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Secure Medical Image Watermarking

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Abstract-

In the area of medical applications, where traditional diagnosis is being replaced by e-diagnosis. This paradigm gave birth to number of applications in healthcare industry like teleconsulting, telesurgery and telediagnosis. All these applications require the exchange of medical images in digital format from one geographical location to another throughout the globe via a cheap and fast network such as Internet. However, digital form of medical image can easily be manipulated through image processing software's. Insurance companies, hospitals as well as patients might want to modify the medical images for a number of reasons. The tampered images may be used for illegal purposes. This paper represents algorithms for Dual watermarks on medical image. Logo as watermark first and Electronic Patient Record as second watermark. It save storage space, avoid detachments, save network bandwidth etc. Results show that there will be increase in the accuracy of proposed system and gives high PSNR value.

Index Terms- DWM (Digital Watermarking), EPR (Electronic Patient Record), MIW (Medical Image Watermarking), DWT (Discrete wavelet transform)

1. INTRODUCTION

In relation to digital image watermarking, another area that is drawing attention is the multiple watermarking, where multiple watermarks are embedded into single multimedia object [11]. Multiple watermarks are normally proposed as a method to provide extra security to an image by embedding two or more secret messages into the cover image. The goals of such schemes are to propose robust watermarking technique that has the properties of confidentiality (only the entitled users have access to the information), availability (ability of an information system to be used in the normal scheduled conditions of access) and reliability. Reliability can be achieved based on Integrity (the information has not been modified by unauthorized people) and authenticity (act as a proof that the information belongs to the correct person). Moreover, the scheme should satisfy two conflicting requirements. The first is that it must not introduce any distortion in the host signal and secondly, the watermark must be immune against intentional or unintentional attacks or removals. Finally, the proposed scheme must be efficient in terms of transparency (the watermark is not visible in the image under typical viewing conditions), capacity (ability to detect watermarks with a low probability of error as the number of cause of a large number of medical images are being generated in various radiology departments all over the world. A vast amount of medical images now exist in electronic format for easy storage and transmission. However, medical image and the corresponding patients information were stored separately now. It is easy to cause information disorder, and increase the storage space. At the same time, when the medical images are transmitted on the Internet, the patients personal information can be easily compromised, tampered, and the other problem of information security. It is an urgent need of security measures in medical information system to serve these problems. Digital watermarking has been introduced as an effective complementary measure to traditional encryption in an attempt to solve above problems. Digital watermarking technology is a frontier research field, and it serves an important role in information security.

Watermarking has become an important issue in medical image security, confidentiality and integrity. Medical image watermarks are used to authenticate (trace the origin of an image) and/or investigate the integrity (detect whether changes have been made) of medical images. One of the key problems with medical image watermarking is that medical images have special requirements. A hard requirement is that

save network bandwidth etc. Results show that there will be increase in the accuracy of proposed system and gives high PSNR value.

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the image may not undergo any degradation that will affect the reading of images. Generally, images are required to remain intact to achieve this, with no visible alteration to their original form. A typical model for e-diagnosis is shown in Fig.1. In e-diagnosis environment a physician take a image of set of images, perform his own diagnosis based on the image and then embed this information with the help of some embedding tool in the image along with patient's personal information such as name, age, and sex etc. and then stores it on the database containing the patient historical data.

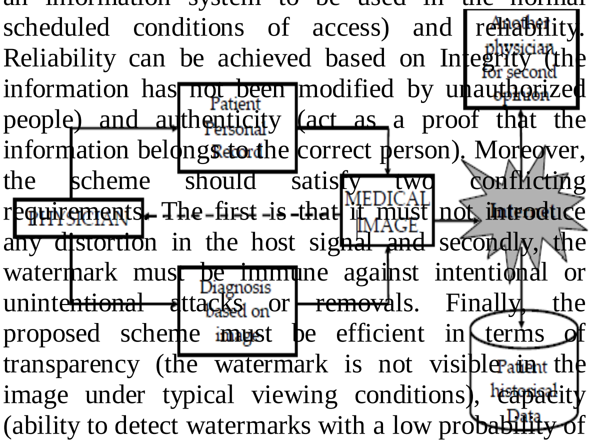

Fig.1. e-diagnosis model [30].

