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Study on Digital Watermarking for Telemedicine Applications

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***Abstract*— Digital watermarking is a data hiding technique which used for improving the security of various multimedia applications and mostly investigated to protect the privacy of patients through telemedicine systems. Telemedicine is a well-known application, where huge amount of medical data need to be securely transferred over the public network and work successfully. DWT (Discrete Wavelet Transform) is using for decomposition. After decomposing the host image divides into four bands (LL, HL, LH, and HH), DWT have been used to embed and extract watermarks in the HL bands of the host image. Simulation results show no visible difference between the watermarked and the original image.**

***Index Terms*— Watermarking, Discrete Wavelet Transform, Telemedicine.**

I. INTRODUCTION

Digital watermarking is the process of transmission information by perceptible and imperceptible embedding it into the digital media. Digital watermark insertion is in the specific domain, i.e. either in the spatial domain or the transform domain. The variety in these domains is that, in case of spatial domain the embedding of the watermark is a simple method. The spatial-domain components of the original image are embedded with the digital watermark; due to the simple temporary behavior the spatial domain has simplicity and easy implementation as its plus points. But on the different, spatial domain method is not protected to image processing operations and other attacks.

A. Properties of watermarking

i) Imperceptibility – A watermark is called perceptible when its presence in the marked signal is noticeable, but non-intrusive and is called imperceptible when the cover signal and noticeable signal are identical with respect to a suitable perceptual metric.
ii) Robustness – It means the watermark is able to survive any logical processing impose on the carrier and is called fragile when it fails to identify a slight modification.
iii) Security – It means the watermarked image should not give any information of the presence of the watermark with respect to un-authorized recognition, or unsuspicious.
iv) Complexity- It describes the cost to detect and encode the watermark information. It gives idea to design complex watermarking procedure and algorithm. So that it can be integrated with different watermarks.

v) Capacity- It means the amount of information that can be stored in a data source.

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B. Watermarking Applications

a) Copyright Protection:- Watermark helps the legal owners of a certain item or property to verify the illegal copies of their works by inserting watermark signature into their digital works. Hence, the detected watermark signature can be used as an evidence to prove ownership of the property.
b) Fingerprinting:-When a customer purchases a digital objects, a unique identity, such as a serial number, is secretly embedded within the digital material. This method discourage customers from redistributing the content. The fingerprinting signature enables the intellectual property owner to identify which customer broke their license agreement.
c) Copy Control:-Owners of a legal property can control the terms of use of their work with watermarking, either copying once, copying many or no copying at all.
d) Authentication:-Watermark signatures are used to identify any illegal variation applied on a cover work, for instance, checking for fake international passport used by fake individuals.

C. *Types of digital watermarking*

watermarking can be divided into visible watermarks and invisible watermarks.
1. Visible Watermarks:- Visible watermarks can be seen by the user, logo and the owner details are identified by person. These technique changes the original signal.
2. Invisible Watermarks:- Invisible watermarks cannot be seen by other party and output signal does not change when compared to the original signal.

II. DISCRETE WAVELET TRANSFORM (DWT)

Discrete Wavelet Transform (DWT):- The DWT divides an image into four parts:-
1. LL: Approximation coefficients matrix
2. HL: Horizontal details coefficients matrix
3. LH: Vertical details coefficients matrix
4. HH: Diagonal details coefficients matrix

The LL sub band is obtained after low-pass filtering both the rows and columns and contains a rough explanation of the image. The HH sub band is high-pass filtered in both directions and have the high-frequency components along the diagonals. The HL and LH sub bands are the results of low-pass filtering on one direction and high-pass filtering in the other direction. After the image is processed by the wavelet transform, most of the information contained in the host image is determined into the LL image. LH sub band contains mostly the vertical detail information which corresponds to horizontal edges. HL band represents the horizontal detail information from the vertical edges. Figure 1 shows the DWT decomposition.

