A New Watermarking Technique for Mammogram Images Copy Right Protection

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Abstract: Recent advances in technology have enabled the digitization of medical images for easy retrieval. However, the retrieval process of digital medical image makes the image prone to illegal distortions and reproduction. In this regards, the confidentiality requirement for medical images must have to be ensured. In this paper, a new spatial domain-based watermarking technique for mammogram image copy right protection is proposed. In the proposed technique, the region of interest (ROI) and region of non-interest (RONI) in the mammographic images are detected using the Sobel edge operator. Afterwards, the image is partitioned into 16 blocks of the same size for determining the white pixels percentage values. Then, the bi-level intermediate significant bit (BiISB) that makes use of two levels of ISB bit-planes are applied for the watermark embedding and extraction. To verify the robustness and imperceptibility of the proposed technique, the normalized cross correlation (NCC) and the peak signal-to-noise ratio (PSNR) are measured. Experimental results show that the proposed technique is robust against image distortions such as median filter, Poisson, JPEG compression, rotation, contrast enhancement and motion blur. The proposed technique also shows to achieve imperceptibility of the mammogram image within the cover image.

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1. Introduction

In recent years, medical technology is growing from the usual analog file system to the digitized file system. This trend in medical technology brought about technology driven medical systems such as the picture archiving and communications System (PACS). These systems have advanced the storage, exchange and distribution of medical files. However, these advances present an open problem to the medical imaging community in the aspects of patient information security for medical image retrieval. Medical information is confidential because the patient information is vital for ensuring accurate diagnosis. On account that the information retrieved have been tampered with, wrong diagnosis are ensued. Therefore, it is important to ensure that medical information is made secure from malicious attacks. The medical system PACS is an integrated management system for archiving and distributing medical image data [1-3]. In a case where the digital medical image is exchanged beyond the PACS environment that lies within a particular hospital network, the digital medical image might be exposed to intruders with malicious intent. Existing Internet security methods such as virtual private network (VPN), data encryption, and data embedding were stated to be insufficient for the guarantee that medical images are not compromised [4]. In this regards, digital watermarking in the medical domain became an additional tool to the repertoire of security measures [5]. Generally, watermarking can be defined as the technique of inserting and transmitting a small amount of information imperceptibly in the host or cover data as a watermark. Recent advances have been made over the years in digital watermarking, but little work is being done in its application in medical domain. Watermarking has found application in areas such as broadcast monitoring, owner recognition, verification of rights, and content authentication [6]. For these applications, a number of the advantages of using watermarking for information security can be counted. But one of the advantages considered in medical image watermarking is with regards to authentication. In watermarking, the authentication data is directly implanted into the image data. Therefore, the authentication information remains unchanged even if the host image is manipulated [6]. This property of the watermarking makes it most appropriate for adding a security mark to digital medical images. Usually watermarking schemes can be categorized as robust, fragile and semi-fragile. The watermarks within the category of robust are difficult to be tampered with, since it can either resist deliberate and non-deliberate modifications. The non-deliberate change, are most often as the result of some image processes such as cropping, scaling, analogue to digital(A/D) conversion, digital to analogue (D/A) conversions, filtering, compression. The effects of these processing functions make the robust watermarking useful for exclusive rights and ownership recognition applications. On the contrary, fragile and semi-fragile watermarks are mostly implemented for content authentication but are used for integrity verification and tamper control, respectively [7]. The fragile watermark can be easily damaged by manipulation and modification [8]. This makes the fragile watermark very sensitive to attack. On the other hand, the semi-fragile watermark can withstand non-deliberate and incidental attacks but can be susceptible to intended manipulation. In a nutshell, the semi-fragile watermarks behave as the robust watermark for a deliberate manipulation, as the fragile watermark for the non-deliberate manipulations [9]. Therefore, the semi-fragile watermarking just like the robust watermarking can withstand the effect of image processing tasks such as JPEG compression and noise addition. In essence, the semi-fragile is most appropriate for cases like PACS environment that are prone to deliberate and non-deliberate attacks). Medical images are often not allowed to be modified in any way and so watermark schemes need to be reversible and the exact pixel value of the image watermarked must be recovered [11,24]. In Medical domain, the region of interest (ROI) and region of non-interest (RONI) are necessary for applying watermark in medical images [11,25]. The medical image ROI plays a significant role in diagnosis, and so there need not be any modification within the ROI during the watermarking process. Even though embedding on the ROI is a risky deal, many watermarking approaches are based on ROI like [12], while some are based on the RONI [13]. As a result of the importance and implications of the choice of points for embedding watermark on digital medical images various domains such as the spatial domain and the transform domain have been defined for embedding watermarks in digital medical images [14,26]. In transform -domain watermarking. The discrete cosine transform (DCT), discrete fourier transform (DFT), discrete wavelet transform (DWT) are all part of the family of the transform-based watermarking. In the transformed-based watermarking, the digital medical images are converted to their respective frequency components. And then a step-wise watermark insertion into the image frequency component follows [15,27]. In spatial-domain watermarking, the watermark is directly inserted in the image in its spatial pixel component. Watermarking in the spatial domain modifies the original image pixel values which are spatially located. In the spatial-based watermarking, the embedding of watermark is inserted at the bit plane pixel level. There are about 8 bit-planes for each pixel value that can be used for the embedding process. The bit planes can basically be group as most significant bits (MSB), least significant bits (LSB) and intermediate significant bits (ISB). The MSB is the 1st bit of each pixels, while the LSB is the last (8th) bit-plane, whereas the ISB are the bits in between the MSB and the LSB, which are the 2nd-7th bit-planes .an illustration of the 8 layered bit-planes for a typical gray scale image can be seen in Figure 3.1. [16].

