PRESERVATION OF REGION OF INTEREST (ROI) OF ULTRASOUND IMAGES USING WAVELET TRANSFORM BASED WATERMARKING IN REGION OF NON-INTEREST (RONI)

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Abstract- In last decade use of advanced electronics and digital equipment's in health care services are increased.In fact in most of the hospitals physicians diagnosis their patients by relying on the provided electronic and digital data(such as Ultrasound,CT,MRI).This results in generation of large number of electronic digital data(i.e. medical images) continuously act various health care centers and hospitals around the world.

This paper focus on the study of ultrasound images watermarking methods for protecting and authenticating medical data. It consist of watermarking technique on Region of Non-Interest(RONI) of the medical image preserving Region Of Interest(ROI).The medical images can be transferred securely by embedding watermark in RONI allowing verification of the legimate changes at reciver end without affecting ROI.Watermarks conveying patients personal and examination data.In purposed system ROI indicated by physician for correct diagnosis purpose.Orignal image is decomposed into 2-level discrete wavelet transform(DWT) along with singular Value Decomposition(SVD) for watermarks.The experimental result shows the satisfactory performance of the system to authenticate the medical images preserving ROI.

Keywords-Ultrasound image, Wavelet transform, Singular Value Decomposition, Watermark, Region Of Interest (ROI), Region Of Non-Interest (RONI).

I.INTRODUCTION

Now a days most physicians rely on Computed Tomography (CT), Magnetic Resonance Imaging (MRI),Ultrasonic and the traditional X-Ray images to diagnose their patient accurately, therefore the exchange of medical images between hospitals has become common in order to share the information for diagnostic, on the other hand, this process needs a considerable amount of memory and bandwidth. One way to overcome this problem is to have the complete medical information of a patient available in one entity rather than over several information systems. This exchange of medical images shows three advantages[1]1:Confidentiality means that only entitled persons have access to the information since some patients do not like to expose their information to the public.2:Reliability which includes: Integrity means the information has not been modified by unauthorized users and Authentication, which is a proof that the information belongs to the correct patient and is issued from the right source.3: Availability which means the access to the information for authorized persons. Different kinds of watermarks meet the parameters of imperceptibility, robustness and capacity to different degrees, these parameters usually conflict with each other. Therefore, an application-dependent trade-off between them is necessary. Medical images are usually comprised of region of interest (ROI) and region of non interest (RONI)[2].The portions of an image which include the significant information for diagnosis are called ROI and therefore should be remained intact during the watermarking (embedding) process. The rest of image is called RONI and hence the watermark may be included in such region. It has been shown that employing digital wavelet transform (DWT) in watermarking of image information shows priority over other data hiding algorithms, especially when DWT is combined with other techniques to improve the robustness [3, 4]. Singular value decomposition (SVD) is one of the most convenient tools of linear algebra with several applications in image compression, watermarking and other areas of signal processing. Most SVD- based watermarking schemes modify the singular values of host image by the singular values of watermark.

This paper presents a watermarking algorithm for medical images in which DWT and SVD are exploited to produce a robust watermarking method. Section2 provides a brief review on Watermarking techniques and SVD concept. In section 3, proposed embedding and extracting algorithms are presented. This is followed by experimental results in section 4 and discussion on results and concluding remarks are presented in the last section.

