Quality Measure for Information Hiding in Medical Images

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ABSTRACT
The present paper proposes a new information interleaving process in which patient text information is embedded in his own medical image. Eleven attributes of patient are embedded inside the same patient medical images considering Magnetic Resonance Image, Angiogram and Computerized Tomography image of that patient body. Authors confirm that this new technique definitely relieve from over burden of storing and transmission of patient information and his scanned images separately. Authors also conclude that this technique provides fool proof security during transmission. The reliability of present technique is measured through statistical parameters such as Normalized Root Mean Square Error, Signal to Noise Ratio, Background Variance and Detailed Variance. Statistical parameters strongly indicate that the present technique to embed the patient information does not degrade the image quality. Authors found that this technique is the robust, efficient technique as observed in results and discussion of section 3.

Keywords: Interleaving, Medical Image, Normalized Root Mean Square Error (NRMSE), Patient information, Signal to Noise Ratio (SNR).

1. INTRODUCTION
Exchange of patient information in the form of text between hospitals through open networks is a very common practice today [1]. But the necessity of secure and authenticated data transfer with maximum speed is vital in the medical world. Now a days, the transmission of patient images and text information of patient separately is a daily routine. But it demands to find an efficient way to transmit them over the internet [7]. The present interleaving of text 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 text information [2]. Digital Watermarking is an efficient method to hide the data such as text, audio file or a digital video in a digital image [3,4].Authors found that interleaving technique also belongs to digital watermarking techniques which belongs to various transformation techniques such as Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT) and Wavelet Transform. However frequency domain approach also suffers from draw backs such as scaling effect [8]. Hence authors attempted in this paper to develop a new interleaving technique to embed 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[6]. 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 the new interleaving of text in images. Section 3 presents results and discussion through tables and visual snapshots. Section 4 presents the concrete conclusions of present new technique to embed text in images and followed by exhaustive references.

2. METHODOLOGY
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 Creating the patient information as text file and reading the same, Encryption of the text file, Interleaving the encrypted text in images followed by retrieving the interleaved text file from images. The other sections deal with performance measurements

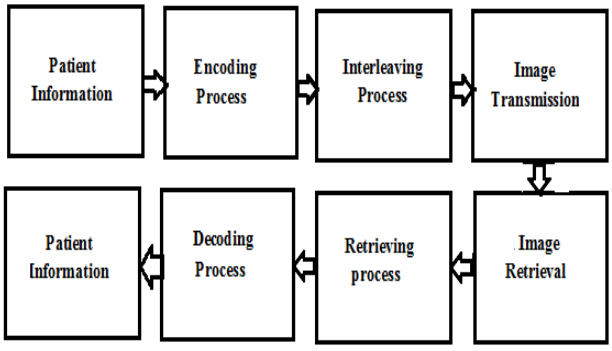


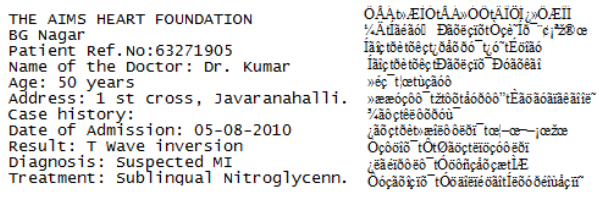
Figure 1. Patient Information on Encoding-Decoding Transceiver System

2.1 Encryption of the Text File

A text file created for the eleven attributes of patient as shown in Fig.2 (a). The document is treated as ASCII code for encryption and encrypted using the equation 1.

$$T_e = (\log(T_0 * 2) * 100) - 300 \quad \text{.....(1)}$$

Where Te is he encrypted text and To is the ASCII code of the original text. The encrypted information (Te) is stored as an integer[1]. The ASCII codes of the encrypted text shown in Fig.2 (b).



a. Original Text Information b. Encrypted Text Information

Figure 2 Encryption of Patient Information

2.2 Interleaving Process

The ASCII code in the text file is swapped with the Least Significant Bit (LSB) of the gray scale image bit by bit. Eight bits of each ASCII code thus replace LSBs of eight consecutive pixels of the image [1]. This cycle of interleaving of ASCII code in consecutive pixels is repeated to include all the characters in the text file. The ASCII codes of the encrypted text shown in Fig.2 (b) are broken into bits and interleaved into the pixels of desired medical images of the patient using equation 2.

