MEDICAL IMAGES AUTHENTICATION THROUGH WATERMARKING PRESERVING ROI

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ABSTRACT.

Telemedicine is a well-known application where enormous amount of medical data need to be securely transferred over the public network and manipulate effectively. Medical image watermarking is an appropriate method used for enhancing security and authentication of medical data, which is crucial and used for further diagnosis and reference. This project focuses on the study of medical image watermarking methods for protecting and authenticating medical data. Additionally, it covers algorithm for application of water marking 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 watermarks in RONI allowing verification of the legitimate changes at the receiving end without affecting ROI. Segmentation plays an important role in medical image processing for separating the ROI from medical image. The proposed system separate the ROI from medical image by GUI based approach, which works for all types of medical images. The experimental results show the satisfactory performance of the system to authenticate the medical images preserving ROI.

KEYWORDS

ROI & RONI, Segmentation, Authentication, security, medical confidentiality

1. INTRODUCTION

Speedy development of internet in every field leads to availability of digital data to the public. Internet has been spread in many applications like telemedicine, online-banking, teleshopping etc. One of this application telemedicine is crucial one, where Internet is used to transfer or receive medical data by healthcare professional. Due to advancement in information and communication technologies, a new context of easier access, manipulation, and distribution of this digital data have been established [1]. The medical images can be readily shared via computer networks and easily used, processed, and transmitted by using great spread network [2, 3].

In the last decades, uses of advanced electronic and digital equipments in health care services are increased. In fact, in most of the hospitals physicians diagnose their patients by relying on the provided electronic and digital data (such as Ultrasonic, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and X-ray images). This results in generation of large number of electro digital data (i.e. medical images) continuously at various health care centers and hospitals around the world.

In number of medical applications, special safety and confidentiality is required for medical images, because critical judgment is done on medical images, which leads to the proper treatment. Therefore, it must not be changed in an illegitimate way; otherwise, an undesirable outcome may results due to loss of decisive information. Therefore, there is a need to provide a strict security in medical images to ensure only occurrence of legitimate changes. Now-a-days exchange of medical images between hospitals located in different geographical location is very common. Moreover, as this exchange of "medical reference data" done via unsecured open networks leads to the condition of changes to occur in medical images and creates a threat which results in undesirable outcome. Considering this fact, demand of security is getting higher due to easy reproduction of digitally created medical images.

For copyright protection and authentication of these medical images, digital watermarking is an emerging technique, which includes the embedding and extraction process. In embedding process some secret information is embedded into medical images. Extraction process deals with the extraction of secret message, which is embedded in the medical image. If failure occurs in extraction process the physician would come to know that there has been some kind of tampering with that image, and he would take precaution of not making diagnosis based on that image. However, if the extraction process extracts the correct watermark, which generally consumes a few seconds, physician can continue with diagnosis.

Medical images hold decisive property and are very crucial and important part of medical information. Such part of the medical image is called as Region of Interest (ROI). The ROI is helpful in providing further diagnosis by the physician. A small bit of distortion in ROI may lead to undesirable treatment for patient. For securing medical images through watermarking ROI should be preserved and the watermarks can be applied on the remaining part of the image called as Region of Non Interest (RONI). Therefore, application of watermarking in medical images can be considered as two-step process which includes:

1. Extracting ROI form the medical images
2. Applying watermarking on RONI

Different algorithms are available for segmentation of ROI on the different types of medical images. Additionally, there are different algorithms available for applying watermarking.

2. REGION OF INTEREST (ROI) SEGMENTATION

Segmentation plays an important role in medical image processing [4, 5]. In medical image analysis segmentation is the first step to be followed, to avoid distortion of ROI [4, 6]. Image segmentation deals with the process of partitioning an image into different regions by grouping together neighborhood pixels based on some predefined similarity criterion [7]. This similarity criterion can be defined by specific properties of pixels in the image. Segmentation in medical imaging is used for extracting the features, image display and for the measurement of image. The goal of segmentation is to divide entire medical image into sub regions i.e. (white and gray matter). In addition, this helps in classifying image pixels into anatomical regions (such as bones, muscles and blood vessels).

Defining the borders of ROI in medical image can simplify the procedure of segmentation. In addition, the step of defining borders of ROI is a crucial one, which helps in determining the result of the application as entire analysis fully relies on the output from segmentation step. There are different approaches (for segmenting the image) defined for the different imaging technologies such as CT, MRI, US, colonoscopy etc. Segmentation is semi-automatic procedure and we need to define a seed point in an image. Therefore, the algorithm, which gives perfect result for one application, might not even work for another. Figure 1 shows the ROI part of medical image, where physician performs the diagnosis.

