Embedding Patient Information In Medical Images Using LBP and LTP

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ABSTRACT

In this paper a new efficient interleaving methodology in which patient textual information is embedded in medical images considering Magnetic Resonance Image, Ultrasonic image and CT images of that patient body. The main disadvantages in traditional techniques to Embed patient information in medical images is inability to withstand attacks and Bit Error Rate (BER) when maximum number of characters to be embedded are absent in proposed algorithm. The New robust Embedding Techniques, Local Binary Pattern (LBP) and Local Ternary Pattern (LTP) are used to embed the patient information in medical images. LBP Technique is mainly used to provide the security for the patient information. Along with the security high volume of patient information can be embedded inside the medical image using LTP technique. Statistical parameters such as Normalized Root Mean Square Error, PSNR (Peak Signal to Noise Ratio) are used to measure the reliability of the present technique. Experimental results strongly indicate that the present technique with zero BER (Bit Error Rate), higher PSNR (Peak Signal to Noise Ratio), and high volume of data embedding capacity achieved using LTP as compared with the other data embedding techniques. This technique is found to be robust and watermark information is recoverable without distortion.

Key Words

Bit Error Rate, Interleaving, Local Binary Pattern, Local Ternary Pattern, Medical Image, Patient information.

1 INTRODUCTION

With the rapid development in multimedia and network technologies, transmission of multimedia data is a daily routine and the security of multimedia data becomes more and more important, since multimedia data are transmitted over the internet [1-4]. Now a days exchange of patient information in the form of text between hospitals through internet is common practice.

Presently interleaving of patient information with image deals with two approaches namely spatial domain and frequency domain. The exhaustive literature survey reveals that spatial domain approach slightly modifies the image pixels. This spatial domain approach is always susceptible to undergo degradation of visuality of image after interleaving textual information [6]. Authors found that interleaving technique belongs to digital water marking techniques which belongs to various transformation techniques such as Fast Fourier Transform, DCT and wavelet

Transform [5]. However frequency domain approach also suffers from draw backs such as scaling effect.

Digital watermarking is nothing but embedding information inside the object in such a way that later it can be detected or extracted to make an assertion about the object. In watermarking techniques the object can be audio [7], video [8, 9, 10], textual [11, 12, 13, 14, 15, 16] data, and black and white textual data [17] called as binary watermark.

Reliable security is necessary to protect the data of digital images and videos. Encryption schemes for multimedia data need to be specifically design` need to protect multimedia content and fulfill the security requirements for a particular multimedia application.

In digital watermarking the quality of the watermarked image has to be quantified through some statistical parameters [18] based on pixel to pixel error measurements like MSE [19] and other error measurements [20].

According to literature in a 512 x 512 gray scale medical image a maximum of 3400 characters could be embedded and recovered without any distortion [21]. If we want to embed more number of characters inside the medical image it results in very low value of PSNR indicating degradation in embedded image.

Hence authors attempted in this paper to develop a new interleaving technique to embed maximum text information in medical images at the bit level rather than at the pixel level in order to trade off the drawbacks of earlier methods. The present paper is organized in four sections. Section 1 presents introduction with respect to the embedding the information in the images highlighting the drawbacks. Section 2 presents a detailed methodology adopted by the authors for interleaving of text in images. Section 3 presents results and discussion through tables and visual snapshots. Section 4 presents conclusions of present technique to embed text in images and followed by exhaustive references.

2 METHODOLOGY

This section provided brief description about encrypting and protecting the Patient data effectively, this encrypted data is passed over to the interleaving procedure which is described in further section where we deal with interleaving this data pixel by pixel into the image LSB plane.