$$Interleaving(n) = \mathrm{Re}m\left(\frac{image\ pixel}{2^n}\right) \ldots 0 \le n \le 7 \text{.....(2)}$$

2.3 Retrieval of Embedded Text

Equation 3 is used for the retrieval of text from interleaved image.

$$T_0 = \exp\left((T_e + 300)/100 - \log(2)\right) \quad \text{.....(3)}$$

2.4 Performance Statistical Measures

A quantitative assessment of the method is obtained by evaluating the Normalized Root Mean Square Error (NRMSE) and Signal to Noise Ratio (SNR) between original image and processed image using equation 4 and 5.

$$NRMSE = \sqrt{\frac{\sum_{X=1}^{N}\sum_{Y=1}^{M}[f(x,y) - f_w(x,y)]^2}{\sum_{X=1}^{N}\sum_{Y=1}^{M}[f(x,y)]^2}} * 100 \text{.....(4)}$$

Based on the fact that human eye is less sensitive to changes in textured areas than in smooth areas, SNR is another parameter that takes in to account the texture of the image.

$$SNR = 10 * \log_{10} \sqrt{\frac{\sum_{X=1}^{N}\sum_{Y=1}^{M}[f(x,y)]^2}{\sum_{X=1}^{N}\sum_{Y=1}^{M}[f(x,y) - f_w(x,y)]^2}} \quad \text{..... (5)}$$

Where N = the total number of columns, M is the total number of rows in the image, f(x,y) is the original pixel intensity, and $f_w(x,y)$ is the modified (interleaved) pixel intensity. Statistical measures before and after interleaving the text information with image are shown in Table1.

2.5 Measurement of Variance

Human visual inspection of image is found to be more effective way to measure quality of images at higher abstract level which is a subjective measurement but not statistical measurement. Hence a simple method has been devised to make the comparison of interleaved images based on two statistical parameters namely Detailed Variance (DV) and Background Variance (BV). Detailed variance parameter is measured considering non uniform areas where as background variance measured with respect to uniform areas of interleaved image. To determine these two parameter algorithmically a known size of *n* x *n* window is considered and processed over the image matrix fixing a fixed threshold value. If the variance is larger than a fixed threshold, the pixel belongs to the detail variance region otherwise it belongs to the background variance region. These two parameters are evaluated keeping each pixel of image with the center pixel of window to generate binary mapping. If the corresponding pixel in the binary map image is white, this variance is accumulated in a detail variance region register, otherwise in a background variance region register. The average background variance, obtained dividing the detail region variance register by the number of pixels in the detail region, and the average detail variance, obtained in an analogous way. Result of DV and BV of original and processed image for different medical images are tabulated in Table 1.

3. 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, SNR, Background variance and detailed variance. These are the important quantitative assessment parameter adopted in the image community to study the quality of interleaved images. Table 1 depicts the various statistical parameter obtained for original and interleaved image. From the Table1 authors conclude that obtained results are agreeable since there is no much difference between mean and standard deviation of interleaved image and original image. These results shows that the visual quality of image is guaranteed up to 95% confidence based on Variance parameter as

observed in Table 1. The snap shots also exhibits that the visual quality of image is always guaranteed based on the histograms obtained before interleaving and after interleaving as shown in Fig. 3(d), 4(d) and 5(d).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. The text can be interleaved into all the pixels of the image. The shape of the histograms signifies that the distribution of pixels remain same before interleaving and after interleaving.

