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Digital Watermarking for Medical Diagnosis

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ABSTRACT

Presently, there is no solid methodology to protect and secure medical data from health care centers from unauthorized copying. Such as, digital watermarking is gaining interest among research scientists in image processing as a new method of protecting multimedia content from unauthorized copying, as the easy communication and manipulation of digital information create a formidable intimidation for information architects and providers. The main objective of this study was to present a new watermarking system applying a five bit LSB (Least Significant Bit) strategy for copyright security of image contents. The new method commences on converting the text information into binary data by representing each character by a length of five bit string and was organized with embedding information into the corresponding image files. The information is extracted from the images by justifying the LSB of eight successive gray values and converting the bits into ASCII characters. There was no visual difference after embedding watermark using both the traditional and the proposed method. However, the proposed LSB method did not prove better than the traditional LSB method. In conclusions, the effectiveness of the method was justified over CT scan, MRI and X-Ray image.

Key words: Digital watermarking, image, diagnosis, digital multimedia, protection, security, medical data, health care centers

INTRODUCTION

A digital watermark is a slice of data implanted in the digital media and concealed in the digital content in such a way that it is attached to its original information. This slice of data, known as watermark, can be identified and recovered later to make a proclamation about the entity. The healthcare centers use Electronic Patient Record (EPR), as a mean to involve the healthcare administration for maintaining disease history of patients and exchange information between network connected clinics. In order to ensure the safety, legitimacy and administration of medical images and information through protection and dissemination, the watermarking approaches are being developed to safeguard the medical evidences. Furthermore, digital watermarking enables to secure data transmission in order to protect medical data from unauthorized person.

Recently, a lot of digital watermarking techniques were found in the literature for copyright protection. Nayak *et al*. (2004) developed a method for watermarking medical images in the spatial domain using error control codes. While, Nambakhsh *et al*. (2006) proposed a technique employing embedded zero-tree wavelet (EZW) approach. Whereas, Guzman *et al*. (2004) included the watermark to the largest detail bands and as an evaluating function for evaluating it, as a product of information pull out in HVS space. They also presented a method depending on the adaptive image watermarking in high resolution sub-bands of DWT where weighting function was the product expression of information pull out from the HVS color space. In another study, Kaewkamnerd and Rao (2000) proposed a wavelet based image adaptive watermarking model where embedding was achieved in the higher level sub-bands of wavelet transform. In order to avoid perceptual degradation of image, the watermark insertion was cautiously accomplished. Chen and Shen (2009) proposed a fragile double image watermarking method employing improved pixel-wise masking and bit substitution approach based on pseudo-random sequence. The method embedded robust watermark into the insensitive part and sensitive part of wavelet coefficients thus making two watermarks non-interfering. Liu and Ding (2009) developed a blind image watermarking method based on wavelet tree quantization. A watermark bit was implanted by comparing the difference with a mean significant difference value and quantified the maximum difference coefficients. Recently, Zhao *et al*. (2010) applied wavelet transform locally and implanted watermark established on chaotic logistic map. However, very recently, Yassin *et al*. (2012) proposed a comprehensive method for digital video watermarking employing a binary watermark image implanted into the video streams. First, each video sequence was decomposed into sub-images employing two level discrete wavelet transform and then the PCA transform was applied for each block in the two bands LL (lower Limb) and HH (Hearing Handicapped). The watermark was implanted into the maximum coefficient of the Patient Controlled Analgesia (PCA) block of two bands. Luo *et al*. (2013) developed a gray image digital watermarking technique combining discrete wavelet transform and discrete cosine transform with singular value decomposition based on chaos and scrambling in images.

The main objective of this study was to explore a method for implanting the EPR data in the medical image to save storage space, to guarantee security of patient information and to get ride of huge database administration. The approach is blind so that the EPR can be recovered from the medical image without original image.

MATERIALS AND METHODS

LSB based digital watermarking: In medical diagnostic centers, the information of patients are stored in separate database such as access, oracle and mysql etc. Such as, it needs huge memory space to keep text information and image separately. For this reason, this research employed watermarking technique in which the text information is kept in the corresponding images. The system is based on Least Significant Bit (LSB) method. The system architectures of the method employed for embedding watermark and extracting watermark of the proposed digital watermarking system are presented in Fig. 1 and 2, respectively.