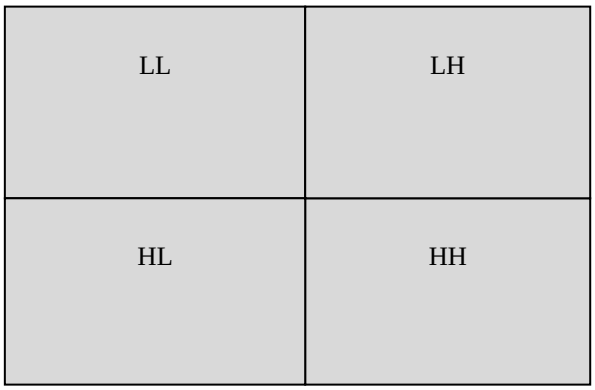

Figure 1: DWT decomposition

III. TELEMEDICINE

The delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of suitable information for analysis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities.

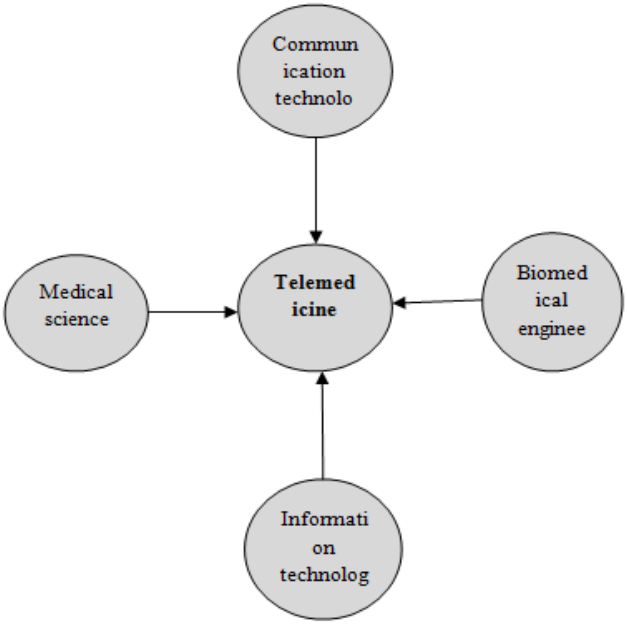

Figure 2: Telemedicine and its component

IV. LITERATURE REVIEW

- **Seyed Mojtaba Mousavi & Alireza Naghsh [1] in 2014** presented Digital watermarking is the procedure of embedding information (i.e., a watermark) into the host object in such a way that the watermark image/data can be detected by authorized individuals.
- **Anumol Joseph1, K. Anusudha [2] in 2013** proposed, the proposed system based on DWT SVD technique. The host image and the watermark images are decomposed by DWT using Haar wavelet. Single level decomposition was applied on the host image and single level decomposition on the watermark images.
- **Vijay R Ayangar and DR. S. N. Talbar [3] in 2010** developed a DFT based techniques and DWT based techniques. The SVD mathematical technique provides an elegant way for extracting algebraic from the image.
- **Rajesh B Raut [4] in 2011** presents a color image watermarking scheme using watermarking Technique in spatial domain and frequency domain. The quantization levels have been computed using the technique for each of the basic colors R, G and B respectively for sampling color images. The original image and the watermark are retrieved using the proposed algorithms. The detection and retrieval techniques presented in this paper have been quantitatively benchmarked with a few contemporary algorithms using MSE and PSNR, BER and SSIM.
- **Fengmei LIANG, Lijia WANG [5] in 2011** proposed an improved color image watermark algorithm based on discrete wavelet transform (DWT). According to the different threshold, a binary image is embedded in the low frequency and medium frequency component of the wavelet decomposition, which prepared great advance on invisibility and quantity of embedded information. Detection process does not require the original image and other additional data, which increases the speed of watermark detection.
- **Bibi Isac and V. Santhi [6] in 2011** have worked on digital image and video watermarking schemes using neural networks.
- **Shuchi Sirmour, Archana Tiwari et al [7] in 2014** developed a hybrid DWT SVD based algorithm for watermark embedding and extracting process. The suggested method is performed by modification on singular value decomposition of images in Discrete Wavelet Transform (DWT) domain. Modification of the appropriate sub-bands leads to a watermarking scheme which favorably preserves the quality. They shown good robustness by using hybrid DWT-SVD method in comparison with DWT based watermarking algorithm using Haar wavelet.
- **A.Umaamaheshvari, K.Thanuskodi [8] in 2012** are described Watermarking is a branch of information hiding which is used to hide pr oprietary information in digital media like photographs, digital music, or digital video. The Medical images are also much important in the field of medicine ,all these medical images are need to be stored for future reference of the patients and their hospital findings hence, the medical image need to undergo the process of compression before storing it.
- **Mohamed M.Abd-Eldavem [9] in 2013** is described a security technique based on watermarking and encryption is proposed to be used for Digital Imaging and Communications in Medicine (DICOM). It provides patient authentication, information confidentiality and integrity based on reversible watermark. To achieve integrity service at the sender side; a hash value based on encrypted MD5 is determined from the image.
- **B. Planitz and A. Maeder [10] in 2013** are described on the degradation of medical images when embedded with different watermarks, using a variety of popular systems.