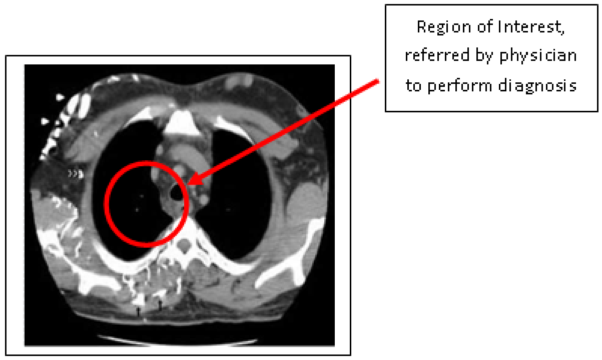

Figure 1: Medical image indicating ROI

We have various existing medical imaging like Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound (US), and Positron Emission Tomography (PET) etc. Here, the most common imaging i.e. CT scan imaging is discussed in detail with their proposed algorithms.

2.1. Computed Tomography (CT)

Computed Tomography (CT) scanning sometimes called Computed Axial Tomography (CAT) scanning [7], is a noninvasive medical test that helps physicians diagnose and treat medical conditions. CT scanning combines special x-ray equipment with sophisticated computers to produce multiple images or pictures of the inside of the body. These cross-sectional images of the area being studied can then be examined on a computer monitor, printed or transferred to a CD. CT scans of internal organs, bones, soft tissue and blood vessels provide greater clarity and reveal more details than regular x-ray exams. Using specialized equipment and expertise to create and interpret CT scans of the body, radiologists can more easily diagnose problems such as cancers, cardiovascular disease, infectious disease, appendicitis, trauma, and musculoskeletal disorders. Hence, the CT scan application is been widely used in medical domain. There are different segmentation methods proposed considering CT scan of different body organs (such as lung, liver, kidney, etc.) This section covers the different segmentation algorithm for CT scan images for protecting the distortion of diagnosis value.

The 2-D and 3-D segmentation of organs in medical application of image processing are classified into model based and non-model based approaches. Non-model based approaches depends on local information such as, texture, intensity, spatial correlation of 2-D organ image in consecutive slices, and the location of the organ in the abdominal area with respect to neighboring structures, e.g., spine and ribs [8]. Various segmentation algorithms are developed using non-model based approach. This section first covers the different segmentation algorithm, which uses non-model based approach. Susomboon et al. [9] presented texture features to perform region classification for extracting liver’s soft tissue. Seo et al. [10] employed a multimodal threshold method based on piecewise linear interpolation that used spine location as a reference point. Forouzan et al. [11] introduced a multilayer threshold technique, in which by statistical analysis of the liver intensity it calculates the threshold value. Both these methods use the local information of the liver’s relative position to the spine and ribs. Non-model based methods for organ segmentation leads to inaccuracies due to variation in imaging condition, because of occurrence of tumor inside the organ and noise. Dependencies on prior information such as texture and image values could cause inaccuracies in segmentation process as feature could change from one patient to another. Moreover, most of these methods are parameter dependent and hence for the best performance it often needs to adjust the parameters from one CT volume to other. In recent years, model-based image segmentation algorithms developed for various medical applications. These methods aim to recover an organ based on statistical information. State-of-the-art algorithms on model-based segmentation are based on active shape and appearance models [8, 12]. Model-based techniques provide more accurate and robust algorithm for segmenting the CT scan image. These techniques also deal with the missing image features via interpolation. The performance of these methods depends on the number and type of training data. Moreover, if the shape to be segmented lies too far from the model space, that might not be detected by many those better methods which is not implemented by statistical model-based approach.

Pan and Dawant [13] reported a geometrical-level set method for automatic segmentation of the liver in abdominal CT scans without relying on the prior knowledge of shape and size. Even if this method depends on a model-based technique, that outperforms threshold-based techniques, but it did not use prior knowledge of the liver shape. Lin et al. [14] presented the algorithm to perform segmentation of kidney, based on an adaptive region growing and an elliptical kidney region positioning that used spines as landmark. H. Badakhshannoory and P. Saeedi [15] incorporated a method for liver segmentation. Based on liver boundary edges to identify liver regions, nonrigid registration and a multilayer segmentation technique are combined in this approach. This method does not affected by the diversity of existing liver shapes, as it does not rely on any shape model. Samuel et al. [16] has proposed the use of Ball-Algorithm for the segmentation of lungs. In this algorithm at the first stage, it applies the grey level thresholding to the CT images to segment the thorax from background and then the lungs from the thorax. Then in the next step to avoid loss of juxtapleural nodules, this method performs the rolling ball algorithm. Julian Ker [17] has presented the method of doing segmentation of lungs, which is named as TRACE method. Due to the possible presence of various disease processes, and the change of the anatomy with vertical position results in variation of size, shape, texture of lungs CT image of different patients. Therefore, the boundary between lung and surrounding tissues can vary from a smooth-edged, sharp-intensity transition to irregularly jagged edges with a less distinct intensity transition. The TRACE algorithm implemented with new perception of a non-approximating technique for edge detection. Shiying et al. [18] have introduced a fully automatic method for identifying lungs in 3D pulmonary X-Ray CT images. The method follows three main steps:

- Lung region is extracted from CT-Scan image by applying graylevel thresholding,
- By using a dynamic programming it identifies the anterior and posterior junction, to separate left and right lungs and
- To smooth the irregularities of boundary along the mediastinum nodule, it implements sequence of morphological operations

Ayman El-Baz et al. [19] have employed a fully automatic Computer-Assisted Diagnosis (CAD) system for lung cancer screening using chest spiral CT scans. This paper presents a system for detection of abnormalities, identification or classification of these abnormalities with respect to specific diagnosis, and provides the visualization of the results over computer networks. The process of detection of abnormalities, identification of these abnormalities can achieve by image analysis system for 3-D reconstruction of the lungs. Riccardo Boscolo et al. [20] proposed method that uses the novel segmentation technique that combines a knowledge based segmentation system with a sophisticated active contour model. This method performs robust segmentation of various anatomic structures. In this approach the user, need to provide initial contour placement, and the required parameter optimization automatically determined by the high-level process. Binsheng et al. [21] reported the algorithm, which used the method of selecting the threshold value by analyzing the histogram. This algorithm initially separates the lung parenchyma from the other anatomical structures from the CT images by using threshold value. By this algorithm structure in CT scan image with higher densities having some higher density nodules, can grouped into soft tissues and bones, leading to an incomplete extraction of lung mask. For having complete hollow free lung mask, morphological closing is applied in this approach. Hossein B. et al. [8] has introduced the model-based segmentation algorithm. In this approach instead of using model information to direct the segmentation algorithm for segmenting an organ of CT scan images, it uses this information to choose a segment with highest fidelity to the organ.

After completing with the segmentation of ROI, needs to proceed with medical image watermarking technique to provide security, authentication and privacy of this medical data. The next section of this paper provides the survey of different available medical image watermarking approaches.

3. MEDICAL IMAGE WATERMARKING

There has been fair amount of work done in the area of medical image processing. Before proceeding with survey of medical image processing, this section covers the foundation of digital watermarking, types of domain and performance measurement. The typical block diagram for medical image watermarking is given in figure 2.

Encoder E embeds the watermark W in medical image to provide security and authentication. Decoder D extracts the watermark from watermarked image. By comparing the extracted watermark with original watermark, one can affirm the tampering of medical image. According to watermark embedding process, watermarking techniques are classified into two different domains.

- Spatial domain: The spatial-domain watermark insertion manipulates image pixels. However, the spatial-domain watermark insertion is simple and easy to implement, it is weak against various attacks and noise.
- Transform domain: The transform-domain watermark insertion is based on the transform coefficients of cover image. It is more robust against attacks. Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), and Discrete Fourier Transform (DFT) are three popular methods in transform domain.

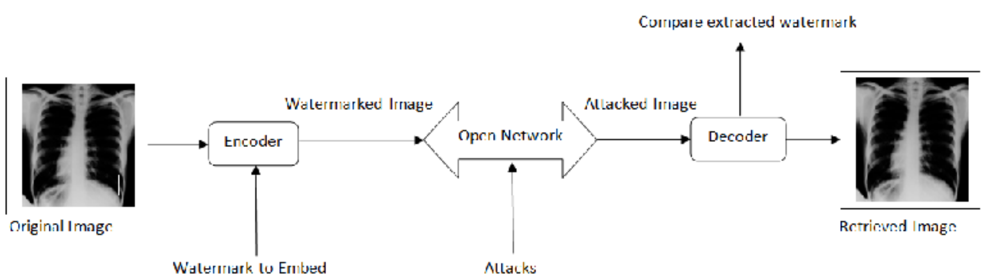

Figure 2: Block Diagram of Medical Image Watermarking

To ensure the reliability and quality of the watermarked image, the performance of watermarking is calculated, which measured in terms of perceptibility. There are two method of calculating the performance measure.

- Mean Square Error (MSE): It is simplest function to measure the perceptual distance between watermarked and original image. MSE can be defined as:

$$MSE = \frac{1}{n}\sum_{i}^{n}(I' - I)^2$$

Where, I is original image and I' is watermarked image.

- Peak Signal to Noise Ratio (PSNR): It is used to measure the similarity between images before and after watermarking.

$$PSNR = 10\log_{10}\frac{\max I^2}{MSE}$$

Where, max I is the peak value of original image.

Numbers of medical image watermarking schemes are reported in this literature survey, to address the issues of medical information security, and authentication.