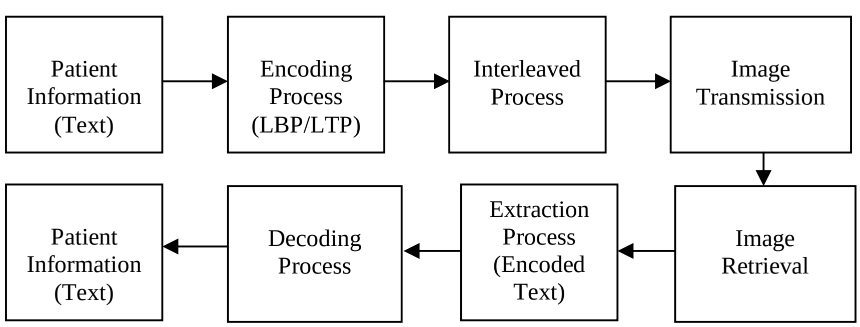


Figure. 1 Block diagram representation of trans-receiver system

Fig.1 indicates the abstract level of methodology adopted by the authors in the present paper. The methods adopted by the authors has been put up in detail in the following sub-sections namely reading the patient information, Encryption of the text file, Interleaving the encrypted text in images followed by retrieving the interleaved text file from images.

Medical images used are 8-bit gray scale of JPEG format with different size like 128x128, 108x108, 256x256 etc. Three images were selected from each of the following modalities, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasound Image.

Normally Patient Information contains 1500 to a maximum of 5000 bytes. In present methodology 100 to 8000 characters each one byte long has been used. 30 images from three modalities like Ultra Sound, MRI and CT were used. An average value is obtained from the results obtained on a set of 30 images from each modality.

2.1 ENCRYPTION OF THE TEXT FILE

a. LBP TECHNIQUE

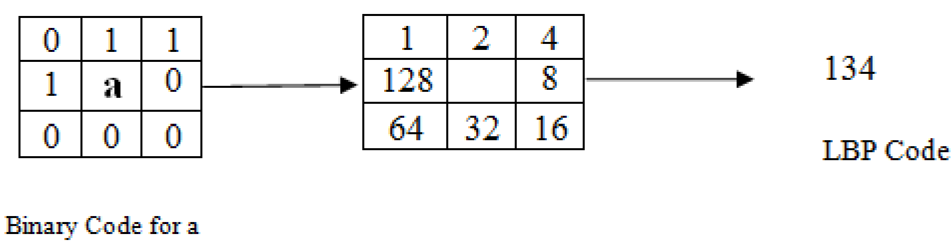


Figure 2 LBP Code for Text

The method of encryption of the text file has been described in this section. LBP is an operator that describes the value by generating a bit code from the binary derivatives of a pixel. In order to provide the security, text file is encrypted using LBP technique and the method is shown in the figure 2. An LBP code for a character was produced by multiplying the binary values of the text information with weights given to the corresponding pixels, and summing up the result.

For a given text file LBP value is computed based on

$$LBP = \sum_{K=1}^{8} g_p^{(K-1)} \times g_c \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where g_p is the gray value of the particular pixel g_c is the binary value of the characters to be embedded inside the medical image.

b. LTP TECHNIQUE

The extended version of the LBP to a two-valued code is called the LTP, in which gray values in the zone of width zero are quantized to zero, those above threshold value are quantized to 1, and those below threshold value are quantized to -1, i.e., indicator $f_1(x,t)$ is replaced with two-valued function (2) and the binary LBP code is replaced by a ternary LTP code, as shown in Fig. 3.

