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Region Based Data Hiding in Medical Images

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Abstract: Medical images are generated and transmitted between hospitals for analysis by physicians who are geographically apart. Moreover, as the patient data is also embedded within the medical images, it is very important to maintain the privacy of patient data. For data hiding in images, many techniques are used. Some techniques will hide data but embedding cause some misrepresentation of image, and some techniques will cause misrepresentation during retrieval. In this paper, new approach of data hiding technique is proposed to hide the data in both Region of Interest (ROI) of medical images and Non Region of Interest (NROI) of medical images and recover the data as well. Medical image and hidden data are recoverable without any loss of data.

Keywords: Data hiding, Medical images, ROI, NROI, LSB

I. INTRODUCTION

Rapid advances in telecommunications technology have made possible for digital medical images to be shared across the world for facilities such as telemedicine, telediagnosis, teleradiology and teleconsultation. Instant diagnosis and understanding of a certain disease as well as remove the number of misdiagnosis has had extensive social and economic impact, which clearly emphasize the need for efficient patient information sharing between experts of different hospitals. In the approach of medical images, the main importance is to secure protection for the patient's records against any act of damaging by unauthorized persons. So, the main concern of the existing automated medical system is to improve some standard solution to preserve the authenticity and integrity of the content of medical images [1, 2].

Accordingly, one solution for handling the above problem is the utilization of digital watermarking. In other words, watermarking can improve the security of medical images by embedding special information, called a watermark or hidden data, in an ambiguous way. Watermark information is typically embedded in a binary format to the pixel value of the host image. This information can later be recovered and checked whether the medical image is appropriate with the actual source or belong to the correct patient [3].

A data hiding technique has the following basic requirements: imperceptibility, robustness, capacity, and security. However, it is not a simple task for data hiding technique to meet all these needs. For example, embedding huge message into an image will cause noticeable artifact. Then again, to enhance the imperceptibility, the capacity of the embedded data will also reduce. Therefore, the users should develop suitable data hiding techniques according to their applications.

Data hiding methods are classified into two broad categories as spatial domain and frequency domain based. Spatial domain methods hide data by modifying the LSB of pixel intensity values whereas modification of the co-efficient values after applying frequency domain transforms are categorized as frequency domain techniques. Some of the popular transforms are Discrete Cosine Transform, Discrete Wavelet Transform, Contourlet Transform, Discrete Fourier Transform, Fourier Transform, Random Transform, and Curvelet Transform.

Reversibility gives the facility to retrieve the exact original input data after the extraction process. This is a technique used to hide additional message into some distortion unacceptable cover media, such as military or medical images, with a reversible approach so that the original cover content can be entirely restored after extraction of the hidden message.

Reversibility can be used to attach crucial data to the media without changing their original contents. The lossless embedding increases the size of the cover image and lossy embedding process cannot be applied to medical field. Recently, reversible data hiding technique, also called lossless data embedding, has attracted the attention of many researchers.

II. RELATED WORKS

Reversible data hiding is very important in data embedding or extraction process.

The rapid growth in internet technology permits us to transmit, share and store secret data. In the field of telemedicine, protected and fast transmission of medical image is a great challenge [4]. Nowadays, in order to have the patient privacy protection in medical image, embed patient data is embedded within the medical image itself. The objective is to embed and transfer secret messages in digital medical images without any error.

The data hiding encompasses hiding data in audio, videos and files [5]. Another problem that arises in storing and the transmission of the medical image and its secret data is how it is stored.

In 1999, Fabien A. P. Petitcolas et.al presented an overview of information hiding in general and classification of information-hiding techniques [6]. In this paper, they have described some common attacks on information hiding systems.

In 2008, K. A. Navas, et.al presented Electronic Patient Report (EPR) data hiding for telemedicine [7]. This paper deals with novel blind and reversible data hiding technique in ROI images using integer wavelet transform and it specifically focused on medical images.

Xinpeng Zhang [8] presented a scheme in which, a content holder encrypts the original image using an encryption key, and a data-hider embeds supplementary data into the encrypted image with a data-hiding key. With an encrypted image containing supplementary data, a receiver may first decrypt it according to the encryption key, and then extract the embedded data and improve the original image according to the data- hiding key. In the scheme, the movement of data extraction is not independent from the activity of content decryption.

Jitha Raj.T et.al discusses about various Reversible Data Hiding Techniques in Encrypted Images with a comparison of their performance [9]. This paper discusses about related works of data hiding and compared with other data hiding methods.