Wakatani [22] presented a medical image watermarking, in order not to compromise with the diagnosis value, it avoids embedding watermark in the ROI. In this algorithm watermark to be embed is firstly compressed by progressive coding algorithm such as Embedded Zero Tree Wavelet (EZW). Embedding process is done by applying Discrete Wavelet Transform (DWT), for transforming the original image using Haar basis. Extraction of watermark is reverse of embedding process. The major drawback of this algorithm is ease of introducing copy attack on the non-watermarked area.

Yusuk Lim et al. [23] reported a web-based image authentication system, for CT scan images. This technique is mainly based on the principal of verifying the integrity and authenticity of medical images. In this approach, the watermark is preprocessed by using seven most significant bit-planes except least significant bit (LSB) plane of cover medical image, as an input to the hash function. This hash function generates binary value of 0 or 1 using secrete key, which is then embedded in LSB bit of cover image to get watermarked image.

Rodriquez et al. [24] proposed a method in which it searches a suitable pixel to embed information using the spiral scan that, starts from the centroid of cover image. Then by obtaining the block with its center at the position of selected pixel, it checks the value of bit to embed. If bit value is 1, then the embedding information is obtained by changing the luminance value of the central pixel by adding the gray-scale level mean of the block with luminance of the block. In addition, if bit value is 0, then luminance value of the central pixel is changed by subtracting the luminance value of block from the gray-scale level mean of the block. While in extraction process, the position of marked pixel is obtained by spiral scan starting from centroid of the cover image. By checking the luminance value of the central pixel with the gray-scale level mean of the block, embedded bit is identified.

Giakoumaki et al. [1] presented a multiple watermarking method using wavelet-based scheme. The method provides solution to the number of medical data management and distribution issues, such as data confidentiality, archiving and retrieval, and record integrity. In this approach up to 4 level DWT is performed on medical image. The algorithm embeds multiple watermarks in different level. A robust watermark containing doctor's identification code is embedded in 4th level as here capacity is not the matter, only required is the robustness. In third level decomposition, the index watermark (e.g ICD-10 or ACR diagnostic codes) is embedded. The method embeds caption watermark holding patients personal information in second decomposition level. Moreover, a fragile watermark is embedded in forth-level decomposition. Extraction process is reverse of embedding process. Experimentation is done on ultrasounds medical images.

Hemin Golpira et al. [25] reported reversible blind watermarking. In this approach during embedding process, firstly by applying Integer Wavelet Transform (IDWT) image is decomposed into four subbands. By selecting two points, called thresholds, according to the capacity required for the watermark data, watermark is embedded. To get watermarked image Inverse Integer Wavelet Transform (IIDWT) is applied. In the extraction process, all of these stages are performed in reverse order to extract watermark as well as host image.

Nisar Ahmed Memonet et al. [26] presented fragile and robust watermarking technique for medical images. The method embeds two different watermarks, the robust watermark and fragile watermark in the medical images. The embedding process starts with separation of ROI and RONI from medical images. The robust watermark containing the electronic patient record (EPR), Doctor's identification code (DIC) and 1st bit-plane of ROI by extracting the LSBs is encrypted by using pseudo random sequence generated by user defined key. Then this resultant watermark is embedded in high frequency coefficient of IWT in RONI part of medical data. The proposed method generates fragile watermark by creating the binary image in tiled fashion and then this fragile watermark is cropped off by the same size as the ROI. The algorithm embeds this fragile watermark into spatial domain of ROI part of medical image. The extraction process is reverse of embedding process.

4. PROPOSED SYSTEM

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 3.