In other scenario, he sends it to another physician in the hospital situated in some remote location for the second opinion, who again makes his own diagnosis and embed the information in the image and sends back to the sender. This exchange of medical images is performed through un-secure open environment like Internet. Numbers of issues are concerned with this exchange of patient records embedded in medical images such as-

1. Authentication: A proof that information belongs to correct patient and is issued from right source;

2. Integrity: Information has not been modified by un-authorized users; and

3. Confidentiality: Only entitled users have access to the information.

These issues also has gained marginal attention due to the availability of large number of image processing software's which can easily copy or modify the images. Thus medical images can easily be copied or tampered with for illegal purposes, for example getting fake health insurance claim from some insurance company. Also tampering of medical images may cause serious results in treatments. With these reasons preventing medical images from forgery has become very important issue.

2. REQUIREMENT OF MEDICAL IMAGE WATERMARKING

Following are the major requirements of Medical image watermarking.

Imperceptibility – It means the embedded watermark should not be visible by human eye.

Capacity – Capacity for embedding the payload must be high.

Authenticity – The entitled users (patient, doctors) should have the access to the medical data.

Reversibility – At the receiving side the reverse of embedding process should be possible to get the original medical image and embedded watermark.

Complexity – According to the e-diagnosis the medical images are transferred from some remote location to other side through internet. In such cases speed becomes an important matter, thus the algorithm should be less complex to reduce the execution time [1].

2.1. Need of Protecting Medical Information

Telemedicine can be divided into number of medical related technologies using computers for distant health care, for example teleradiology, telepathy, telecare, telesurgery, teledermatology and teleneurology [1, 2] Teleradiology is clinically beneficial and cost-effective alternate to conventional specialist treatment [3, 4]. It provides the infrastructure for rapid response to highly important medical care independent of the geographical barriers. Critically ill or injured patients can be treated locally by effective communication with a distant specialist provided by wireless technology [5]. Flexible and rapid access to expert opinion and advice at the point of care is also provided with improved management of medical resources [6].

Patients requiring care would benefit from locally provided services as they would have immediate access to a second opinion if required. A likely scenario may be the patient in a remote location, who would have the exibility to call their specialist. A mobile phone could be used to discuss the management of medical problem along with the transmission of diagnostic images. Early methods of care for patients in these locations imply transportation to hospital, assessment, admission, diagnosis, treatment, and eventually results in the patient being discharged. Long journeys from remote locations to a central hospital are a problem for families and weaken the connection with primary health care and social services [7]. If the local or remote hospital has the facilities for effective wireless telemedicine, diagnosing or treating specialists can know nearly as much about the patients if they are examining them directly. Admission is less complex and may result in fewer patients requiring admission and treatment. This is the cost effective solution for hospitals where funding may be limited. One of the most pressing challenges in communicating any type of medical data over long distances in a wireless environment is to maintain that the data has not been changed during communication in an undesirable way.

Medical images are very crucial and important part of medical information. In a number of medical applications, medical images require special safety and confidentiality, because critical judgment is done on the information provided by medical images. Therefore, they must not be changed in an illegitimate way; otherwise an undesirable outcome may ensue due to loss of essential information.

2.2 Advantages of Electronic Patient Records

EPRs and the ability to exchange health information electronically can help you provide higher quality and safer care for patients while creating tangible enhancements for your organization [34]. EHRs help providers better manage care for patients and provide better health care by[34];

- Providing **accurate, up-to-date, and complete information about patients** at the point of care
- Enabling quick access to patient records for more coordinated, efficient care.
- Securely **sharing electronic information** with patients and other clinicians
- Helping providers more effectively **diagnose patients, reduce medical errors, and provide safer care**
- Improving patient and provider interaction and communication, as well as **health care convenience.**
- Enabling safer, **more reliable prescribing**
- Helping promote **legible, complete documentation** and accurate, streamlined coding and billing
- Enhancing privacy and security of patient data
- Helping providers **improve productivity** and work-life balance.
- Enabling providers to **improve efficiency and meet their business goals.**
- **Reducing costs** through decreased paperwork, improved safety, reduced duplication of testing, and improved health.