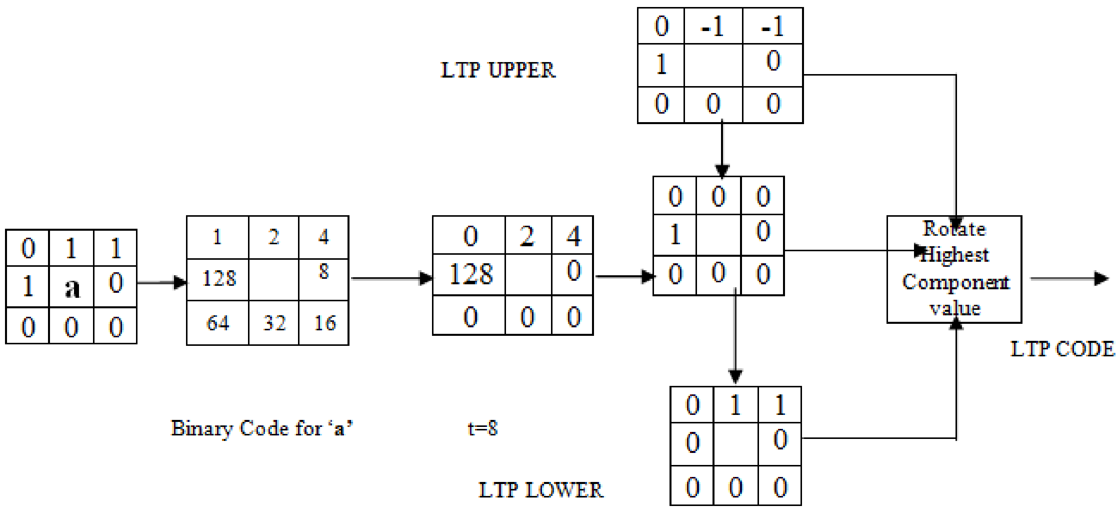


Figure 3 Local Ternary Code for a Text

3. INTERLEAVING PROCES

The binary data obtained from the LBP/LTP code of the text file is swapped with the Least Significant Bit (LSB) plane of the gray scale image bit by bit. Eight bits of each LBP or Five bits of LTP code thus replace LSBs of consecutive pixels of the image. This cycle of interleaving of LBP/LTP code in consecutive pixels is repeated to include all the characters in the text file. The LBP/LTP codes of the encrypted text shown in figure5 (b) are broken into bits and interleaved into the pixels of desired medical images of the patient.

Using LBP method we could embed a maximum of $\frac{M \times N}{8}$

Using LTP method we could embed a maximum of $\frac{M \times N}{5}$.

Where M- Total Number of Row, N- Total number of Column of a particular image.

Using LTP technique we could almost double the number of embedding patient information inside the medical image.

4. STATISTICAL PARAMETER MEASURE

a. NRMSE

A quantitative assessment between original image and processed image is obtained by evaluating the normalized root mean square error (NRMSE) using equation 3

$$NRMSE = \sqrt{\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}\left[g(i,j) - g_w(i,j)\right]^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}\left[g(i,j)\right]^2}} * 100 \quad \ldots\ldots 3$$

Where N = the total number of columns, M is the total number of rows in the image, g(i,j) is the original pixel intensity, and $g_w(i,j)$ is the modified (interleaved) pixel intensity.

b. MSE and PSNR

Peak signal to Noise Ratio (PSNR) and Mean Square Error (MSE) are used to measure the quality of the image. MSE is the cumulative squared error between original image and image with patient data, whereas PSNR is a measure of the peak error. The mathematical formulae for the two are

$$MSE = \frac{1}{XY}\sum_{I=1}^{X}\sum_{J=1}^{Y}\left[G(I,J) - G'(I,J)\right]^2 \quad \ldots\ldots(4)$$

$$PSNR = 20 * \log_{10}\left(255 / \sqrt{MSE}\right) \quad \ldots\ldots(5)$$

Where G(x,y) is the original image, G'(x,y) is the approximated version (which is actually the image with patient information) and M,N are the dimensions of the images. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction. Lower MSE (and a high PSNR), you can recognize that it is a better one.

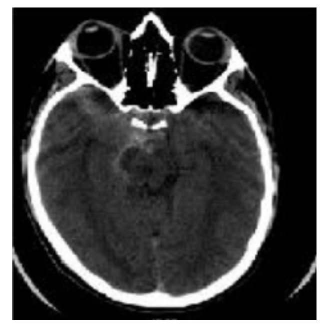
5. RESULTS AND DISCUSSION:

This section presents a detailed results and discussion obtained by the authors in the present work. The results are presented in the form of tables and snap shots. The measurable statistical parameters are NRMSE, MSE and PSNR. These are the important quantitative assessment parameters adopted in the image community to study the quality of interleaved images.