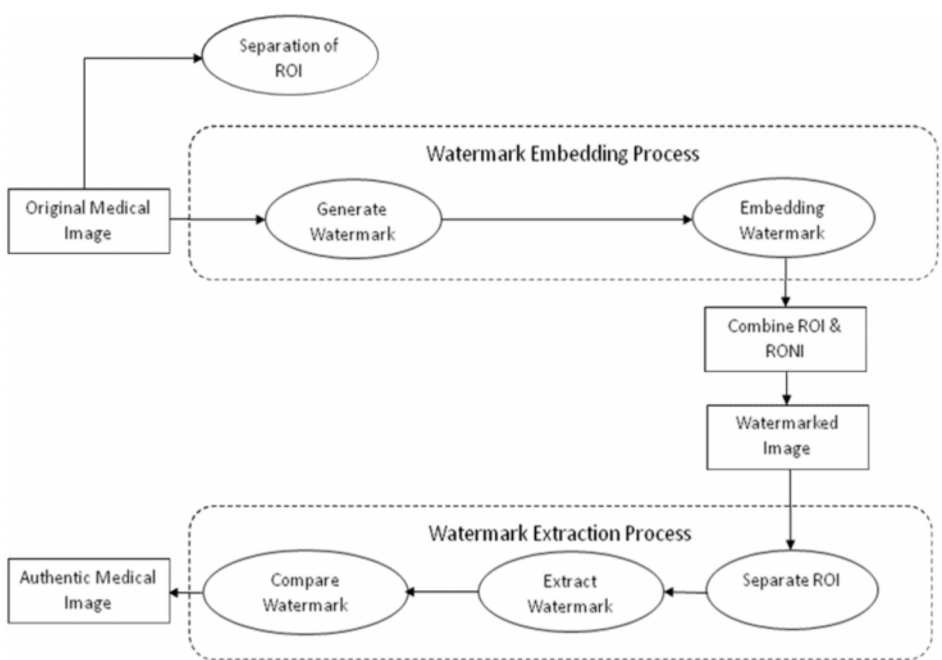

Figure 3: Medical Image Watermarking Approach Preserving ROI

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 benefit 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.

In watermark extraction phase, first step is to separate the ROI from the watermarked medical image. The remained 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 or manipulation to the watermarked medical image over the public network.

4.1 Separating ROI from medical image

As discussed earlier for separating ROI “Segmentation method” is used. However segmentation is semi-automatic procedure and it needs to define a seed point in an image. Therefore, the algorithm, which gives perfect result for one type of application, may not even work for another.

In proposed system for separating ROI the Graphical User Interface (GUI) is implemented, so that it will work for all kinds for medical image (such as CT scan, MRI, X-Ray, Ultrasound, etc.). In this method user has an option to select the part of medical image (square in size) which has critical information and used for the reference of physician. This GUI based system returns the Xmin, Xmax, Ymin, Ymax pixel values of selected ROI region and image of selected ROI. This resulted ROI image can be saved, so that it can be combined with the resultant watermarked image.

Steps in ROI separation approach

1) Mouse click function: For selecting the ROI, mouse clicking function is used.
2) Done button: To get the output after selection process, done button is implemented.
3) Storing handles: For safe storing the pixels values of selected ROI (Xmin,Xmax, Ymin and Ymax) and image of selected ROI, the storing handles are used.
4) Start button: It is implemented to clear the stored handles to start again the process of selecting ROI.
5) Zooming option: It is provided for zooming the image, so that the image will be clear to select the ROI.

4.2 Medical Image Watermarking System

For the implementation of Medical Image Watermarking, we referred the algorithm proposed by Giakoumaki et al. [1]. The algorithm provides solution to the number of medical data management and distribution issues, such as data confidentiality, archiving and retrieval, and record integrity. The medical watermarking system embeds the multiple watermarks. The watermarks used to embed are text watermark. In this approach medical image is decompose with 4-level lifting based DWT transform.

The lifting based DWT is a better method to obtain the wavelet transform. For the development of second generation wavelet the lifting based DWT approach is proposed. Advantage of second generation wavelet over first generation wavelet is that, it does not use the translation and dilation of the same wavelet prototype in different levels. Using the Euclidean algorithm any classical wavelet filter bank can be decomposed into lifting steps. The lifting based DWT consists of three stages i.e. split, predict and update.

In split stage the input signal x[n] get divided into two subsets i.e. even set s[n] and odd set o[n]. This process is known as lazy wavelet transform. The predict step use the linear combination of elements in one subset to guess the values of the other subset with assumption that the subsets produced in the split stage are correlated with each other. The predicted values would be close to the original values if the correlation between both the subset is high. Generally the linear combination of the even subset elements are used to predict odd subset values. Although there are chances of loss of properties of signal such as mean value in the predict step. The predict step causes the loss of some basic properties of the signal like mean value, which needs to be preserved. The update step lifts the even sequence values using the linear combination of the predicted odd sequence values so that the basic properties of the original sequence is preserved [5].

4.2.1 Integer to Integer Transform:

It was observed that usually when wavelet transforms is performed on integer sequence it gives floating point coefficients. As per Calderbank [6] wavelet transform which will map integers to integers can be build with the help of lifting structure. This can be achieved by rounding off or updating the filter in each lifting step before its addition or subtraction. The invert of the lifting steps can be produced by following the exact reverse operation and flipping the signs.

4.2.2 Proposed Method:

The watermarks used in this approach:

1) Doctors identification code
2) Indexed watermark
3) Patients reference identification code
4) Patients diagnosis information
5) Patients 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 Discrete Wavelet Transform (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 into 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.

4.2.3 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 4-level 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

$$Q(f) = \begin{cases} 0, & \text{if } \left\lfloor \left(\frac{f-s}{\Delta} \right) \right\rfloor \text{ is even} \\ 1, & \text{if } \left\lfloor \left(\frac{f-s}{\Delta} \right) \right\rfloor \text{ is odd} \end{cases}$$

Where s is a user-defined offset for increased security, f is frequency coefficient produced by haar wavelet transform and Δ, the quantization parameter, is a positive real number. Moreover Δ is defined as Δ =2^l.