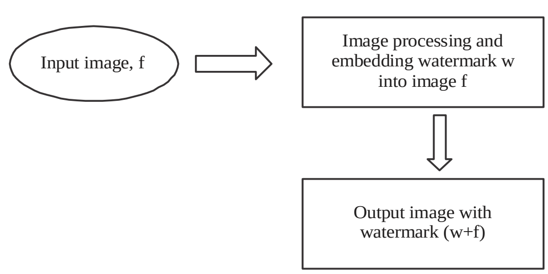

Fig. 1: Watermark embedding process

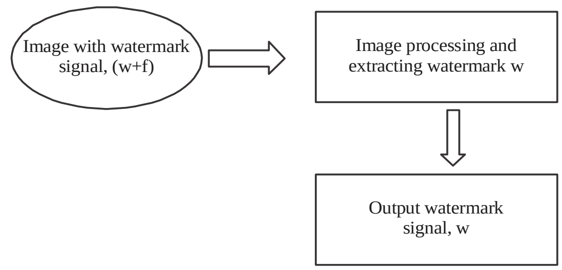

Fig. 2: Watermark extraction process

The traditional methods for digital watermarking denote each character as an ASCII value (Dhar *et al*., 2010; Bamatraf *et al*., 2011; Chopra *et al*., 2012). So eight bits were used to represent each character and it encountered some problems. Firstly, these were not secured, because no encryption technique was used during embedding information in images. Secondly, traditional LSB method was very sensitive to noise. To overcome these problems, this study proposed a new LSB method, which is described step by step as follows.

In this proposed method, only 5-bits were used to represent one character. The character and corresponding value used in this method are given below:

- 0-25 is used for A-Z letters binary value (00000-11001)
- 0-9 reused for 0-9 digits binary value (00000-01001)
- ‘space’ represented by 26 binary value (11010)
- ‘:’ represented by 27 binary value (11011)
- ‘/’ represented by 28 binary value (11100)
- ‘-’ represented by 29 binary value (11101)
- ‘.’ represented by 30 binary value (11110)
- New line equal 31 binary value (11111)
- One pixel is to be used to represent one bit. So, five pixels need to represent one character

The flow chart of the proposed LSB method to embed necessary information is shown in Fig. 3.

The main steps of the proposed method for embedding the desired information are given bellow:

- **Step 1:** Conversion of the text information into binary data, B. Each character is represented by five bits
- **Step 2:** Selection of a seed value (which will act as password) to generate a pseudo-random number. The pseudo-random number will be 0-4
- **Step 3:** If the bit position of each character is equal to the pseudo-random number the logical NOT the bit
- **Step 4:** Selection of the border pixel for embedding information in which, the top most three rows are for name, mobile and age, while the bottom most three rows are for the name of the hospital or clinic, name of the doctor and diagnosis, whereas the left most two columns are for gender and weight