II Watermarking methods

A:- Domain selection

Watermarking method can be distinctly divided into two basic categories [5]: 1: Spatial domain and 2: Frequency domain. Spatial domain schemes embed watermarks in pixels of an image directly. The least significant bit (LSB) scheme is the most common method to embed watermarks in an image [6]. The main advantage of this approach is its simplicity while it presents a low robustness which is its main disadvantage.2: Frequency domain watermarking, for example, using the DFT (Discrete Fourier Transform), DCT
(Discrete Cosine Transform) and DWT (Discrete Wavelet Transform) which are difficult to detect the watermarks. Discrete Wavelet Transform has excellent spatial localization, frequency spread, and multi resolution characteristics similar to the theoretical models of the human visual system (HVS). The HVS splits an image into several frequency channels, which each channel processes the corresponding signals independently, the dyadic wavelet decomposition performs the similar image resolution by dividing the image into different bands with different frequency. 2-D DWT process the image by 2-D filters in each dimension. The filters divide the input image into four non-overlapping multi resolution sub-bands LL, LH,HL and HH. HH, HL and LH contain the diagonal, horizontal and vertical details of the image, respectively while the LL sub-band contains the coarse details of the image. To obtain the next coarser scale of wavelet coefficients, the LL sub-band is further decomposed until L-level wavelet coefficients are produced. Fig. 1 illuminates 2-level decomposition.

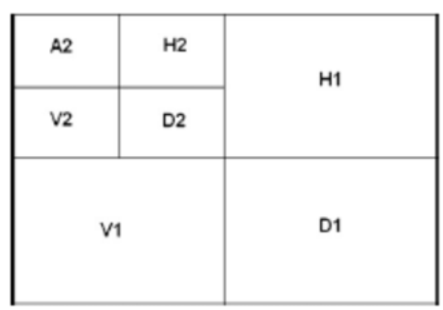


Fig. 1.2- level DWT composition

The approximation sub-band is not selected because manipulation of the low frequency sub-band will impose sever degradations on the reconstructed image as the most of the energy is concentrated in this subband. The sub-bands which have higher energy are more robust against common attacks. Therefore, in the second level of wavelet transform, the 2 sub-bands with higher energy are selected as the place to embed the watermark bits. These sub-bands are divided to non-overlapping blocks of

8*8 pixels and then the SVD transform is used to these blocks.

B:- Embeding of watermark in Region Of Non-Interest (RONI)

Singular value decomposition (SVD) is one of the most useful tools of linear algebra with several applications in image compression, watermarking and other areas of signal processing[7]. SVD packs maximum signal energy into a few coefficients as possible. Every real matrix A can be decomposed into a product of 3 matrices.

$$A = U\Sigma V^T \quad (1)$$

where U and V are orthogonal matrices.

It is important to note that the singular value decomposition of digital images presents the following properties [8]

1) The singular value of image is stable which means that it does not change much after applying common attacks and so watermarked image quality is not reduced and its changes are not noticeable with human eyes.

2) Each singular value specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image layer. An important property of SVD – base watermarking is that the largest of the modified singular values against signal processing attacks change very little.

3) This Singular value decomposition method is used to embed the watermark in Region of non-interest of the image.

Our approach focuses on embedding watermark in RONI region of medical image by preserving ROI. This approach helps in isolating ROI region i.e.not to distort the critical area of medical image, which will be referred by physician for the diagnosis. The system diagram for this approach is shown in Figure 2:- The system process carried away in three stages:

1. Watermark embedding process
2. Watermark extraction process
3. Watermark authentication process

In first phase of system separating the ROI from the original medical image provides RONI region for embedding watermark. This step isolates ROI from embedding process. In this phase multiple watermarks are embedded into the RONI area of medical image. Embedding multiple watermarks ensure high security of medical image as it carries high payload and it will be more complex to break the system. Here fragile watermarking system is used to get the benifit of identifying whether a medical image is tampered or not? After the completion of embedding process the separated ROI is combined with the produced watermarked medical image. The resultant watermarked medical image is then sent to the receiver.

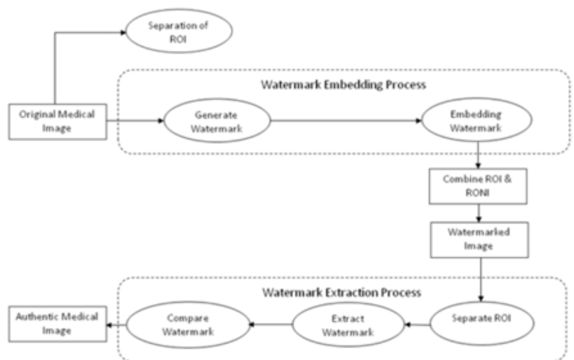


Figure:-2 Medical Image Watermarking Approach Preserving ROI

In watermark extraction phase, first step is separating the ROI from the watermarked medical image. The remaining watermark extraction process is exact reverse of embedding process, where the embedded watermark will be extracted from the watermarked medical image. The watermark authentication is achieved by comparing the extracted watermark with the original watermark. This process helps in identifying if any tampering manipulation to the watermarked medical image over the public network.