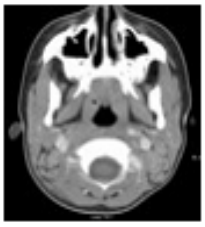


Fig 3a. Original Image

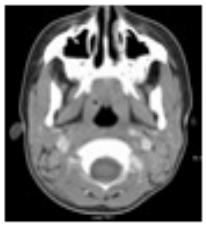


Fig 3b. Interleaved Image

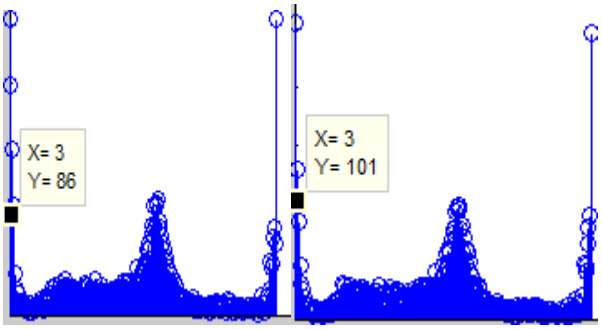


Fig 3c.Original Image Histogram

Fig3d. Interleaved Image Histogram

Fig 4a. Original Image

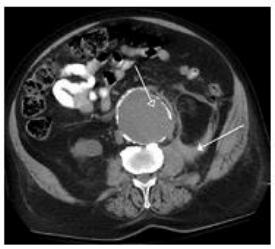


Fig 4b. Interleaved Image

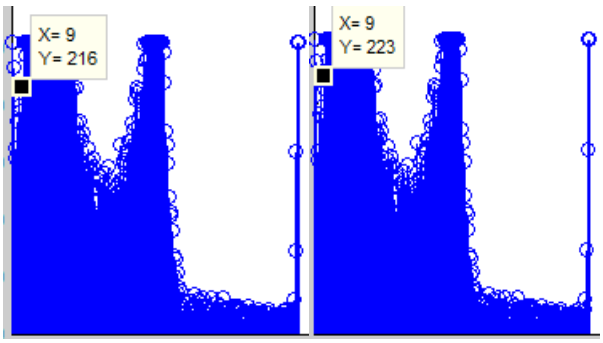


Fig 4c.Original Image Histogram

Fig4d. Interleaved Image Histogram

Fig 5a. Original Image

Fig 5b. Interleaved Image

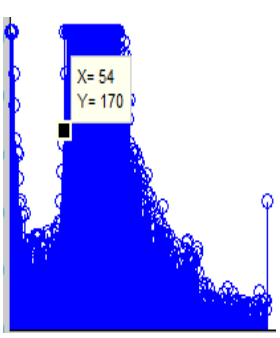


Fig 5c.Original Image Histogram

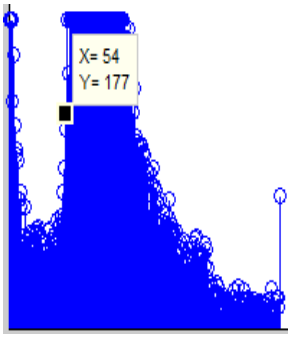


Fig5d. Interleaved Image Histogram

4. CONCLUSIONS

This paper has presented a technique of interleaving patient information such as text documents with medical images for efficient storage and transmission in the internet. Text files are encrypted using a logarithmic technique. The LSB of the pixel is chosen for data interleaving because, the resulting degradation of image is minimal. The technique is tested for different images like MRI, CT and angiogram. The statistical measures indicate that obtained results are agreeable and it is concluded that image quality did not degrade after interleaving. The covariance statistical measure indicates that present method gives more NRMSE compare to SNR. Hence further algorithm could be modified to reduce NRMSE. The proposed technique of interleaving data into an image can also be used for transmission purpose with security. 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 authenticated persons.

Table1 Statistical measures

Modality	Image Size	NRMSE	SNR(db)	Background Variance		Detailed Variance	
				Original	Processed	Original	Processed
MRI Image	128x128	0.2296	52.7817	18	18	1121	1121
	256 x256	0.1148	58.7977	16	16	564	564
	512 x512	0.0583	64.6808	13	13	292	292
Angiogram	128x128	0.3186	49.9342	15	16	673	673
	256 x256	0.1538	56.2611	13	13	671	671
	512 x512	0.0785	62.0998	09	09	433	432
CT	128x128	0.3655	48.7427	23	23	927	927
	256 x256	0.1849	54.6613	23	23	701	701
	512 x512	0.0942	60.5185	16	16	419	419

5. REFERENCE

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