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Security in Telemedicine using DWT-CDCS

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ABSTRACT
Copyright protection of digital media is the very first application that comes to mind for digital watermarking. In the past, duplicating artwork was quite complicated and requires great efforts to create the work looks just like the original. However, in present digital world it is very simple for anyone to duplicate or manipulate digital data. The digital image watermarking allows the watermark to be embedded visibly or invisibly in the original image for identification of the owner. This concept can also be used for other media, such as digital video and audio.

Telemedicine is a well-known application of digital watermarking. In this application security & authentication for medical data is very important. Hiding the data into the medical image provide the security over the public network. Authentication verifies whether the image certainly belongs to the right patient Authentication of medical data used for further diagnosis and reference.

This paper focused on the methods of medical image data hiding for security and authentication. High capacity data hiding is achieved with CDCS (Class Dependent Coding Scheme). As well as data is effectively hided with discrete wavelet transform.

Embedding watermarks in RONI (region of non interest) protects the ROI (region of interest) of medical image, which is diagnostically important part of medical images. Segmentation plays an important role in medical image processing for separating the ROI from medical image.

General Terms
Medical image segmentation is done to protect diagnostically important part called region of interest (ROI). Text embedding is done in the rest part of an image called region of non interest (RONI).

Also medical data can be embedded with LSB technique in medical image which is processed with discrete cosine transform.

Keywords
CDCS, data hiding, medical image, ROI

1. INTRODUCTION
Now days, because of great development in technologies, the business related applications are running on digital way for example communication, networked multimedia system, and digital data storage etc. After the revolution in internet & digital world all the business environment are achieving effectiveness & security using digitalization of business application with the help of internet. Telemedicine is one of the important applications, where healthcare professional uses internet to transfer or receive the medical data[15].The biomedical images which can be readily shared by using computer networks and are easily available to use, also these can be processed as well as transmitted with internet. Telemedicine reduces distance barrier due to that it is easy to provide medical services in remote areas which are not accessible easily. It is useful in critical and emergency situations of patients. Medical diagnosis determines a possible disorder or diseases. Diagnosis based on patient's consultation, physical examination and medical tests. Medical test such as laboratory, biosignal (ECG, EEG), Image analysis etc are used, shown in figure below.

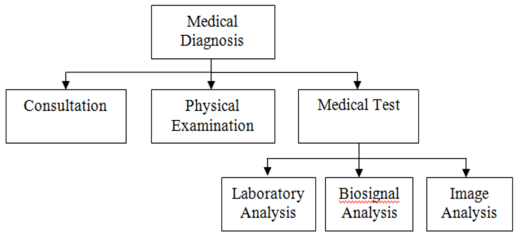

Figure 1 Medical Diagnoses

Figure 1 illustrate typical e-diagnosis model. Physician can get patient report via email or any web tool through the internet. Doctor can refer digital report of the patient to other experts to get the second opinion. For the future diagnosis, this medical data can be stored in the healthcare's database [3]. As the critical diagnosis are depends on medical images or medical data, security and confidentiality are the main issues in it [15]. So that medical data should not be changed by unauthorized person otherwise, patient suffers from wrong treatment due to the change in diagnosis information. That's why medical data should have highly secured. In recent years, due to wide use of internet, it is more convenient to transfer the medical images or patient information regarding his/her diagnosis among hospitals, which are located in the different geographical location. Many times this referenced medical data transfer is done via unsecured open networks. These will leads to change in medical images (for example, one patient's reports or medical images are replaced by other patient) are makes the wrong diagnosis. Considering this fact, medical data should have highly secured.
Embedding of the watermark into medical image is process for copyright protection [3,8]. And authentication of that medical image is achieved by extracting watermark. In embedding process, secrete data in the form of text, image or audio has been embedded into original medical image and resultant image is call watermarked image.