III Method

In recent days the wavelet analysis got a good recognition in research and development area due to its characteristic of providing time and frequency information simultaneously. As per research the retina of the eye splits an image in to several frequency channels i.e. approximately one octave. In multi resolution decomposition the image is divided into bands of equal

bandwidth on a logarithmic scale. There is lot of similarity between the signal processing of the human visual system
(HVS) and scaling decomposition of the wavelet transform which can be achieved by watermark embedding to the masking property or quantization method [9].

A:-Description

The watermarks used in this approach:
1. Doctor's identication code
2. Indexed watermark
3. Patient's reference identication code
4. Patient's diagnosis information
5. Patient's treatment information

The listed watermarks used in this proposed watermarking scheme helps in addressing different issues and concerns in healthcare management system, Such as confidentiality of medical data, recovering original image without any distortion, data integrity, authentication and efficient data management. Confidentiality of medical data is achieved by embedding watermark using Integer to Integer Discrete Wavelet Transform (IDWT), which confirms the imperceptibility property. This property ensures the embedded watermark will be invisible to the normal human eye and the watermark can be extracted by the one who knows the embedding and extraction algorithm applied in this system. By applying Inverse IDWT at the receiver end original image can be recovered without any distortion. Also the distortion to the ROI has already been avoided by separating the ROI before embedding the watermark in to the medical image. Medical data integrity is achieved by using fragile watermarking system, so any manipulation on medical image data leads in distortion of embedded watermark. For the authentication purpose the included watermarks such as doctor's identification code, patient's identification code will ensures the entitled users can access or modify the medical data. To provide efficient data management in this system the indexed watermark is embedded which helps in retrieving the image for the future reference if needed using database query. The watermarks are inserted in different decomposition levels and sub-bands depending on their type. They can be independently embedded and retrieved without any intervention among them. By integrating this idea into different medical acquisition systems like Ultrasound, CT and MRI etc. This system can be applied in different applications such as e-diagnosis or medical image sharing through picture archiving and communication.

IV Algorithm

In this algorithm the multiple watermarks embedding technique is used. Where depending on the quantization of selected coefficients the multiple watermarks embedding procedure is used. This prevents any modification to the watermark bits by granting integer changes in spatial domain of medical image. This can be achieved by applying 2-levl haar wavelet transform to decompose the host medical image. Moreover it gives the output as coefficients, which are in the form of dyadic rational numbers. These coefficients denominators are in powers of 2. The multiple of 2^l (l is decomposition level) number adding or subtracting
to the produced coefficient value, assures that the inverse DWT provide integer pixel values. Wavelet transform generally provides the coefficients which are real numbers. By applying the quantization function it assigns the binary number to every coefficient. This quantization function is defined as

$$Q(f) = 0, \quad if \left\lfloor \left(\frac{f-s}{\Delta} \right) \right\rfloor is\ even$$

$$Q(f) = 1, \quad if \left\lfloor \left(\frac{f-s}{\Delta} \right) \right\rfloor is\ odd$$

(2)

Where s is a user defined offset for increased security, f is frequency coefficient produced by haar wavelet transform and , the quantization parameter, is a positive real number. Moreover Δ is defined as $\Delta=2^l$. The quantization procedure is shown in Figure 3:-

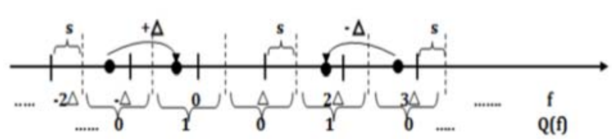


Figure 3:- Quantization Procedure

As explain earlier, addition or subtraction of a multiple of 2^l value to the haar wavelet coefficient results in integer pixel values, after applying inverse DWT. During the embedding process the algorithm add or subtract an appropriate constant to the haar coefficient chosen for watermark casting.