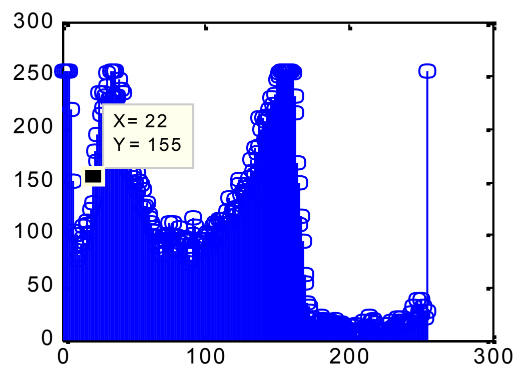
The proposed method is applied on more than 100 different images with different sizes. However the present paper shows one of them of size 128 * 128.

The snap shots exhibits that the visual quality of image is always guaranteed based on the histograms obtained before interleaving and after interleaving as shown in Figure 4.The image quality is not degraded on the account of the fact that the change in the LSB of a pixel changes its brightness by one part in 256 which is shown in the histogram plot. The text can be interleaved into LSB of all the pixels in an image. The shape of the histograms signifies that the distribution of pixels remain same before interleaving and after interleaving. Change in the pixel value specified in the histogram indicates presence of text data (0 or 1) inside the medical image.

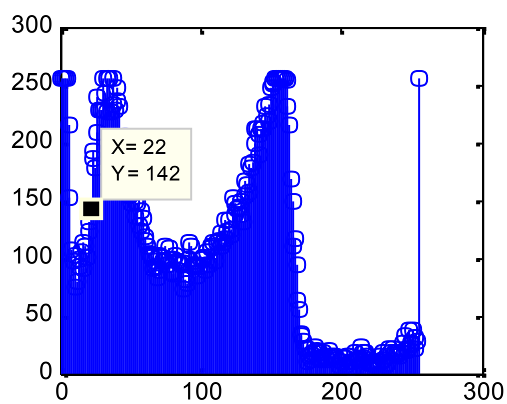
a Original image



b Interleaved image



C Original image Histogram



d Interleaved image Histogram

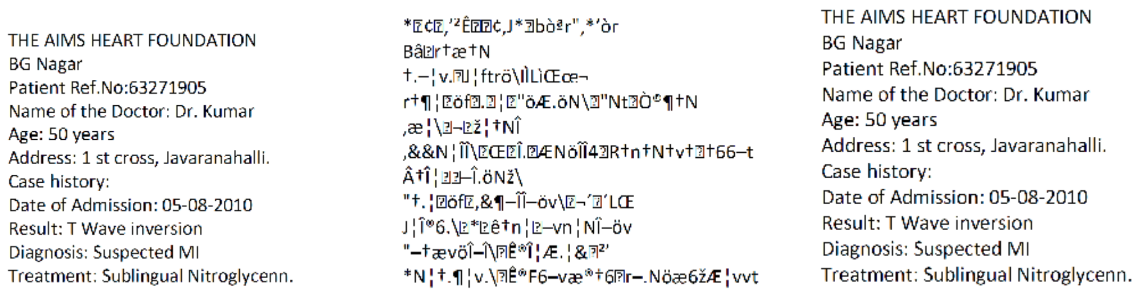
Figure 4 Data Embedding using LBP/LTP Technique

The experiments were carried out in 128 x 128 gray scale medical images. In the proposed method using LBP we could embed a maximum of 2048 characters in one plane and 3276 characters using LTP technique and recovered without a single distortion. By making use of three LSB planes maximum of 9828 characters could be embedded using LTP.

