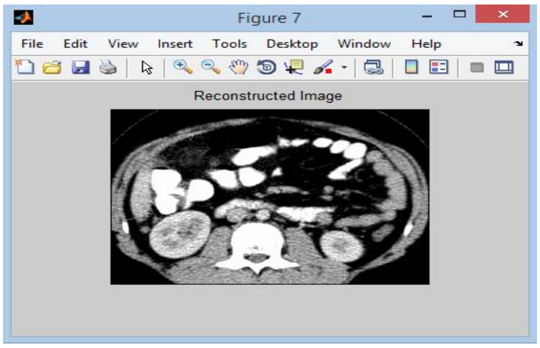

Fig 7: Reconstructed CT image

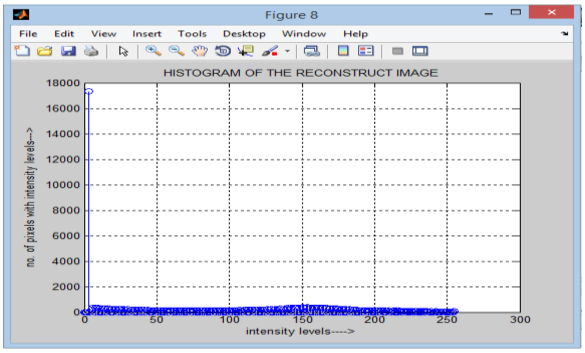

Fig 8: Histogram of recovered CT image

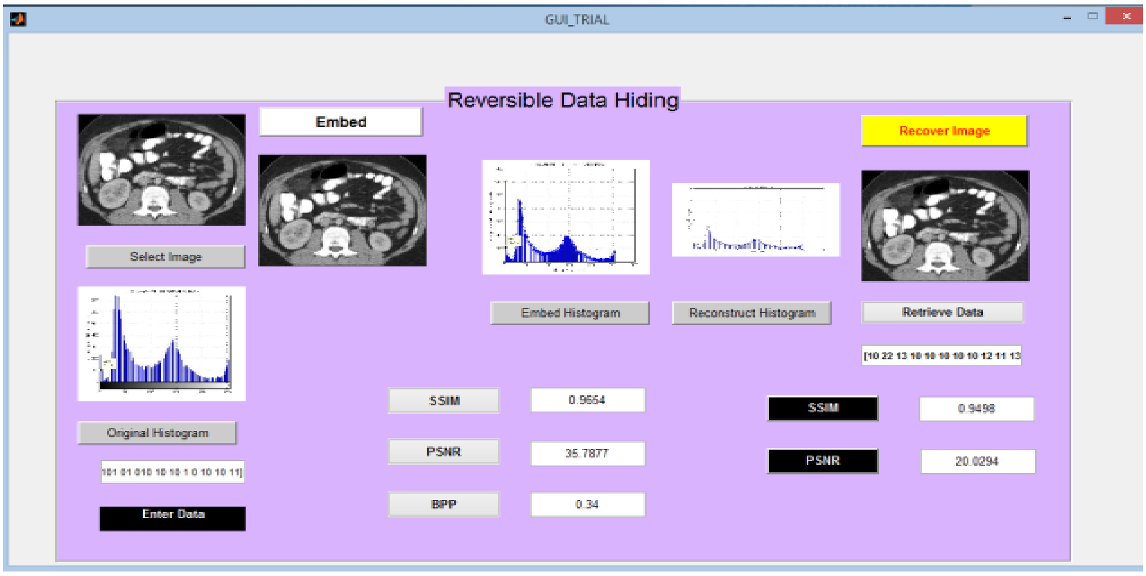

Fig 9: Functioning using GUI

Table 1: SSIM and PSNR of Embedded and Recovered medical images.

Image	Size	Embedded		Recovered	
		SSIM	PSNR	SSIM	PSNR
MRI	225*225	0.97	36.13	0.98	23.54
CT	191*264	0.96	34.57	0.95	28.32
X-Ray	256*256	0.89	37.74	0.9	19.44
Ultrasound	454*348	0.65	37.73	0.75	24.68

Table 2: BPP and No. of bits Embedded in medical images.

Image	No. of bits Embedded	BPP	Max. BPP
MRI	3978	0.078	0.62
CT	2202	0.043	0.34
X-Ray	4777	0.072	0.58
Ultrasound	4589	0.029	0.23

IV. CONCLUSION

In this study, we have developed a technique to hide the information in the medical images and to retrieve them efficiently and the results are shown in Tables 1 and 2. The suggested method of information embedding in the grey-scale image offers great embedding capacity. Still the variation in the BPP (bits per pixel) among the test images shows that this parameter is highly dependent on the image and on the interpixel correlation respectively. It is very suitable for application where performance is of great importance. In this study, we choose histogram modification, we will compare the performance of other techniques in future work.

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