A) The algorithm for embedding multiple watermarks is explained below:

Step 1: Indicate the ROI region from the host medical data by physican for proper diagnosis purpose. Which results in image of RONI region.
Step 2: Save the removed ROI from medical image.
Step 3: The multiple watermarks to be embed into a original image is generated by reading the patient's information file from text document.
Step 4: Apply the 2-level Haar wavelet transform to original medical image to obtained a gross image approximation at the lowest resolution level and a sequence of detail images corresponding to the horizontal, vertical, and diagonal details at each of the two decomposition levels.
Step 5: On each decomposition level the watermark bitwise is embedded into the key determined coefficient f, which is obtained by applying wavelet transform according to the following condition:
1. If $Q(f) = w_i$, the coefficient is not modified
2. Otherwise,the coefficient is modified so that $Q(f) = w_i$, using the following equation:

$$f = f + \Delta; \text{ if } f \leq 0 \quad (3)$$
$$f = f - \Delta; \text{ if } f \geq 0 \quad (4)$$

Step 6: The pre watermarked image is produced by performing the corresponding two level inverse wavelet transform.

Step 7: The resultant watermarked image is obtained.

B)The watermark extraction process

It is similar to that of embedding one except that at the receiving end extractor should have the knowledge of location of the embedded watermark. This can achieve by the key based embedding and detection. With this type of method access to the watermark by unauthorized users is prevented. The algorithm for extraction process to recover the host medical image is explained below.

Step1: The resultant watermarked image is taken.

Step2:Apply the 2level haar wavelet transform to the image which is created from step 1, which results in a image approximation at level two and sequence of images corresponding to the horizontal, vertical, and diagonal details at each of the two decomposition levels.

Step3:Identify the location of watermark by key based detection.

Step4:Extract the watermarks by applying quantization function defined in equation (2) which recovers the original coefficient. Convert the extracted binary watermark to text watermark.

Step5:The pre output image is obtained by applying inverse 2-level haar wavelet transform.

Step 6: Finally get the original host ultrasound image.

V RESULTS

For testing purpose 50 ultrasound images of size 256x256 pixels; all images were collected by the same physican using the same equipment and ultrasound system settings,in order to avoid deviation in image statistics.

A) Quantitative measures:-

1) Peak signal-to-noise ratio (PSNR):-

The quantitative assessment of the quality of the watermarked images was conducted using both the peak signal-to-noise ratio (PSNR) and the weighted PSNR metrics. The PSNR is not well correlated with perceptual quality, however, it provides an efficient measure of image distortion in terms of numerical values, which convey important information in medical applications, e.g., in the case of diagnosis support systems.

The PSNR is measured in decibels and is defined as follows:-

$$\mathrm{PSNR}(I,\hat{I}) = 10\log_{10}\left[\frac{\left(\max_{\forall(m,n)} I(m,n)\right)^2}{\frac{1}{N_I}\sum_{\forall(m,n)}(\hat{I}(m,n)-I(m,n))^2}\right] \quad (5)$$

where *I* and *I* are the original and watermarked images, respectively, *N*I is the number of pixels in the image, and max ∀ (*m, n*) *I*(*m, n*) is the maximum gray value of the original image. The denominator of the PSNR is the average sample mean squared error.