3. FOUNDATIONS OF PROPOSED METHEDOLOGY

3.1 . Discrete Wavelet Transform

Discrete Wavelet Transformation (DWT) of image produces the multi-resolution representation of image. A multi-resolution representation provides a simple hierarchical framework for interpreting the image information. At different resolutions, the details of an image generally characterize different physical structures of the image. At a low level resolution, these details correspond to the larger structures which provide the image content. Wavelet transformation consist of two main steps namely DWT and IDWT (Inverse DWT). DWT segments a digital signal into high frequency quadrant and low frequency quadrants. The low frequency quadrant is split again into two more parts of high and low frequencies and this process is repeated till the signal has been entirely decomposed. In watermarking, generally 1-5 level of decompositions is used. The reconstruct of the original signal from the decomposed image is performed by IDWT. Several types of wavelets exist for decomposition. Some examples include Haar, Daubeschies, Coiflets, Symlets, Morlets, Mexican Hat Meyer and Biorthogonal wavelets. More generally, application of DWT divides an image into four sub-bands (Figure1a), which arise from separable applications of vertical and horizontal coefficients. The LH, HL and HH sub-bands represents detailed features of the images, while LL sub-band represents the approximation of the image. To obtain the next coarse level, the LL sub-band is further be decomposed (Figure 1b), thus resulting in the 2-level wavelet decomposition. The level of decomposition performed is application dependent. The present work considers decomposition up to two levels.

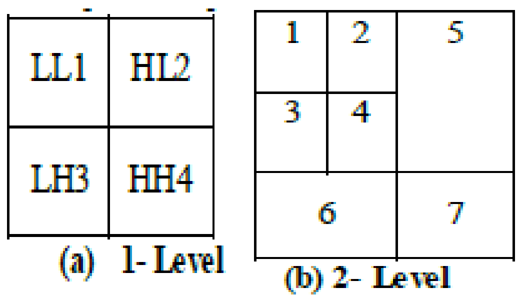

Figure 2: Wavelet Decompositions [33]

3.2. Arnold Scrambling Transform (AT)

Scrambling transformation [4] as a means of encrypted technology is applied in the pretreatment stage of the watermarking, after scrambling transformation, one meaningful watermarking will become a meaningless, chaotic image. If you do not know the scrambling algorithm and keys, the attacker cannot recover it even if he gets the watermarking from the embedded watermarking. And thus plays a role of secondary encryption. Additionally, after scrambling transformation, it will upset the relationship between the space locations of pixels and make it evenly distributed in all space of the carrier image. This will improve the robustness of the algorithm. Two-dimensional Arnold scrambling transformation is defined as follows:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \bmod N \qquad x, y \in \{0, 1, 2 \cdots, N-1\} \quad (1)$$

Wherein, x, y is the pixel coordinates of the original space: x', y' is the pixel coordinates after iterative computation scrambling; N is the size of the rectangular image, also referred to as a step number. By the above formula the corresponding inverse transform formula can be obtained [4].

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \bmod N \qquad x, y \in \{0, 1, 2 \cdots, N-1\}$$

It is easy to restore the original initial state according to the corresponding iterations.
Arnold transformation is cyclical, when iterate to a step, will regain original image. So if you do not know cycle and iterations, you will not be able to restore the image. Therefore, cycle and iterations can exist as a private key. Meanwhile, different image, because the desired effect is different, iterations should also be changed according to your need.

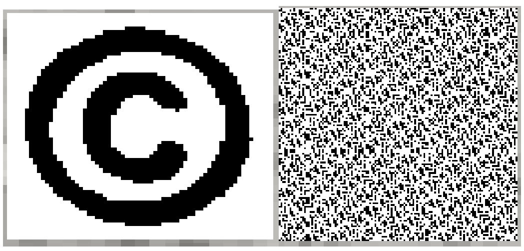

Fig.3. A. Watermark 1. Hospital Logo.
B. Arnold scrambles of hospital logo

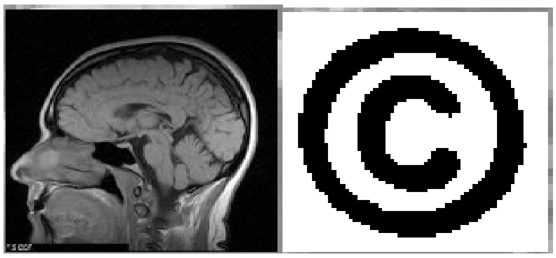

Fig.4. A. Watermarked Image. B Extracted Watermark.