2. Problem Statement

The LSB is the most straight-forward method of watermark embedding [17]. The LSB has been widely used for embedding watermarks algorithm given the fact that extraordinarily high channel capacity of using the entire cover for transmission is possible with the LSB, therefore a smaller object may be embedded multiple times [17]. Most digital watermarking schemes utilize the LSB for embedding and extracting watermark in the spatial domain, which are usually hidden [18]. However, due to the high frequency features that constitutes the LSB, it is usually prone to malicious attack and embedded watermark can be easily replaced. Embedding and extracting watermarks in the spatial domain are usually of low computation, which does not generally affect image quality. Though the spatial domain guarantees the imperceptibility of watermarked images but in terms of robustness the spatial domain is not so appropriate, thus are prone to a number of attacks [19]. The spatial domain watermarking schemes are also prone to compression, image zoom-in and zoom-out. The effect of these actions on the image makes the copyright undetectable [20]. domains were represented to different watermarking attacks. Though the watermarking schemes in the spatial domain are considered frial in terms of robustness, the spatial-based schemes can also be defiant to attackers except the attacker has access to the extracting key.

3. The Proposed Scheme

A new spatial domain-based watermarking scheme for mammogram image is presented. We utilize two existing approaches, which are the BiISB and multi-watermarking. In the embedding and extracting phases, two levels of ISB bit-planes that are high-order-ISB (5th, 6th and 7th) and low-order-ISB (2nd, 3rd and 4th) are used. These levels of ISB can be shown in table1.The BiISB is known to increase robustness as well as the multi-watermarking method, though the BiISB also present visual imperceptibility.

TABLE I. 8bit gray scale bit-planes

Bit-planes	MSB	ISB						LSB
		High-Order			Low-Order			
	8^{th}	7^{th}	6^{th}	5^{th}	4^{th}	3^{rd}	2^{nd}	1^{st}

a. Region of Interest and Region of Non-Interest Determination

Fig 1: cover image

To determine the ROI and RONI for the main mammogram image (cover image), the edge of the mammogram image is detected and then partitioned to 16 blocks of the same size. Cover image is shown in Figure 1.

b. Edge detection

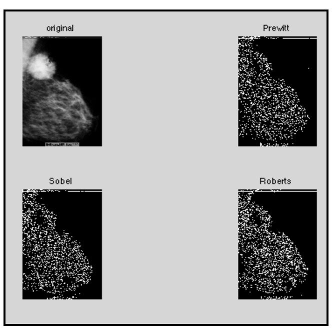


Fig. 2: cover image after applying edge detectors

Several methods for edge detection such as the Canny, Hough transform, Prewitt, Sobel operator and the Roberts edge detection method exist which are applied in the cover image, the results are shown in Figure 2, however, the Sobel edge detection method is considered for this research due to the fact that it is widely used and have been found to be useful for medical image preprocessing [21,28].