Image quality is measured with a number of widely used metrics, which have been applied elsewhere in image processing. The general conclusion that arises from the results is that typical watermark embedding can cause numerical and perceptual errors in an image.

- **Nisreen I. Yassin, Nancy M. Salem [11] in 2013** are described the watermark includes the electronic records for patients with three different sizes. Experimental results show high imperceptibility and robustness against attacks. The maximum PSNR achieved by the proposed technique is 61 dB while the least is 45 dB. The maximum number of characters embedded in the medical video frame is 146 characters.
- **K.Anusudha, N.Venkateswaren [12] in 2014** are described a watermarking technique in wavelet domain which uses the Electronic Health Record (EHR) as watermark and hospital logo as the reference image. Embedding of the EHR data is based on energy band selection and in reference to the bit location in the reference image. Performance of the proposed method was tested for four modalities of medical images; MRA, MRI,Radiological, and CT. Simulation results show no visible difference between the watermarked and the original image.Moreover, the proposed watermarking method is robust against a wide range of attacks such as JPEG compression,Gaussian noise addition, histogram equalization, contrast adjustment, sharpening and rotation.
- **R.Lakshmi Priya1, V.Sadasivam [13] in 2015** are described emerging techniques for protection of medical images through watermarking. Medical images are often transmitted over insecure channel. Telemedicine enables medical diagnosis and patient care using modern medical equipments. These equipments generate huge volume of data every day.Hence protection of medical image is very crucial. Watermarking in medical images is commonly used for content authentication, effective data distribution and management, storage, security, safe archiving, controlled access retrieval and captioning.
- **Arathi Chitla and Chandra et al [14] in 2015** are described digital watermarking plays a very important role in authenticating the medical images, content verification, preserving the image quality and enhancing the data security.
- **Hui Liang Khor, Siau-Chuin Liew et al [15] in 2016** are described watermarking research has been done on single frame medical image which is impractical in the real environment. A digital watermarking on multiframes medical images is proposed. In order to speed up multiframes watermarking processing time, a parallel watermarking processing on medical images processing by utilizing multicores technology is introduced.
- **Nisreen I.R. Yassin [16] in 2016** is described Telemedicine is an emerging science that can help in solving the modern global health problems. Exchanging medical images and Electronic Patient Records (EPR) between clinicians, specialists, and radiologists provides a platform for discussing and consulting diagnostic and therapeutic problems. Using Information and Communication Technologies (ICT) in the transmission of medical information for improving healthcare access, diagnosis, and treatment requires various means for security and privacy issues, since, digital information can be easily attacked to be duplicated and manipulated.
- **Kaiser J. Giri, Mushtaq Ahmad Peer and P. Nagabhushan [17] in 2015** are described a secure and robust watermarking technique for color images using Discrete Wavelet Transformation. The main motion behind using the wavelet transformation is to get a detailed description of the image data, so as to identify the more appropriate portion of the image for consideration of watermark embedding.