According to [21], an improvement in algorithm is recognized by a high PSNR or a lower MSE. With this, the results of the present method with high PSNR prove that reconstructed image will match the original image. Similarly, according to the report of [22], a PSNR value in the range 20-40 indicates that the resultant image is a very good match to the original image. In accordance with this report, the results shown in table (1) to table (3) of the proposed algorithms produce PSNR values in the range 45dB to 70dB for both LBP and LTP techniques proving that the proposed algorithms does not degrade the images with the patient information inside the medical image.

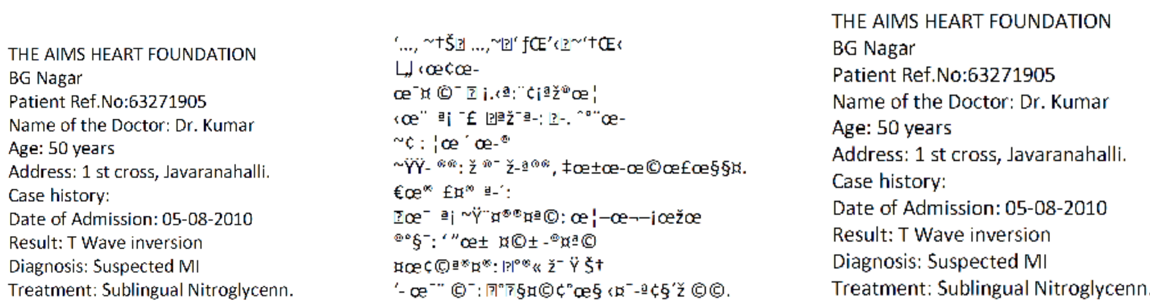
From the table (1) to table (3) it is clear that LTP technique results with a minimum NRMSE and maximum PSNR for the same number of characters embedded inside the medical image which is the most requirements for embedding Techniques.

During transmission of embedded image through communication channel, noise could get added which will cause an effect in retrieval of patient information at the receiver side. To study the effect of channel noise, Speckle noise is added with the embedded image. The Patient information was recovered from this image. In the proposed method using LBP and LTP the BER was observed to be zero and is shown the figure 5 and figure 6.



a. Original Image b .Encoded Patient Information c. Retrieved Patient Information

Figure 5 Encoded and Decoded Patient Information Using LBP Technique



a. Original Image b .Encoded Patient Information c. Retrieved Patient Information

Figure 6 Encoded and Decoded Patient Information Using LTP Technique

Table1: Performance metrics of LBP and LTP for MRI

MODALITY	SIZE	CHARACTER	LBP PSNR Mean±Deviation	LBP NRMSE Mean ±Deviation	LTP PSNR Mean±Deviation	LTP NRMSE Mean±Deviation
MRI	128*128	100	68.75±1.26E-01	1.12E-01 ±3.42E-02	68.88±1.34E-01	1.10E-01±3.38E-02
		200	65.64±1.39E-01	1.58E-01 ±4.71E-02	59.12±1.34E-01	1.57E-01 ±4.77E-02
		500	65.73±1.08E-01	1.58E-01 ±4.75E-02	65.84±9.39E-02	1.56E-01 ±4.72E-02
		800	59.76±1.24E-01	3.15E-01 ±9.37E-02	59.79±6.58E-02	3.14E-01 ±9.39E-02
		1000	58.77±8.35E-02	3.53E-01 ±1.06E-01	58.84±7.85E-02	3.50E-01 ±1.04E-01
		1200	57.99±9.81E-02	3.86E-01 ±1.15E-01	58.02±4.16E-02	3.85E-01 ±1.15E-01
		1500	57.033±7.37E-02	4.32E-01 ±1.29E-01	57.00±3.71E-02	4.30E-01 ±1.29E-01
		1800	56.25±6.71E-02	4.72E-01 ±1.41E-01	56.28±4.77E-02	4.71E-01 ±1.41E-01
		2000	55.8±6.36E-02	4.97E-01 ±1.48E-01	55.82±0.03943	4.96E-01 ±1.49E-01
		2500	NA	NA	53.05±0.03508	5.69E-01 ±1.53E-01
		3000	NA	NA	51.98±3.1E-01	6.80E-01 ±1.76E-01
	256*256	100	71.53 ± 2.28	8.77E-02 ±2.84E-02	71.59±2.29	8.53E-02±2.80E-02
		500	64.48 ± 2.31	1.97E-01 ±6.49E-02	64.54±2.36	1.96E-01±6.36E-02
		1000	61.48 ± 2.3	2.79E-01 ±8.9E-02	61.54±2.33	2.76E-01±8.97E-02
		1500	59.69 ±2.32	3.43E-01 ±1.11E-01	59.76±2.34	3.40E-01±1.11E-01
		2000	58.46 ± 2.33	3.95E-01 ±1.29E-01	58.52±2.34	3.93E-01±1.28E-01
		3000	56.05 ± 2.34	4.88E-01 ±1.36E-01	56.74±2.32	4.82E-01±1.29E-01
		4000	55.38 ± 2.35	5.74E-01 ±1.52E-01	55.7±2.32	5.25E-01±1.38E-01
		6000	53.84 ±2.37	6.21E-01 ±1.72E-01	53.95±2.31	6.16E-01±1.42E-01
		8000	52.03 ±2.39	7.2E-01 ±1.99E-01	52.53±2.28	6.93E-01±1.47E-01
		10000	NA	NA	50.01±2.25	7.59E-01±1.52E-01
		13000	NA	NA	47.31±2.22	8.03E-01±1.58E-01