C Nagaraju et.al proposed embedding patient information and Electrocardiogram which is further encrypted to ensure greater security in spatial domain [10].

Mary Shanthi Rani et.al have proposed a new approach combining visual cryptography and steganography techniques for providing multilevel multimedia security [11][12]. Some novel message hiding techniques in RGB Domain are presented in [13]-[15].

Although most of current reversible data hiding schemes could embed more hidden data into the image with low distortion, the performance of reversible data hiding still can be enhanced. In this paper a novel reversible data hiding scheme based on the Region of Interest (ROI) and Least Significant Bit (LSB) is presented.

III. PROPOSED WORK

A new method of text data hiding into a medical image is proposed in this paper. This method is well-suited for hiding patient particulars into a medical image generating a stego image. Both the image and hidden patient data are retrieved at the receiving end without any loss which is very important for medical diagnosis.

The Proposed method has two phases:

1. Data hiding using LSB method
2. Recover the hidden data

A. *Region of Interest*

In the first phase of data hiding, the medical image and patient data to be hidden are read and the patient data is embedded into the medical image. In the data hiding process, firstly the locations for hiding the data in medical image matrix are to be found out. (i.e.) ROI and NROI (Non Region of Interest) of medical image matrix.

B. *Least Significant Bit*

Least Significant Bit (LSB) embedding is an easier approach in steganography. Like all steganographic methods, it embeds the data into the cover image so that it cannot be recognize by a casual observer. The technique works by changing some of the bits in a given pixel with information from the data in the image. While it is possible to embed data into an image on any bit-plane, LSB embedding is performed on the least significant bit(s).

Figure 1. (A) Original Medical image

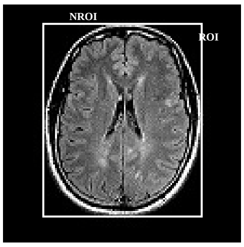


Figure 1. (B) Image With Region Of Interest

Table I. Data Hiding Method

Parity	*Hidden data Message bit*	*Modification*
Even	0	No change occurs
	1	Reverse the LSB
Odd	0	Reverse the LSB
	1	No change occurs

C. *Embedding process using LSB Method*

The steps of the proposed algorithm is outlined as

Steps:

- Read the input medical image.
- Split color image into Red, Green and Blue (RGB) Channels
- Take out the Region of Interest by locating the rectangle enclosing it, with its top left and bottom right co-ordinates as shown in Figure.1 (B).
- Read the text data
- Convert each character of text into its consequent ASCII value.
- Count the ASCII values to avoid replication of hiding same text characters.
- Embed the binary value of ASCII value in ROI of cover image using table I.
- First embed hidden text count and then the hidden data into red channel of cover image and then green and blue.

For example, Let the hidden text be “abc” and its ASCII values are stored in a variable, h= (97, 98, 99). As the hidden text count is 3. The binary values of 3*abc is stored as a binary vector Binvec=00000011001010100110000101 100010011000 11.

Color image split into Red, Green and Blue (RGB) Channels. Region of Interest separately taken by locating the rectangle enclosing it, with its top left and bottom right co-ordinates. Red channel selected as cover media and embed the binary values one by one in ROI. Parity of pixel intensity value is checked. In figure 2 first pixel value parity is even and hidden first binary value is 0, so no change occurs in that pixel. As the second pixel value parity is odd and hidden second binary value is 0, So Reverse the LSB of that pixel. Likewise embed all the binary values using table I.

68	69	70	…..	…..
69	70	71	…..	…..
70	71	72	…..	…..
…..	…..	…..	…..	…..
…..	…..	…..	103	104

01000100	01000101	01000110	…..	…..
01000101	01000110	01000111	…..	…..
01000110	01000111	01001000	…..	…..
…..	…..	…..	…..	…..
…..	…..	…..	01100111	01101000

01000100	01000100	01000110	…..	…..
01000101	01000110	01000111	…..	…..
01000110	01000111	01001000	…..	…..
…..	…..	…..	…..	…..
…..	…..	…..	01100111	01101000

68	68	70	…..	…..
69	70	71	…..	…..
70	71	72	…..	…..
…..	…..	…..	…..	…..
…..	…..	…..	103	104

Figue 1. Embedding Process

D. *Recovering the hidden data and cover image*

The steps of the recovery process is outlined as follows

Steps:

- Read the stego image.
- Split color image into Red, Green and Blue (RGB) Channels.
- Take out the Region of Interest by locating the rectangle enclosing it, with its top left and bottom right co-ordinates.
- Extract the hidden data binary values using table II.
- Read the LSB value from the Red Channel up to * ASCII value which gives the text count.
- Then read LSB continuously for text count times.
- Replace the LSB using table II.