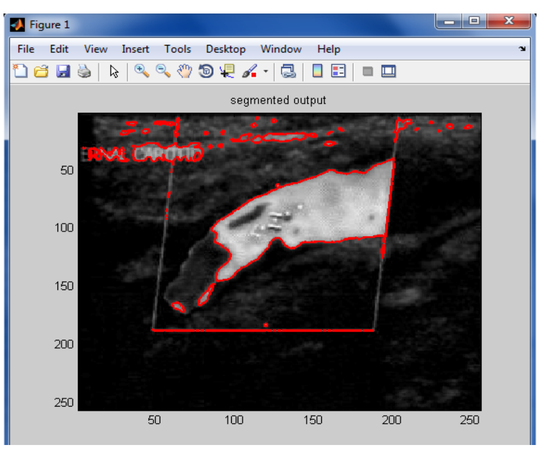


Figure 4:- Segmented output

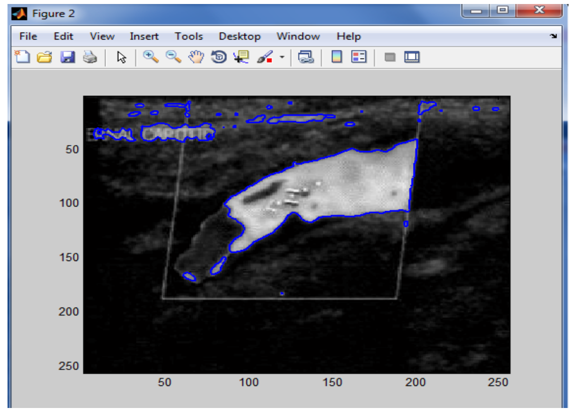


Figure 5:- Segmented output(500 Iteration)

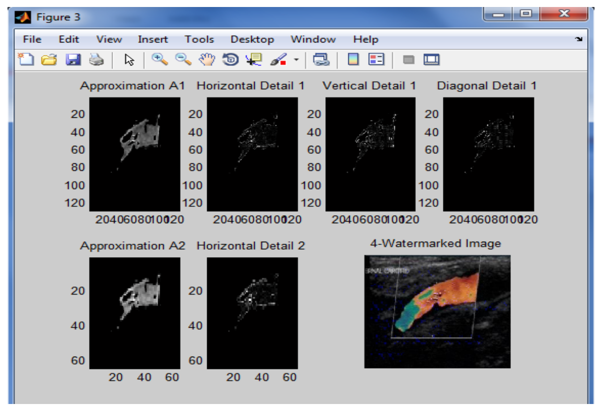


Figure 6:- Tree Structure of 2-level DWT.

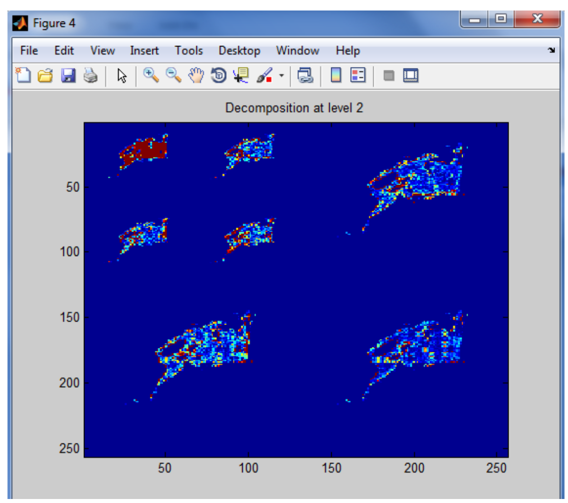


Figure 7:- Two-level Haar DWT Of an ultrasound image.