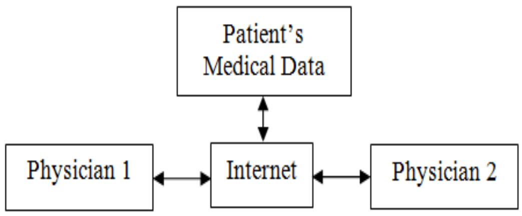

Figure 2 Typical e-diagnosis models

In extraction processing, secret data is extracted from the watermarked image. If there is error in extraction process, it will show that image gets tampered. Physician does not diagnose on such tampered images.

2. PROPOSED SYSTEM

Proposed work describes an image watermarking method for medical images. This proposed method helps to increases the security and capacity of robust watermark. Patient's report is used as a watermark. To increase the capacity of hiding data, class dependent coding scheme is used. Discrete wavelet transform is used to decompose the cover image into four subbands each of same size as that of the original image. By embedding the watermark in the four subbands the proposed scheme became more robust to common attacks and achieves secure data transfer. Proposed work consist blind watermarking technique and tested the algorithm for various attacks. Blind watermarking is based on CDCS-DWT algorithm. Since high hiding capacity is possible with CDCS as well as it effectively embedded into medical image and scheme became more robust to common attacks hence the name High capacity & effective medical image data hiding using CDCS.

2.1 Watermark Embedding Algorithm

1. Medical image (N x N) acquisition & convert into grayscale image of size 512x512 & is used as input image.
2. Input image separated into two parts - Region Of Interest (ROI) & Region Of Non Interest (RONI) by using GUI
3. Data (Text file containing patient report) acquisition & convert each character into 6 bit binary number by using CDCS
4. Redundant & interleaving bits are added in CDCS code
5. Divide RONI image into 8x8 blocks
6. Apply DWT to each block of size 8x8, block decomposed into four subbands LL, LH, HL, HH.
7. Select valid blocks & quantized ,non-zero predefined coefficients are considered for embedding the data
8. By using LSB method CDCS bits are embedded into non-zero coefficients
9. Apply IDWT to subbands & reconstruct block of size 8x8
10. Combine all blocks to form embedded RONI image
11. Watermarked image is obtained by combining embedded RONI & ROI images.

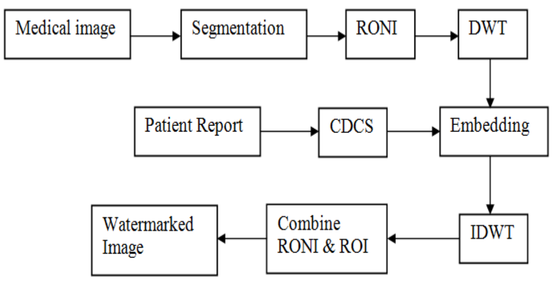

Figure 3 Block Diagram of Embedding Process

2.2 Watermark Extraction Algorithm

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.

1. Watermarked image separated into two parts - Region Of Interest (ROI) & Region Of Non Interest (RONI) by using GUI
2. Divide RONI image into 8x8 blocks
3. Apply DWT to each block of size 8x8, block decomposed into four subbands LL, LH, HL, HH
4. Select valid blocks & extract data bits from predefined coefficients
5. Apply Inverse CDCS to extracted bits & reconstruct patient report
6. Calculate bit error rate & correlation coefficient of ROI

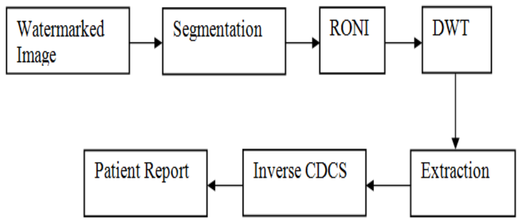

Figure 4 Block Diagram of Extraction Process

3. METHODOLOGY

3.1 Class Dependent Coding Scheme

Class dependent coding scheme is the simple technique which is based on probability of the occurrence of characters used in patient report [1]. Characters are divided into three categories, class A, class B, & class C. Most frequently used characters are comes under Class A. Class B consists less or average frequently used characters and Class C consist rarely used characters. Each class has two bit code 00, 01 & 10 for Class A, B, & C respectively.