Table II. Data Extraction Method

Parity	*Hidden data*	*LSB of Stego image Data*	*Host Image Data*
Even	0	0	No Change
		1	Reverse the LSB
Odd	1	0	Reverse the LSB
		1	No Change

In extraction process, hidden data is extracted using table II. Firstly red channel selected for extract the hidden data, and then Region of Interest is taken by locating the rectangle enclosing it, with its top left and bottom right co-ordinates. After that parity of pixel intensity value checked, and then count value extracted from the ROI. After that hidden data extracted from ROI and the pixel value replaced using table II.

IV. Result and Discussion

The amount of distortion in medical image due to the data hiding is measured through quality assessment parameters NRMSE, PSNR and MSE.

A. *NRMSE*

Quality of the processed image with patient data is measured by evaluating the Normalized Root Mean Square Error (NRMSE) using equation 1.

$$NRMSE = \sqrt{\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}[I(i,j)-I'(i,j)]^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}[I(i,j)]^2}} * 100 \qquad ...(1)$$

Where N = number of columns, M is number of rows in the image, I(i,j) is the original pixel intensity, and I'(i,j) is the processed pixel intensity.

B. *MSE and PSNR*

Like NRMSE, Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the other two error metrics used to measure the quality of the image. MSE and PSNR between the original image and processed image are measured using following equations.

$$MSE = \frac{1}{M \times N}\sum_{i=1}^{N}\sum_{j=1}^{M}[I(i,j)-I'(i,j)]^2 \qquad \ldots(2)$$

$$PSNR = 10 \times \log\left(\frac{255^2}{MSE}\right) \qquad \ldots(3)$$

This section gives respectively detailed results and discussion obtained by the authors in the present work. The results are represented in the form of tables and snap shots.

The proposed method is tested using medical images of size 512x512 with RGB channels. Secret data are hidden near Region of Interest in medical image so that there will not be any visible distortion after hiding data.

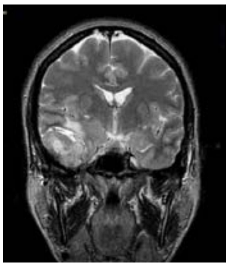
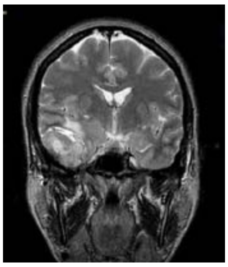
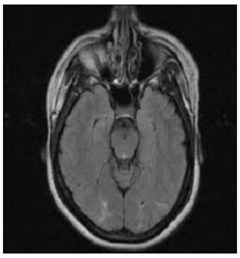
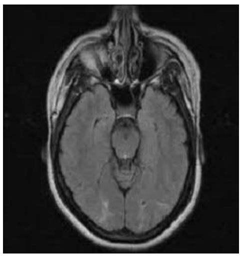
The performance of the proposed system is analyzed by measuring NRMSE, MSE, and PSNR that are tabulated in Table III.

Table III. Performance of Proposed system

Image Size	*Character*	*PSNR*	*NRMSE*	*MSE*
128*128 ROI	100	45.00	1.07	2.0582
	200	42.84	1.37	3.3823
	500	38.70	2.21	8.7644
128*128 NROI	100	69.00	0.07	0.0082
	200	57.93	0.24	0.1047
	500	50.87	0.54	0.5328
256*256 ROI	100	52.54	0.45	0.3620
	200	49.52	0.64	0.7254
	500	45.25	1.05	1.9408
256*256	100	75.01	0.03	0.0020
	200	72.00	0.05	0.0041

NROI	500	68.02	0.08	0.0103
512*512 ROI	100	55.66	0.32	0.1765
	200	52.66	0.45	0.3521
	500	49.85	0.62	0.6736
512*512 NROI	100	81.03	0.02	0.0005
	200	78.02	0.02	0.0010
	500	74.04	0.04	0.0026

Table IV. Visual Comparison of Original Image and Stego Image

Original Image	***Stego Image***
 128*128	 128*128
 256*256	 256*256
 512*512	 512*512

In this proposed method 100, 200 and 500 characters are hidden in the medical Images. The graphical representation of the comparison of PSNR values of different sizes of ROI and NROI regions are presented in Figure 2, Figure 3 and Figure 4.