The Sobel edge detection method is applied to the spatial image in order to specify ROI and RONI for the mammogram image. A threshold of 0.01 was used so as to detect only important features of the image. Afterwards, the detected image is then partitioned.

c. Partitioning

The edge maps for the mammogram image is divided into 16 blocks. The partition is achieved by dividing the image height by four (4) and diving image width by four (4). In this case, the mammogram is of 256*162 pixels in size, and so they are both divided by four, this is shown in Figure 3.

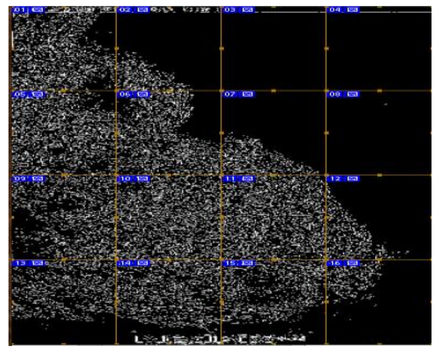


Fig. 3: cover image after Sobel edge detection and partitioning to 16 blocks.

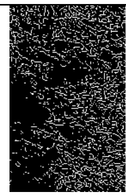
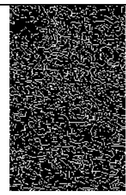
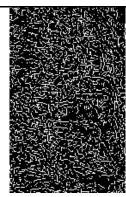
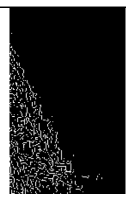
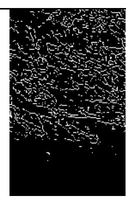
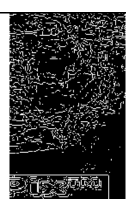
Each of the partitioned block represent image edge features block and each are of 256*162 in size. The new image values are of white represented by 1 and black represented by 0, the values show the presence of a feature and non-feature, respectively. Then, the percentage of the white pixels of each block is calculated. Given in table 2 is the percentage of white pixels in each block.

As can be seen in the Table 2, the RONI for the partitioned mammogram image can be observed. The blocks with small white pixel percentage are easily identified as the RONI since we indicated that percentages of white within two percent can be classified as RONI. The lowest percentages within the stipulated two percent are chosen for watermark embedding and their various block number are then used as the secret key for watermark embedding and extraction.

d. Proposed Embedding Scheme.

The multi-watermarking concept adopted in the proposed technique, is of two copies of watermark image, which are made to contain patient's information such as mammographic image like case number, age, gender, diagnosis that are inserted into the image. The two copies of the watermark image are then embedded into two blocks of images known as RONI.

Table2: blocks of cover image and their white pixel percentage value

Block No	Block Image	White Pixel Percentage	Block No	Block Image	White Pixel Percentage
1		19.12	9		16.11
2		6.04	10		22.69
3		0.57	11		23.03
4		0.39	12		5.56
5		20.74	13		10.63
6		17.50	14		17.84
7		6.22	15		15.05
8		0.01	16		4.20