Class dependent coding scheme consist capital letters, special and alphanumeric characters. Based on Huffman encoding, the variable length class code (CC) have been designed to represent each class.

3.2 DWT

The image is high and low-pass filtered along the rows and the results of each filter are down- sampled by two. Those two sub-signals correspond to the high and low frequency components along the rows and are each of size N by N/2. Each of those sub-signals is then again high and low-pass filtered, but this time along the column data. The results are again down-sampled by two. h(-m) and g(-m) are the low pass and high pass analysis filters, while the corresponding low pass and high pass synthesis filters are h(m) and g(m) ; c_j and d_j are the low band and high band output coefficients at level j.

DWT analysis is given by [29]

$$c_{j+1}[m,n] = \left(c_j(m,n) * h[-m]\right) \downarrow 2 \qquad (1)$$

$$d_{j+1}[m,n] = \left(c_j(m,n) * g[-m]\right) \downarrow 2 \qquad (2)$$

Similarly DWT synthesis is given by

$$c_{j+1}[m,n] = \left[\left(c_j(m,n) \uparrow 2\right) * h[m] + \left(d_j(m,n) \uparrow 2\right) * g[m]\right] \quad (3)$$

3.3 Robustness Test

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) is simplest function to measure the perceptual distance between watermarked and original image.

$$MSE = 1 \div n \sum_{i}^{n} \left(I' - I\right)^2 \quad (4)$$

Where, I is original image and I is watermarked image.
Peak Signal to Noise Ratio (PSNR) is used to measure the similarity between images before and after watermarking.

$$PSNR = 10 \log_{10} \max I^2 \div MSE \quad (5)$$

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

4 RESULT

The proposed blind algorithm is tested with different medical images. These medical images are taken from eye hospital, dental hospital and medical case study websites.
In the proposed work, different Patient's reports with various data capacity are selected. Those reports are converted into the CDCS bits. Redundancy & interleaving bits are added prior to each CDCS bit. Capacity of All this medical data has tested on DWT –CDCS algorithm. Salt & paper noise is applied to check the PSNR value and BER.
Results are shown in table below for given medical image. Figure 5, 6 & 7 shows graphic representation of PSNR, MSE, BER and NCC in table 1.

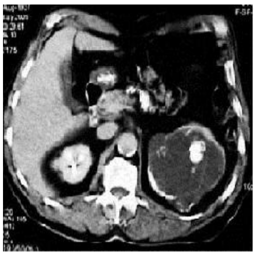

Image 1

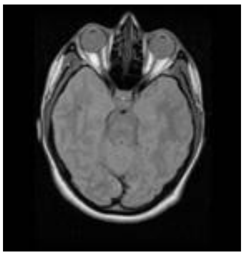

Image 2

Table 1 DWT-CDCS Result on Image 1

DWT-CDCS Results after various attacks on Image 1					
Attacks	**PBS (%)**	**MSE**	**PSNR (dB)**	**BER (%)**	**NCC of ROI**
Without Attack	29.1667	0.30265	53.3214	0	0.98834
Salt & Paper	29.1667	0.57791	50.5122	6.2325	0.98937
Gaussian	29.1667	16.4139	35.9787	48.109	0.94771
Speckle	29.1667	12.4251	37.1878	21.6387	0.94058
Poisson	29.1667	5.4603	40.7587	28.2913	0.95685
Blurring	29.1667	2.0662	44.9791	21.2885	0.98525
Sharpening	29.1667	10.7706	37.8084	51.7507	0.96677
Rotation by 90	29.1667	84.1284	28.8814	45.2381	-0.13857

Table 2 DWT-CDCS Result on Image 2

DWT-CDCS Results after various attacks on Image 2					
Attacks	**PBS (%)**	**MSE**	**PSNR (dB)**	**BER (%)**	**NCC of ROI**
Without Attack	29.1667	0.27713	53.704	0	0.66269
Salt & Paper	29.1667	0.53577	50.841	1.4706	0.95483
Gaussian	29.1667	15.3999	36.2556	51.4706	0.53685
Speckle	29.1667	8.7255	38.7244	30.042	0.861
Poisson	29.1667	4.4257	41.671	33.2633	0.72944
Blurring	29.1667	0.46727	51.4351	16.8768	0.91365
Sharpening	29.1667	2.585	44.0062	46.2185	0.91576
Rotation by 90	29.1667	28.5282	33.5781	41.8768	0.58847