Table2: Performance metrics of LBP and LTP for CT

MODALITY	SIZE	CHARACTER	LBP PSNR Mean±Deviation	LBP NRMSE Mean ±Deviation	LTP PSNR Mean±Deviation	LTP NRMSE Mean±Deviation
CT	160*160	100	65.85±5.47E-02	1.23E-01 ±6.81E-03	66.03±3.39E-02	1.21E-01±6.91E-03
		500	58.84±4.05E-02	2.77E-01 ±1.54E-02	58.95±1.32E-02	2.73E-01±1.62E-02
		1000	55.9±3.66E-02	3.88E-01 ±2.29E-02	55.96±3.81E-02	3.86E-01±2.25E-02
		1500	54.16±4.27E-02	4.74E-01 ±2.75E-02	54.21±2.88E-02	4.72E-01±2.72E-02
		2000	52.93±4.68E-02	5.47E-01 ±3.22E-02	52.96±3.16E-02	5.45E-01±3.15E-02
		2500	51.95±2.63E-02	6.12E-01 ±3.64E-02	51.99±2.47E-02	6.09E-01±3.59E-02
		3000	51.16±3.12E-02	6.71E-01 ±4.01E-02	51.194±1.90E-02	6.69E-01±3.94E-02
		4000	NA	NA	51.1±2.26E-02	7.17E-01±3.62E-02
		5000	NA	NA	49.85±2.14E-02	7.60E-01±3.78E-02
	208*208	500	59.53 ±1.27	3.35E-01±4.16E-02	59.59 ±1.27	3.33E-01 ±4.12E-02
		1000	57.12 ±3.41E-02	4.47E-01±8.46E-02	57.18 ±4.61E-02	4.44E-01 ±8.41E-02
		1500	55.38 ±2.28E-02	5.46E-01±1.03E-01	55.42 ±3.12E-02	5.44E-01 ±1.03E-01
		2000	54.15 ±3.71E-02	6.30E-01±1.20E-01	54.16 ±4.24E-02	6.28E-01 ±1.18E-01
		2500	53.16 ±3.58E-02	7.00E-01±1.30E-01	53.21 ±3.01E-02	6.96E-01 ±1.28E-01
		3000	52.39 ±3.53E-02	7.71E-01±1.46E-01	52.41 ±2.74E-02	7.69E-01 ±1.45E-01
		4000	51.13 ±6.84E-02	8.76E-01±1.73E-01	51.15 ±2.77E-02	8.76E-01 ±1.72E-01
		5000	NA	NA	50.62 ±2.50E-02	8.89E-01 ±1.93E-01
		6000	NA	NA	49.32 ±2.43E-02	9.54E-01 ±2.12E-01