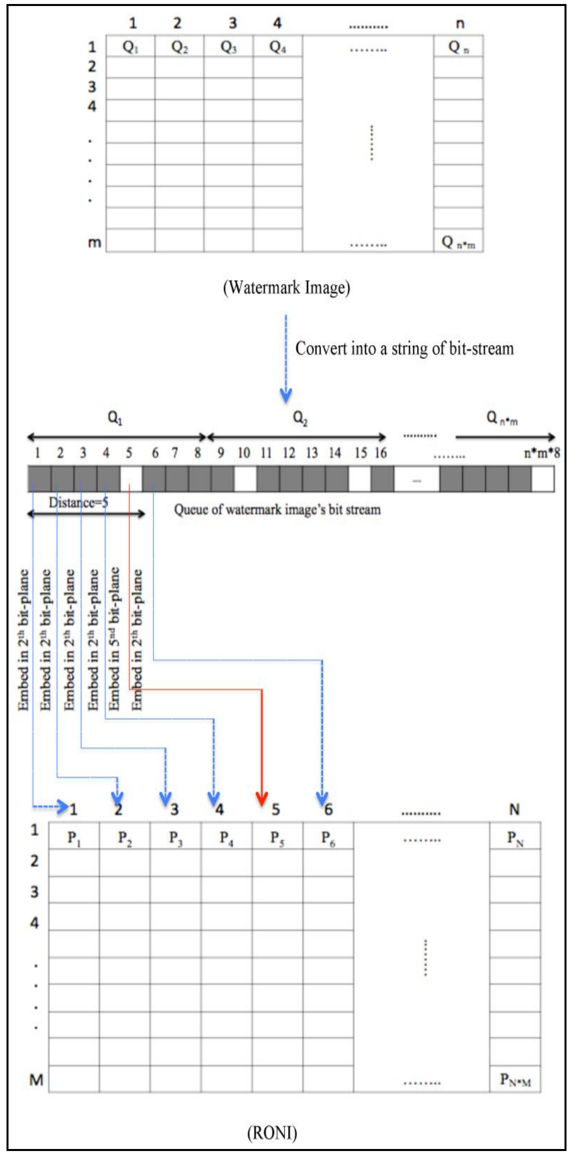


Fig4: Block diagram

e. Bi-level of ISB-bit-plane

The BiISB is applied for inserting watermark into the two different levels of ISB (low order and high order). The Low-order-ISB bit plane is used for preserving visual invisibility, 4 bits of watermark are embedded into the low-order-ISB bit plane (2nd bit-plane) of the image. Subsequently, one bit-plane of the watermark is then inserted into the high-order-ISB bit-plane (5th bit-plane). The process of embedding is continued until all the image bits are embedded into the host image. This process of the BiISB that ensures that the space for low-order-ISB are occupied and the use of one bit of high-order-ISB; individually preserves image quality makes digital image watermarking more robustness, respectively.

A measure of distance is introduced for determining the distance between any of the two locations among two pixels with high-order bit plane in the host image and each bit-plane carries one bit of watermark for the bit-stream. This distance measure is used as the secret key for embedding and extracting watermark.The Length measure denoted as L is used to show the number of bits which are read from watermark bit-stream. For the initial stage, which starts with zero (0), it represents for the number of read image bits. The step iteratively adds one until to the last bit of the watermark bit stream.

In a case where the distance equals 5, the 2nd and 5th bit plane are chosen as low-order bit plane and high-order bit plane, respectively. This embedding process can be seen in Figure 4. From the block diagram in the Figure 4, it can be observed that the first step to watermark is to convert the image into bit-streams. Then define a distance measure for each bit of the watermark bit-stream embedded into one pixel of the RONI. In this scenario, the first four bits of the bit-streams namely; 1st, 2nd, 3rd and 4th are embedded into the 2nd bit-plane of four pixels of RONI, respectively, while the 5th one is embedded into the 5th bit-plane of 5th RONI's pixel. subsequently, the other four bits of bit-stream (that is, the 6th,7th,8th and 9th) are embedded into the 2ndbit-plane of the pixels for the 6th,7th,8th and 9th of RONI and 10th bit of bit-stream embed into the 5th bit-plane of 10thRONI's pixel. The process is continued until the last bit watermark's bit stream are embedded.

f. Proposed Extracting Scheme

The BiISB is also used here for extracting two bits of watermark from two different ISB levels. In the extraction time the bit-planes, which are used for embedding watermark and secret keys must be known. In each step of extraction one bit of watermark is extracted and the extraction algorithm computes mod (L, dis), if it is not equal to "0" then it means that the current pixel value for the host image carries one bit that has been embedded into the low-order-ISB. The bit extracted from low-order-ISB bit-plane of host image is queued and then if the calculation result equals "0", the current pixel value is of one bit. This bit is embedded into the high-order-ISB and is extracted from high-order-ISB bit-plane. The bit is then queued again.