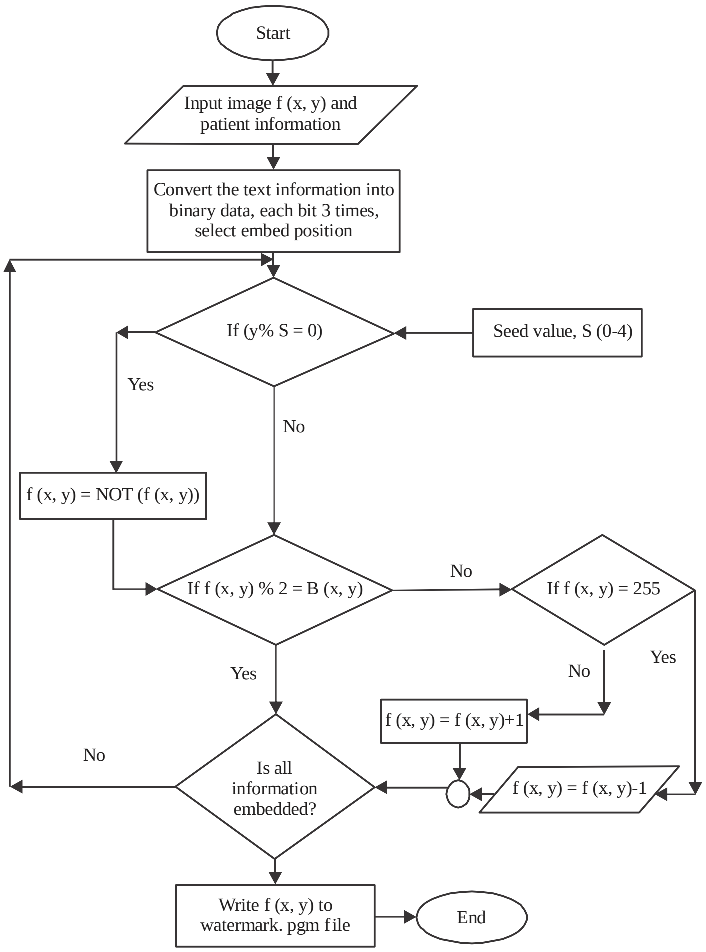

Fig. 3: Flowchart of the LSB based watermarking method

- **Step 5:** Insertion of binary data B into original image as watermark
  If the inserted bit is not equal to the least significant bit of f (x_i, y_j) then
  If f (x_i, y_j) is not equal 255, increase the gray value of f (x_i, y_j) by 1.
  Else decrease the gray value of f (x_i, y_j) by 1.
  Otherwise f (x_i, y_j) will remain the same
- **Step 6:** Overall, each bit follows Step-5 three times

RESULTS AND DISCUSSION

Experimental results: The effectiveness of the proposed method was justified over some experimental procedures. In order to embed the required information, the proposed LSB method was employed to the corresponding image as shown in Fig. 4. In order to see, whether the information is being embedded perfectly, the LSB method read the least significant bit of five successive gray values and converted the bits to ASCII character. After extracting information from image, as shown in Fig. 4, the following information was obtained (Fig. 5).

In order to measure the performance of the proposed LSB method over traditional LSB method, the same sample image sets were used and compared. Both the traditional method and the

Fig. 4: Sample medical image after embedding using proposed LSB

Name: MD. Moniruzzaman
Mobile No.: 01724528435
Age: 30 years
Gender: Male
Weight: 64 kg
Blood Pr.: 120/80
Date: 04-01-2011
Clinic name: Popular Diagnostic Centre
Dr. name: DR. Morafizur Rahman
Diagnosis: Brain tumar

Fig. 5: Extracted information from image, shown in Fig. 4

proposed method were applied on three types of medical images such as CT scan, MRI and X-Ray of different sizes. The experimental results for CT scan, MRI and X-Ray image are presented in Fig. 6-8, respectively.

Performance: Both the traditional and the proposed methods can embed and extract information from image accurately if the image is not affected by noise. Therefore, in order to measure the performance of traditional and proposed LSB methods, experiments were carried out on noisy images. Computation of the accuracy was performed using the following equation:

$$\text{Accuracy rate} = \left(\frac{N_C}{T_W}\right) \times 100\% \quad (1)$$

Where:
N_C = Number of extracted correct words
T_W = Total words

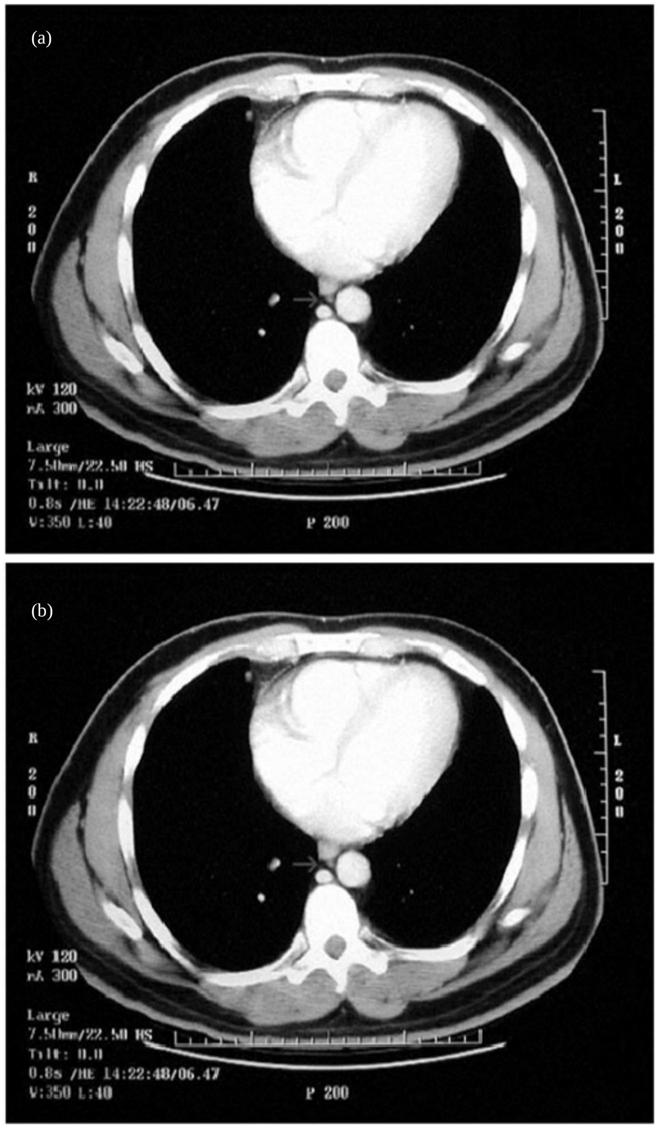

Fig. 6(a-b): Brain tumor CT scan image (928×728) after embedding, EPR (a) Employing traditional LSB method and (b) Employing proposed LSB method

Table 1: Performance comparison between traditional and proposed LSB methods

		Accuracy rate before adding noise (%)		Accuracy rate after adding noise (%)	
Image	Image size	Traditional LSB method	Proposed LSB method	Traditional LSB method	Proposed LSB method
CT scan	928×728	100	100	12.50	100.00
MRI	350×381	100	100	15.38	100.00
X-Ray	560×390	100	100	35.71	100.00
Lena	500×500	100	100	50.00	94.44

In order to add noise gray levels of 600 randomly selected pixels, the experimental images were changed before and after adding some noise in CT scan, MRI, X-Ray and Lina images. The comparison of accuracy rate of both methods is presented in Table 1.

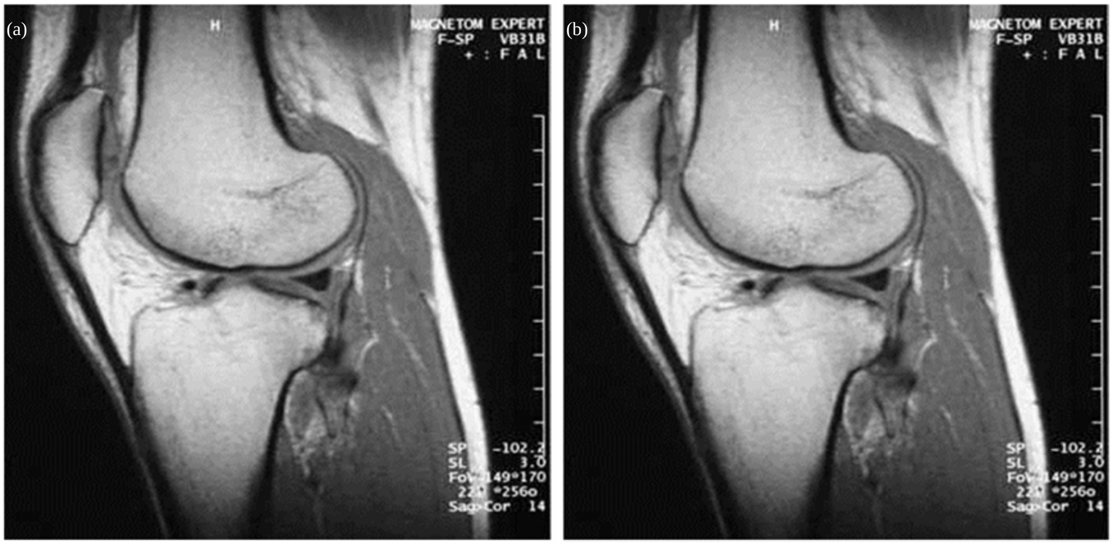

Fig. 7(a-b): Knee MRI image (350×381) after embedding EPR, (a) Employing traditional LSB method and (b) Employing proposed LSB method