The algorithm for embedding multiple watermarks is explained below:

Step 1: Separate the ROI region from the host medical data using GUI based mouse clicking approach. Which results in image of RONI region, name it as original medical image.

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, and converting it into binary.

Step 4: Apply the 4-level Haar-lifting wavelet transform to original medical image, to obtain 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 four decomposition levels.

Step 5: On each decomposition level the watermark bit w_i is embedded into the key determined coefficient f, which is obtained by applying wavelet transform according to the following condition:

a) If $Q(f) = w_i$, the coefficient is not modified.

b) Otherwise, the coefficient is modified so that $Q(f) = w_i$, using the following equation:

   $f = f + \Delta$, if $f \le 0$

   $f = f - \Delta$, if $f > 0$

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

Step 7: The resultant watermarked image is obtained by combining the saved ROI with the pre watermarked image.

The watermark extraction process 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.

Step 1: Remove the ROI region from the received watermarked image with the help of Xmax, Xmin, Ymin and Ymax parameter provided with watermarked image.

Step 2: Apply the 4-level lifting-haar wavelet transform to the image which is created from step 1, which results in a image approximation at level four and sequence of images corresponding to the horizontal, vertical, and diagonal details at each of the four decomposition levels.

Step 3: Identify the location of watermark by key-based detection.

Step 4: Extract the watermarks by applying quantization function defined in equation 5.3, which recovers the original coefficient. Convert the extracted binary watermark to text watermark.

Step 5: The pre output image is obtained by applying inverse 4-level haar wavelet transform.

Step 6: combine the separated ROI region to the pre output image to get the original host medical image.

5. EXPERIMENTS AND RESULTS

The proposed system has been applied against different type of medical image such as, CT scan, MRI, X-Ray and Ultrasound. We have tested the system over different size of medical images like 320 X 256, 384 X 384, and 512 X 512.

The applied watermark was consists of:

1. Doctor’s Identity: G123468
2. Indexing for database: 321-123.13
3. Patient's identification: sonika c rathi.190.85.04567851
4. Diagnosis Information: light.sugar healthy extra.spicy no.fats 12189.75.1
5. Treatment applied to the patient: painkiller.hgkkfgjklfd abcdefmglkh bkjdh kds.yeio

The results after applying the system against CT scan, MRI, X-Ray and Ultra-sound are shown below:

5.1 The experiments and results of the system without attacks

The system is applied on different images considering their image size and noted corresponding results, which are shown in Table 1 and Table 2. The table shows the PSNR value for ROI extracted from host image and ROI extracted from watermarked image. As the corner pixel values of ROI image are changed the PSNR is not ∞ but there correlation is approximately 1. So, the selected ROI should be large enough to not compromise with the diagnosis value. The table also provides the PSNR value for embedded image and original image and their respective mean square difference.

Table 1 Results for CT scan and MRI Imaging

Type of Imaging	**CT Scan Imaging**			**MRI Imaging**		
Size	**320 X 256**	**384 X 384**	**512 X 512**	**320 X 256**	**384 X 384**	**512 X 512**
MSE	6.81	4	2.11	6.86	3.84	2.22
PSNR	39.83	42.23	44.71	39.4	42.28	44.7
PSNR of ROI	38.69	43.2	45.12	37.24	41.2	44.12
Correlation of ROI	0.9963	0.9994	0.9998	0.9962	0.9993	0.9998

Table 2 Results for X-Ray and Ultrasound Imaging

Type of Imaging	**X-Ray Imaging**			**Ultrasound Imaging**		
Size	**320 X 256**	**384 X 384**	**512 X 512**	**320 X 256**	**384 X 384**	**512 X 512**
MSE	6.93	3.92	2.16	6.93	3.92	2.16
PSNR	39.6	42.18	44.63	39.6	42.18	44.63
PSNR of ROI	38.69	41.2	45.12	37.24	43.2	44.12
Correlation of ROI	0.9963	0.9993	0.9998	0.9962	0.9994	0.9998

5.2 The experiments and results of the system with attacks

The different attacks applied on watermarked medical image are:

- Salt and pepper noise attack
- Cropping attack
- Histogram equalization
- Sharpning attack
- Sampling attack
- Copy-paste attack
- JPEG compression attack

The Figure 4 shows the original watermarked image and attacked water-marked image of ultrasound image. Here the Down and Up sampling attack is applied on watermarked ultrasound image. The attack is applied with one factor of down sampling and 1 factor of up sampling on the watermarked image. The Figure 4 clearly shows that both the images are look like same, which is by normal human eye the difference between the two images, is not visible. However the extracted watermark from the attacked image is totally different than the embedded one. The embedded and extracted watermark values are shown in Figure 5.