4. Performance Analysis of the Proposed Scheme

Using the Peak signal to noise ratio (PSNR), the imperceptibility of the watermark process can be determined. The PSNR is used to measure image quality. In order to determine the value of the PSNR for the proposed scheme the original image and the watermarked image are used. The PSNR can be defined mathematically as:

$$PSNR = \log 10\,[MAX_I^2/MSE] \times 10 \qquad (1)$$

Where MAX_I refers to the maximum value of pixel in the host image that it is calculated in an 8-bit gray scale image, and is derived as:

$$MAX_I = 2^8-1 \qquad (2)$$

The mean squared error (MSE) can be determined based on the following equation:

$$MSE = [1/(m \times n)] \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [(I_{ij} - K_{ij})^2] \qquad (3)$$

Where I (ij) and K(ij) are the value of the pixel (i,j) of the host image, and the value of the same pixel in the watermarked image, respectively [22].

A Similar measure for calculating the amount of imperceptibility in watermarking system, is the normalized cross correlation (NCC). The NCC is a parameter or evaluating robustness of the purposed algorithm. The NCC is an important for determining the performance factor in any extracting component. The NCC can be expressed as:

$$NCC = \frac{\sum_x \sum_y W(x,y)W'(x,y)}{\sum_x \sum_y [W(x,y)]^2} \qquad (4)$$

Where, W'(x,y) is the extracted watermark and W(x,y) is the watermarked image.

5. Experimental Results and Discussions

Through experimental validation, it can be shown that the proposed spatial domain-based watermarking scheme shows robustness and imperceptibility for watermarked digital medical images. The results of the experiments are presented.

A. The Peak Signal-to-Noise Ratio (PSNR).

The PSNR value for the 50 blocks are derived from the given mammogram image where calculated using Equation (1). Then, the PSNR for the 50 samples were averaged, which results in about 59.2652 db. This value indicates that there is no perceptual dissimilarity between the original and the watermarked images.

B. The Normalized Cross Correlation (NCC)

The NCC determines the differences between the main watermark image and the watermark image that have been passed under some forms of distortions. The distortions used are geometric attack, filtering, additive noise, contrast enhancement and motion effect, distortions. The determined NCC values for the distortions are shown in Table 3.

Table3: NCC values of proposed method in comparison with LSB

Type of Attack	Proposed Method	LSB
Median Filter	0.9731	0.67
Gaussian Noise	0.9051	0.90
Salt and Peppers	0.9912	0.99
Speckle	0.9728	0.97
Poisson	0.8126	0.71
Rotation	0.8949	0.80
JPEG Compression	0.9051	0.57
Motion Blur	0.7628	0.18
Blurred	0.9721	0.97
Contrast Increasing	0.9701	0.56

The Table 3 shows the values derived when observing for the effect of some image distortions on 50 watermarked image samples. It can be observed that the proposed method is more robust as compared to the LSB. The robustness is observed based on the NCC values for median filter, Poisson, JPEG compression, rotation, contrast enhancement and motion blur, which are by far greater than the values of the LSB method.

6. Conclusion

In this paper we proposed a new spatial domain-based watermarking technique. The robustness of the proposed method was determined using the PSNR and the NCC to measure the quality of the watermarked medical mammogram images. The value of the NCC for the proposed method against the LSB showed that distortions by median filter, additive noise, cropping, and motion effect and contrast enhancement do not affect the watermarked images. Moreover, the high value of the PSNR 59.2652 db obtained using the proposed technique showed that the watermarked image is highly imperceptible.

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