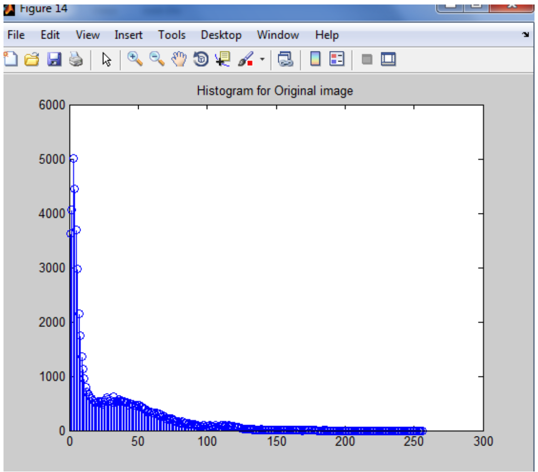


Figure 8:- Histrogram For Original image

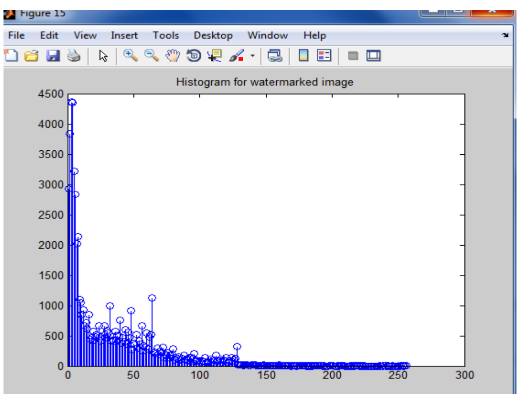


Figure 9:- Histrogram Of Watermarked image

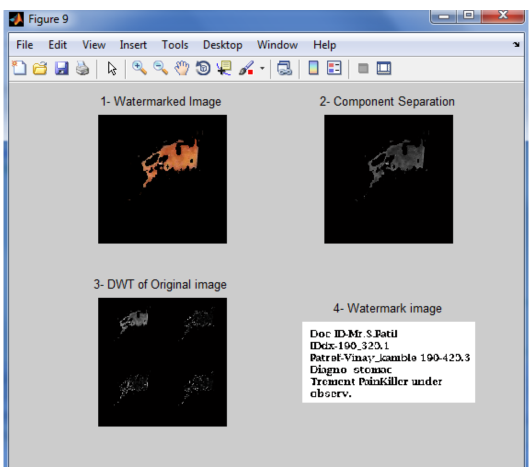


Figure 10:- Retrived Watermark image

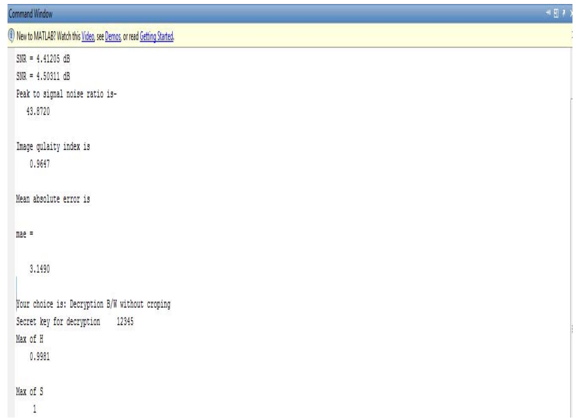
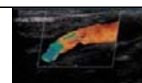
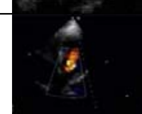
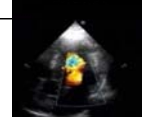


Figure 11:- Output Results

Table I

The corresponding results of PSNR and Image Quality Index for Ultrasound images.

Sr No.	Ultrasound Images	PSNR(dB)	Image Quality Index
1		43.8720	0.9647
2		43.5463	0.9554
3		45.9946	0.9424
4		44.1299	0.9618
5		44.9521	0.9248
6		46.6103	0.9514
7		46.7202	0.9557
8		46.3375	0.9171
9		46.2318	0.9625
10		46.3672	0.9513

VI. Conclusion

There exist various medical image watermarking algorithms which provide the confidentiality of medical data, recovering original image without any distortion, data integrity, authentication and efficient data management. Also the different segmentation algorithms are in place, which vary for the types of medical images such as MRI, CT scan, X-ray and Ultrasounds etc.

Here the proposed system used an algorithm to embed watermark image in Region of Non-interest (RONI) without affecting Region Of Interest (ROI).The ROI region which is considered as a critical data and used as a reference by the physician for the treatment will be safe. Singular value decomposition has become one of the most popular watermarking algorithms. In this Paper we uses the combination of digital wavelet transform and SVD has been presented. Experiments proved that the algorithm can embed the watermarks into images and the detector can retrieve the original image.

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