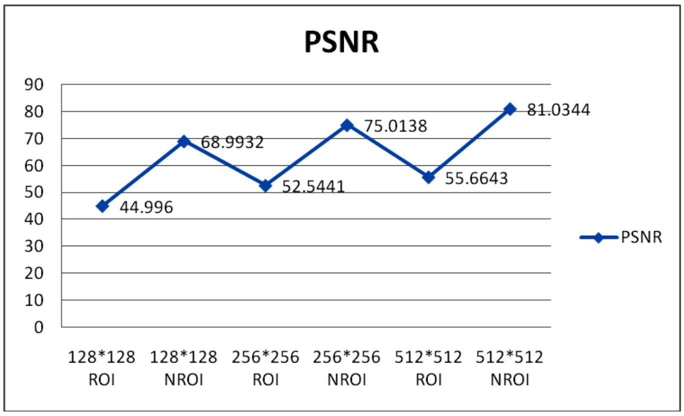
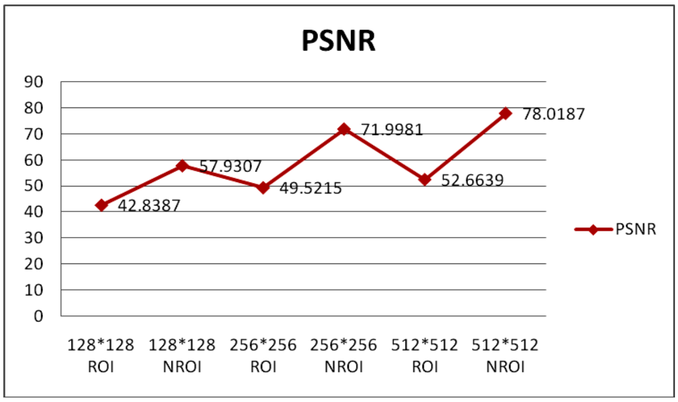
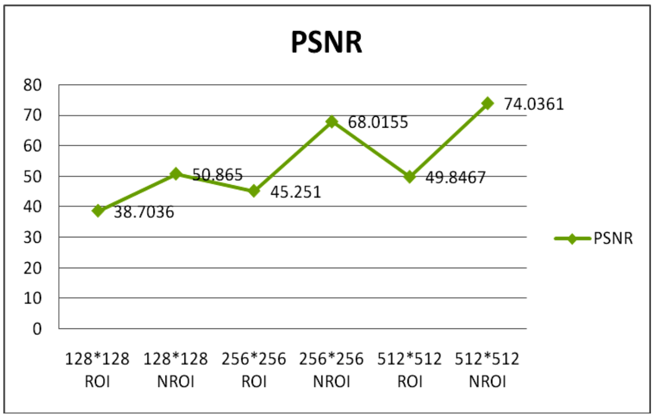


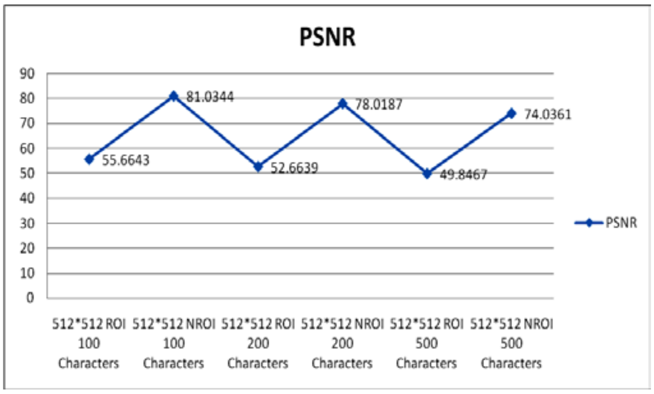
Figure 2. Comparison of PSNR values for different sizes of ROI and NROI region (100 Characters)



Figue 3. Comparison of PSNR values for different sizes of ROI and NROI region (200 Characters)



Figue 4. Comparison of PSNR values for different sizes of ROI and NROI region (500 Characters)



Figue 5. Comparison of PSNR values for different payload sizes of ROI and NROI region

V. CONCLUSION

This paper has presented a technique of embedding patient information inside medical images for efficient storage. The experimental results reveal that the proposed method yields high quality images even after hiding data, making the medical image visually agreeable for good medical diagnosis. In this method, we can get hidden data and cover image accurately without any loss when retrieving hidden data and cover image.

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