V. PROPOSED METHOD

Proposed technique to hide watermarks with more energy in an image. This makes the watermarked image more robust. The Discrete Wavelet Transform (DWT) is chosen for watermarking. DWT decomposition can be exploited to make a real-time watermark application. Thus the Discrete Wavelet Transform method is performed for this project to implement the Robust and Invisible Watermarking.

A. Watermark Embedding:

1. Read the color image and find HSV coefficients and apply level one DWT on HSV coefficients.
2. Take the HL (horizontal sub-band) coefficients into consideration for the watermark embedding.
3. Rearrange the watermark which a grey scale image by splitting each intensity value into three digits using the modulus operator resulting three different digit streams.
4. Embed these digit streams into three coefficient steams of the host image correspondingly.
5. Perform the inverse DWT to obtain the watermarked image

B. *Watermark Extraction:*

1. Read both original as well as watermarked images respectively.
2. Perform level one DWT on both the image and consider HL sub-bands in each case and perform the subtraction correspondingly to obtain the watermark W
3. Reconstruct the watermark W.

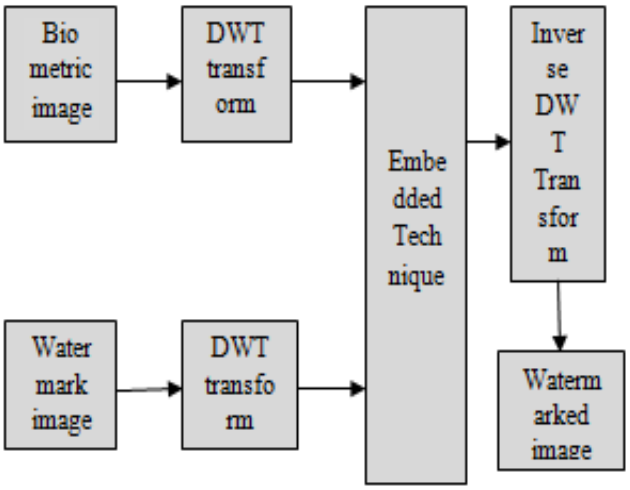

Figure 3: Watermark Embedding

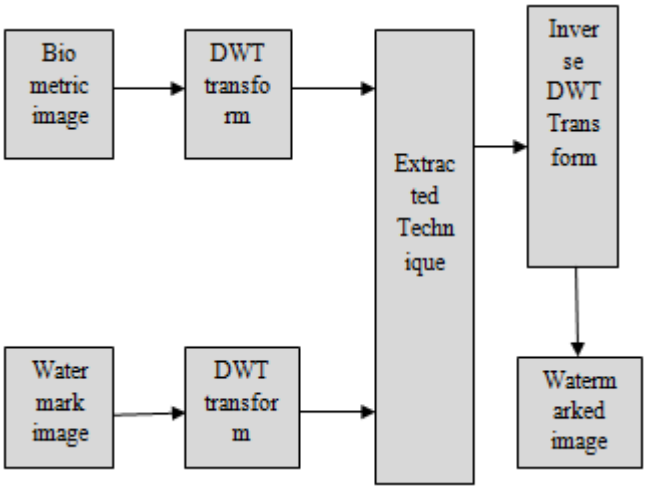

Figure 4: Watermark Extraction

VI. EXPERIMENTAL RESULTS

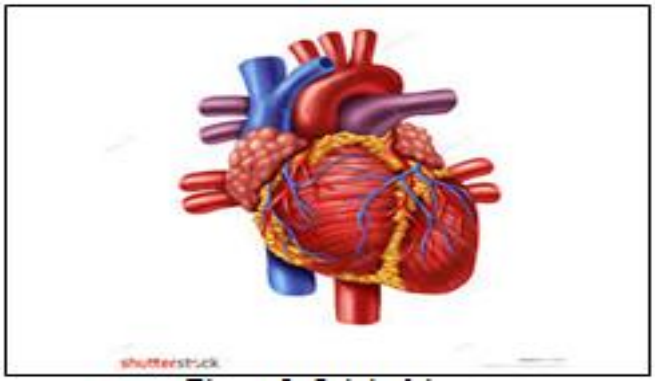

Figure 5: Original image

Figure 6: Watermark image

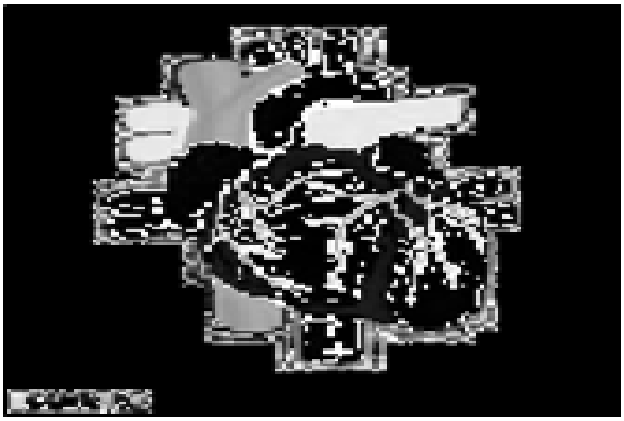

Figure 7: coefficient of H

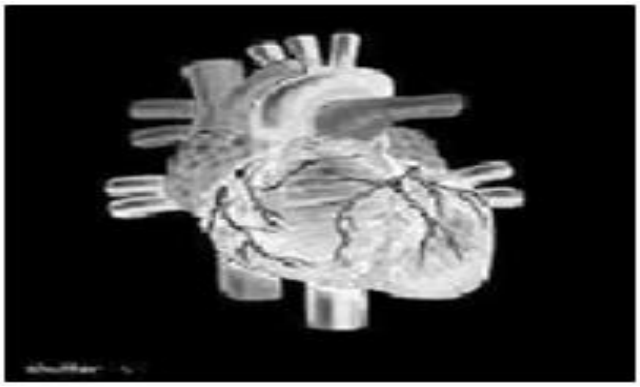

Figure 8: coefficient of S

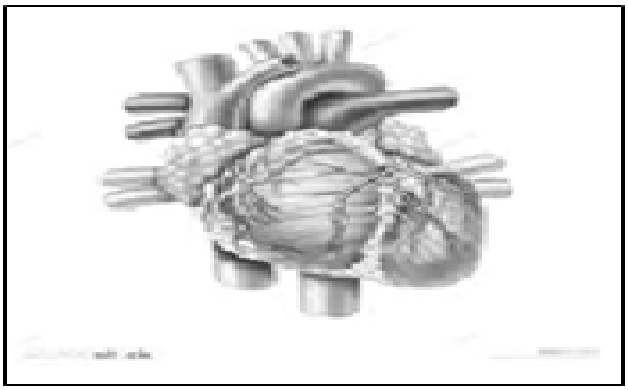

Figure 9: coefficient of S

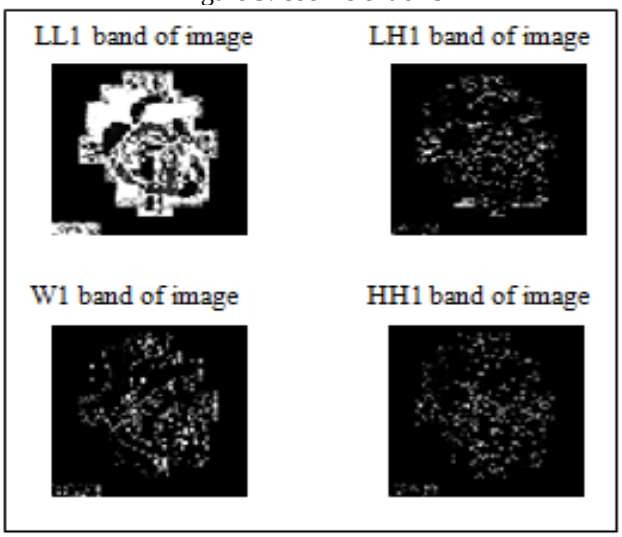

Figure 10: 1-level DWT on H

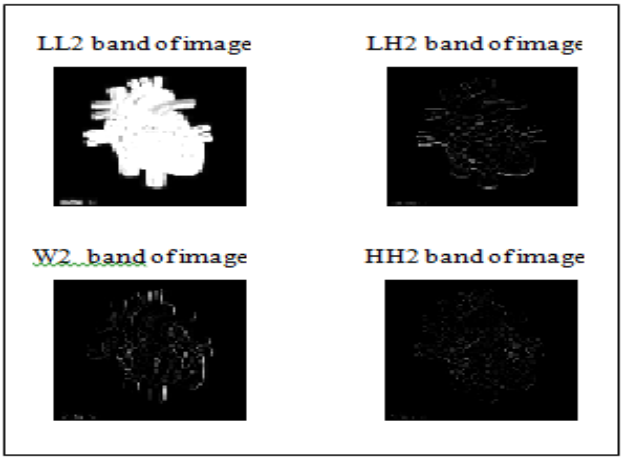

Figure 12: 1-level DWT on S

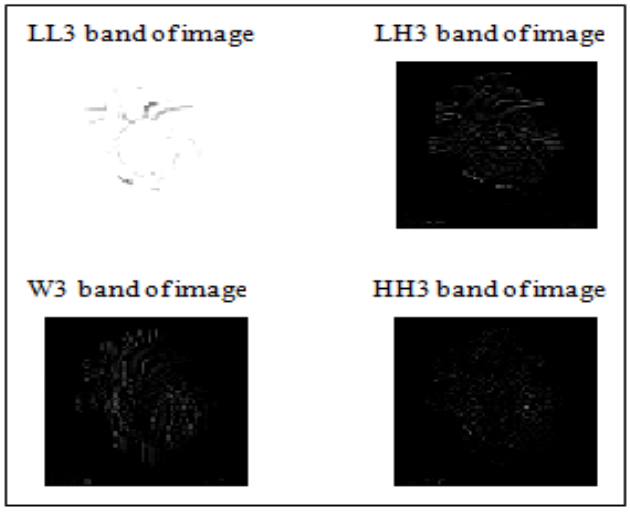

Figure 13: 1-level DWT on S

Figure 14: Embedded coefficients of H

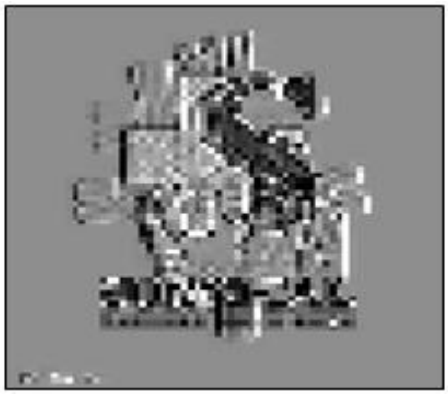

Figure 15: Embedded coefficients of S

Figure 16: Embedded coefficients of V