Fig. 8(a-b): Finger X-ray image (560×390) after embedding EPR, (a) Employing traditional LSB method and (b) Employing proposed LSB method

It is evident from data in Table 1 that the information is being destroyed if the image is affected by noise in traditional LSB method. But the probability of destroying information in the proposed LSB method was less than traditional method. Because proposed method embeds each bit three times. If one bit is changed by affecting noise, it can be recovered from the other two bits. The

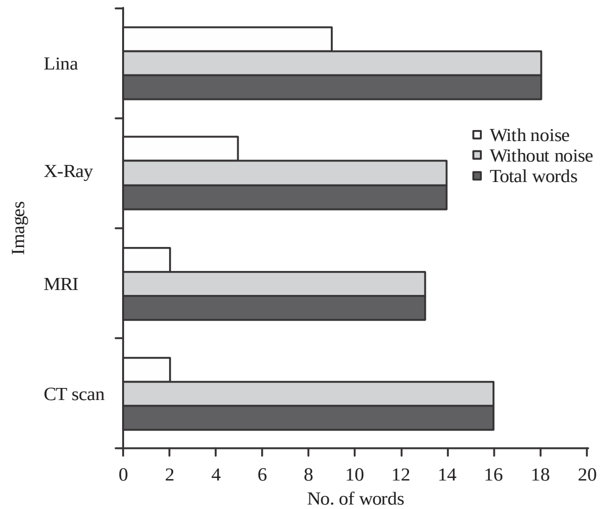

Fig. 9: Performance analysis of the traditional method

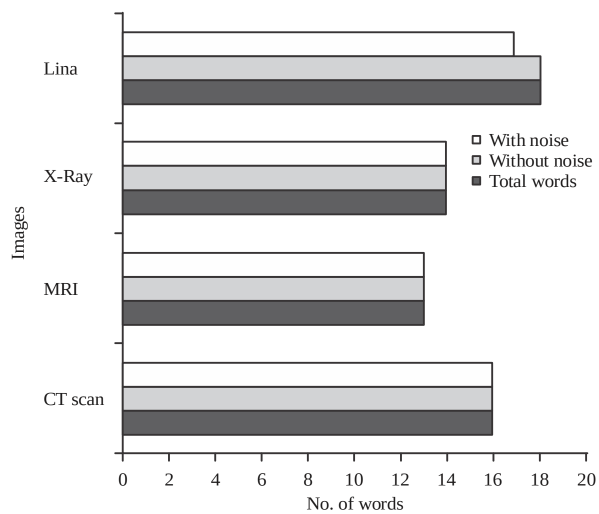

Fig. 10: Performance analysis of the proposed LSB method

performance of the traditional method and the proposed method is shown in the bar chart (Fig. 9 and 10). Figure 9 represents the bar chart of the traditional method and Fig. 10 represents the bar chart of the proposed method, where *x*-axis represents number of words and y-axis represents images. Similar results were reported by many researchers, who presented a wavelet-based algorithm embedding watermarks into the wavelet coefficients employing a quantization of designated coefficients (Giakoumaki *et al*., 2006), proposed a method for implanting patient's diagnosis in the medical images (Kallel *et al*., 2007) and developed a wavelet-based watermarking method through pixel-wise, masking in digital images over HVS color scheme (Barni *et al*., 2001).

CONCLUSIONS

This study proposed a new digital watermarking method employing Least Significant Bit (LSB) strategy. Experimental results indicated that the proposed watermarking system performs durable strength against noise addition. Although, there is no visual difference after embedding watermark using both the traditional and the proposed methods, the proposed LSB method did not prove better than the traditional LSB method with three folds considerations i.e. (1) The proposed method is less affected by noise, (2) The proposed LSB method is more secured because it is password protected and (3) The proposed method uses 5-bits to represent one character, whereas traditional method needs 8-bits to present one character. In this context, this research will allow to explore a new way of implanting the EPR data in the medical image to reduce space complexity to guarantee security and to get rid from huge database. In conclusion, using this method any text information can be transferred with high security due to its password protection.

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