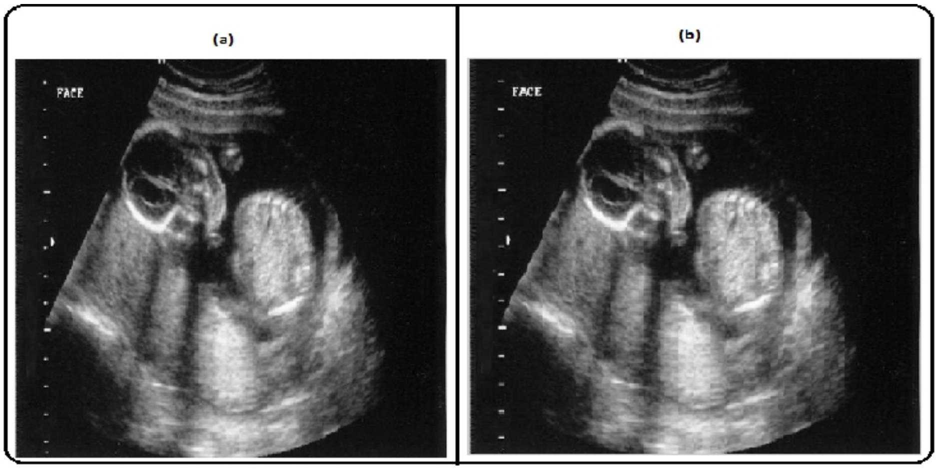

Figure 4: (a) The original watermarked Ultrasound image, (b) The image after up and down sampling attack

```
Embedding watermark value

DocID sonika_rathi
IIdx 460-512.2
PatRef sonika_c_rathidnfksdgjigsj
Diag normal_diaetdghbjkbfkjsdlfsdjlkjglkdjgbdjgksdkjglksdj
Trtmt painkillerndshhvsdijgidjis

Extracted watermark value

DocID q/'lkaO
IIdx ~Iø¥t 072
PatRef s/fiKa_c_p`tkmdndksdg*mf{júÿÿÿ
Diag n¯3C¡j¾loAUt!Ac-&ªde{lcc| ulJoKjozótdodeñ'åòäuâvt
Trtmt `mnachMgqiEmäf zHh¶óGmê§MxMaIWÿ óíî~có
ÿ{ï ðÿný)Á

d =

    1.7765


p =

   45.6351
```

Figure 5 Embedded and extracted watermark values after down and up sampling attack on Ultrasound image

6. CONCLUSION AND FUTURE WORK

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 separate ROI from the host medical image that will be applicable for all types of medical images. Separated ROI can be stored with xmin, xmax, ymin, and ymax value so that at the end of embedding process before transmitting watermarked image, the segmented ROI can be attached with watermarked image. So the ROI region which is considered as a critical data and used as a reference by the physician for the treatment will be safe.

Proposed system uses DWT approach for embedding the watermark, instead of DWT use of Complex Wavelet Transform (CWT) will make the system more robust and secure. The current proposed system can further be extended to provide more secured system. This can be done by encrypting the watermark using secret key, before embedding it into medical images. Having the automated tool for separating the ROI from medical image will provide faster system and more accurate system, which will be easier for end user. The watermark before embedding can be compressed and then embedded. This will lead to more secured system. Also, it will take more effort to break the system.

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8. REFERENCES

[1] Giakoumaki, Sotiris Pavlopoulos, and Dimitris Koutsouris, (Oct. 2006) "Multiple Image Watermarking Applied to Health Information Management", IEEE Trans. on information technology in biomedicine, vol. 10, no. 4

[2] Imen Fourati Kallel, Mohamed Kallel, Mohamed Salim BOUHLEL, (2006) "A Secure fragile Watermarking Algorithm for medical Image Authentication in the DCT Domain", IEEE

[3] M.S.Bouhlel, (Mars 2002) "Conception d'une banque d'images medicales sur INTERNET", 3eme Rencontres Institutionnelles: Rhones Alpes/ Tunisie (RIRAT'02). Tozeur, Tunisie, 21-22

[4] Preeti Aggarwal, Renu Vig, Sonali Bhadoria, and C.G.Dethe , (September 2011) "Role of Segmentation in Medical Imaging: A Comparative Study", International Journal of Computer Applications (0975 – 8887), Volume 29– No.1

[5] Pradeep Singh; Sukhwinder Singh, Gurjinder Kaur, (2008) "A Study of Gaps in CBMIR using Different Methods and Prospective, Proceedings of world academy of science, engineering and technology", volume 36 , ISSN 2070-3740, pp. 492-496.