Arnold Transform has special property that given image comes to its original state after specific number of iterations. These specific number of iterations termed as 'Arnold Periodicity'. Hence Arnold Transform is used as efficient technique for increasing security in watermarking schemes [31].

4. PROPOSED SYSYTEM

4.1. Frame work of proposed system

Following figure shows the work structure of proposed system.

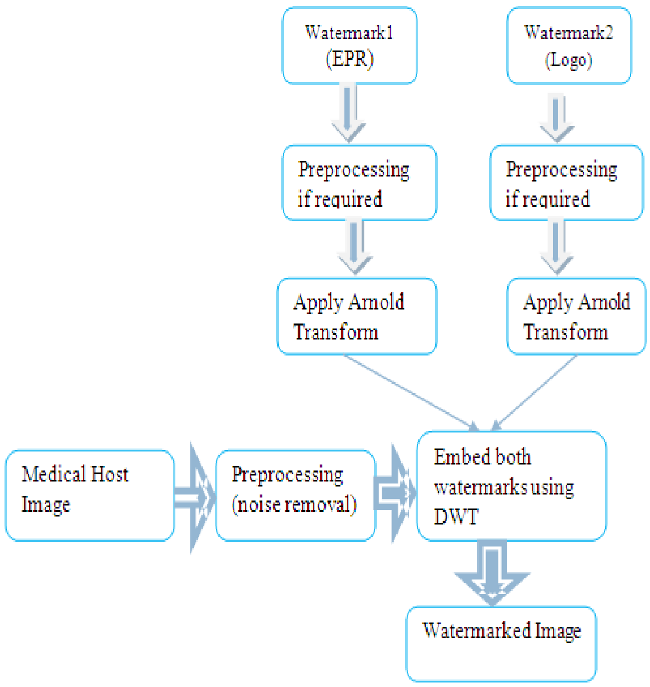

Fig.5. Proposed system work structure.

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5. EXPERIMENTAL RESULTS

This section reports the result obtained for one such set. Similar results were observed for all other images also. The cover image, watermark1 and 2 images and extracted image with PSNR value is shown in Figure 7 to 10**.**
Fig.7 shows gray scale base images of size 512 x 512 which is as host image.

Fig.6.. Original /Host MRI image of size 512x512

Fig.7 A. Watermark1. Logo. B. Watermark2 EPR

Fig.8. shows the logo as watermark1 and the second watermark is EPR. as shown in fig.8.b. The algorithm was tested on more standard images and other gray scale images. Figure.6-9 shows few more examples and results for image watermarking.

Fig.8. Watermarked Image.

Fig. 9. Extracted watermark1 and watermark2.

Table1. Results for CT scan and MRI Imaging

Type of Imaging	**CT Scan Imaging**	**MRI Imaging**
Size	512x512	512x512
MSE	0.2991	0.1370
PSNR	53.37db	56.76db

6. CONCLUSION AND FUTUREWORK

Focus will be given on Dual methodology for developing the Medical image watermarking system as it can combine the advantages of EPR data hiding for Less storage space and avoid detachment along with logo watermark for authentication. And additive security is maintained by applying Arnold transform on both the watermarks.
Experimental results proved that the proposed algorithm is efficient in terms of quality and further, the results also proved that storing watermarks using DWT and Arnold Transform provides more robustness to the proposed technique. The present work uses gray scale images of image.md dataset.
The embedding process when tested on various standard images performed watermarking imperceptibly and no visible traces or distortions could be noted in the resultant watermarked copies. For objective measurement of the quality of the watermarked images. PSNR was measured. And the results for various test cases showed that PSNR values are even better.
Proposed system uses DWT approach for embedding the watermark, instead of DWT use of Complex Wavelet Transform (CWT) will make the system more robust.

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