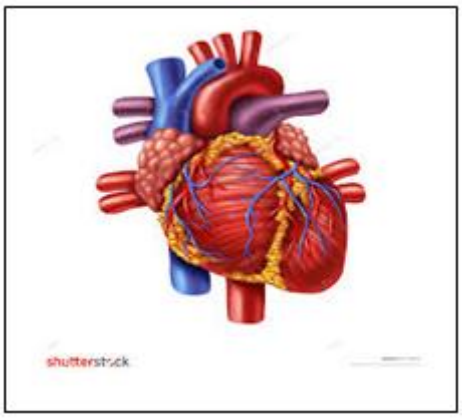

Figure 17: Watermarked image

VII. CONCLUSION

In this paper different attribute for digital watermarking like types of watermarking, properties, techniques, applications are presented. Aim of this paper is to give the complete information about watermarking and discrete wavelet transform in telemedicine application. This paper presents a novel watermarking technique, in which discrete wavelet transformation is used as a tool to analyze the image data by decomposing the image into various coefficients having different resolution. This Paper proposes classification of the digital watermarking in the feature of robustness, application and perceptivity. Steps of embedding and extracting algorithm are explained. This paper is implication of watermarking applications in medical imaging to attain privacy and security. It was shown that the watermarking assures the authenticity and integrity of a medical image.

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