[6] Zhen Ma, Joao Manuel, R. S. Tavares, R. M. Natal Jorge, (2009) "A review on the current segmentation algorithms for medical images", 1st International Conference on Imaging Theory and Applications (IMAGAPP), Lisboa, Portugal, INSTICC Press, pp. 135-140.

[7] Nisar Ahmed Memon, Anwar Majid Mirza, and S.A.M. Gilani, (2006) "Segmentation of Lungs from CT Scan Images for Early Diagnosis of Lung Cancer", World Academy of Science, Engineering and Technology 20.

[8] Hossein Badakhshannoory and Parvaneh Saeedi, (September 2011) "A Model-Based Validation Scheme for Organ Segmentation in CT Scan Volumes", IEEE Trans. on biomedical information, vol. 58, no. 9,

[9] R. Susomboon, D. Raicu, and J. Furst, (2007) “A hybrid approach for liver segmentation”, in Proc. 3-D Segment. Clin.-MICCAI Grand Challenge

[10] K. Seo, L. C. Ludeman, S. Park, and J. Park, (2005) “Efficient liver segmentation based on the spine”, Adv. Inf. Syst., vol. 3261, pp. 400–409

[11] A. H. Forouzan, R. A. Zoroofi, M. Hori, and Y. Sato, (2009) “Liver segmentation by intensity analysis and anatomical information in multislice CT images”, in Proc. Liver Segment. Intensity Anal Anatomical Inf. Multi-Slice CT Images, vol. 4, pp. 287–297

[12] T. F. Cootes, C. J. Taylor, and D. H. Cooper, (2001) “Statistical models of appearance for medical image analysis and computer vision,” Proc. SPIE, vol. 4322, pp. 236–248

[13] S. Pan and B. M. Dawant, (2001) “Automatic 3D segmentation of the liver from abdominal CT images: A level-set approach,” Proc. SPIE, vol. 4322, pp. 128–138

[14] D. T. Lin, C. C. Lei, and S. W. Hung, (Jan 2006) “Computer-aided kidney segmentation on abdominal CT images”, IEEE Trans. Inf. Technol. Biomed.,vol. 10, no. 1, pp. 59–65

[15] H. Badakhshannoory and P. Saeedi, (2010) “Liver segmentation based on de-formable registration and multilayer segmentation,” in Proc. IEEE Int. Conf. Image Process., pp. 2549–2552

[16] Samuel G. Armato III, Maryellen L. Giger and Catherine J. Moran, (1999) “Computerized Detection of Pulmonary Nodules on CT Scans”, RadioGraphics, vol. 19, pp. 1303-1311

[17] Julian Kerr, (May 2000) “The TRACE method for Segmentation of Lungs from Chest CT images by Deterministic Edge Linking”, University of New South Wales, Department of Artificial Intelligence, Australia

[18] Shiying Hu, Eric A.Huffman, and Joseph M. Reinhardt, (June 2001) “Automatic Lung Segementation for Accurate Quantitiation of Volumetric X-Ray CT images”, IEEE Transactions on Medical Imaging, vol. 20, No. 6

[19] Ayman El-Baz, Aly A. Farag, Robert Falk, and Renato La Rocc, (Jan 2002) ” Detection, Visualization, and Identification of Lung Abnormalities in Chest Spiral CT Scans: Phase 1”, International Conference on Biomedical Engineering, Cairo, Egypt

[20] Riccardo Boscolo, Mathew S. Brown, Michael F. McNitt-Gray, (2002) “Medical Image Segmentation with Knowledge-guided Robust Active Contours”, Radiographics, vol. 22, pp. 437-448

[21] Binsheng Zhao, Gordon Gamsu, Michelle S. Ginsberg, (2003) “Automatic detection of small lung nodules on CT utilizing a local density maximum algorithm”, Journal of Applied Clinical Medical Physics, vol. 4, No. 3

[22] A. Wakatani, (Jan 2002) “Digital Watermarking for ROI Medical Images by Using Compressed Signature Image", Proceedings of the 35th International Conference on System Sciences,

[23] Yusuk Lim, Changsheng Xu, and David Dagan Feng, “Web based Image Authentication Using Invisible Fragile Watermark”, Pan-Sydney Area Workshop on Visual Information Processing (VIP2001), Sydney, Australia

[24] C.R. Rodriguez, F. Uribe Claudia, T. Blas Gershom De J, (2007) “Data Hiding Scheme for Medical Images”, IEEE 17th International Conference on Electronics, communications and computers

[25] Hemin Golpira and Habibollah Danyali, (2009)“Reversible Blind Watermarking for Medical Images Based on Wavelet Histogram Shifting”, IEEE

[26] Nisar Ahmed Memon, S.A.M. Gilani, and Shams Qayoom, (2009) “Multiple Watermarking of Medical Images for Content Authentication and Recovery”, IEEE

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