Table3: Performance metrics of LBP and LTP for ULTRSOUND

MODALITY	SIZE	CHARACTER	LBP		LTP	
			PSNR Mean±Deviation	NRMSE Mean ±Deviation	PSNR Mean±Deviation	NRMSE Mean±Deviation
ULTRA SOUND	108*108	100	67.39 ±1.58E-01	1.75E-01 ±2.64E-02	67.43 ±1.41E-01	1.74E-01 ±2.70E-02
		200	64.38 ±1.32E-01	2.51E-01 ±3.74E-02	64.42 ±1.24E-01	2.46E-01 ±3.80E-02
		500	60.4 ±7.87E-02	3.91E-01 ±5.86E-02	60.42 ±4.02E-02	3.90E-01 ±5.91E-02
		800	58.33 ±6.72E-02	4.97E-01±7.47E-02	58.37 ±4.92E-02	4.94E-01±7.38E-02
		1000	57.36 ±6.87E-01	5.56E-01±8.38E-02	57.4 ±4.85E-02	5.53E-01 ±8.26E-02
		1200	56.56 ±6.08E-02	6.09E-01±9.17E-02	56.6 ±4.40E-02	6.06E-01±9.08E-02
		1400	55.89 ±5.99E-02	6.58E-01 ±9.89E-02	55.93 ±4.04E-02	6.55E-01±9.85E-02
		2000	NA	NA	51.37 ±3.79E-02	7.49E-01 ±1.01E-01
		2300	NA	NA	49.84 ±3.18E-02	8.69E-01 ±1.04E-01
	128*128	100	69.54±1.87	1.37E-01 ±3.15E-02	69.61 ±1.83	1.36E-01 ±3.05E-02
		200	66.47±1.86	1.96E-01 ±4.48E-02	66.53 ±1.84	1.94E-01 ±4.33E-02
		500	62.44±1.90	3.12E-01 ±7.16E-02	62.52 ±1.85	3.09E-01±6.95E-02
		800	60.4±1.88	3.95E-01 ±9.00E-02	60.48 ±1.85	3.91E-01 ±8.79E-02
		1000	59.3±4.96E-01	4.40E-01±6.30E-02	59.39 ±5.43E-01	4.35E-01±6.28E-02
		1200	57.7±5.37E-01	4.56E-01±6.73E-02	58.03 ±5.83E-01	4.45E-01±6.50E-02
		1500	58.51±7.58E-01	4.66E-01 ±7.10E-02	58.9 ±6.80E-01	4.61E-01±6.93E-02
		1800	56.37±6.32E-01	5.43E-01 ±7.54E-02	56.07 ±6.42E-01	5.20E-01 ±7.43E-02
		2000	55.81±6.54E-01	6.58E-01 ±9.85E-02	55.86 ±6.61E-01	6.54E-01±9.78E-02
		2500	NA	NA	53.43 ±6.82E-01	6.95E-01 ±8.36E-02
		3000	NA	NA	51.29 ±6.99E-01	7.43E-01±9.80E-02

4. CONCLUSIONS

This paper has presented a technique of interleaving patient information such as textual information with medical images for efficient storage. The technique is tested for different images like MRI, CT and Ultrasound. The statistical measures indicate that obtained results are agreeable and it is concluded that image quality did not degrade after interleaving. From the results it is clear that LTP technique resulting in high volume of information storage capacity with minimum NRMSE and High PSNR as compare to the previous methods. Experimental results proved that the proposed algorithm is efficient in terms of quality and further, the results also proved that storing watermarks using LBP and LTP provides more robustness to the proposed technique. The present study considered single value fixed threshold but multi value fixed threshold could be tried as a future work. This interleaving could also be enhanced as a security means to reach authenticate persons.

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