Image 3

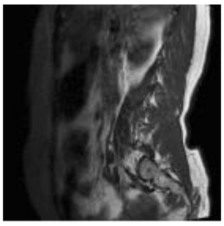

Image 4

Table 3 DWT-CDCS Result on Image 3

DWT-CDCS Results after various attacks on Image 3					
Attacks	**PBS (%)**	**MSE**	**PSNR (dB)**	**BER (%)**	**NCC of ROI**
Without Attack	29.1667	0.30647	53.267	0	0.9629
Salt & Paper	29.1667	0.56765	50.59	1.1905	0.95872
Gaussian	29.1667	19.7223	35.1812	50.1401	0.84461
Speckle	29.1667	19.2374	35.2893	51.0504	0.84864
Poisson	29.1667	8.1625	39.0126	48.5294	0.94746

Blurring	29.1667	1.2902	47.0242	18.2073	0.96074
Sharpening	29.1667	6.7372	39.846	50.9104	0.95393
Rotation by 90	29.1667	75.1017	29.3743	46.0084	0.004701

Table 4 DWT-CDCS Result on Image 4

DWT-CDCS Results after various attacks on Image 4					
Attacks	**PBS (%)**	**MSE**	**PSNR (dB)**	**BER (%)**	**NCC of ROI**
Without Attack	29.1667	0.29618	53.4152	0	0.96543
Salt & Paper	29.1667	0.55467	50.6905	1.4006	0.95206
Gaussian	29.1667	18.0405	35.5683	50.4202	0.80208
Speckle	29.1667	9.2714	38.4594	43.1373	0.88406
Poisson	29.1667	5.2915	40.895	42.9272	0.98225
Blurring	29.1667	0.60193	50.3354	12.1849	0.88867
Sharpening	29.1667	3.2694	42.9861	47.1289	0.96511
Rotation by 90	29.1667	53.3449	30.8599	47.8992	0.07639

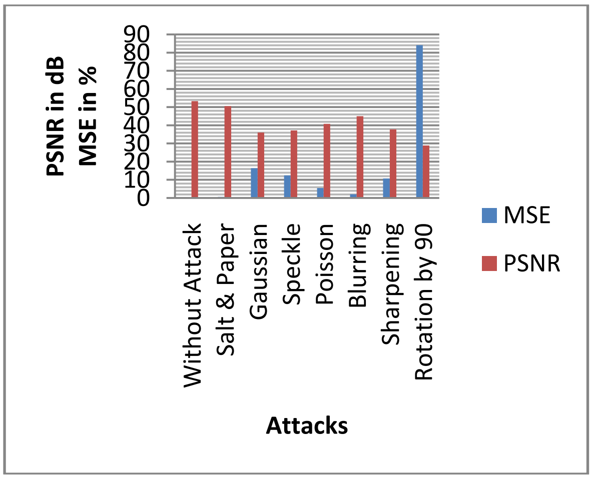

Figure 5 Graphical Chart for PSNR & MSE

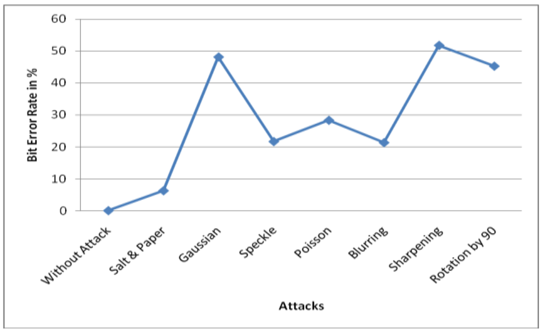

Figure 6 Graphical Chart for BER

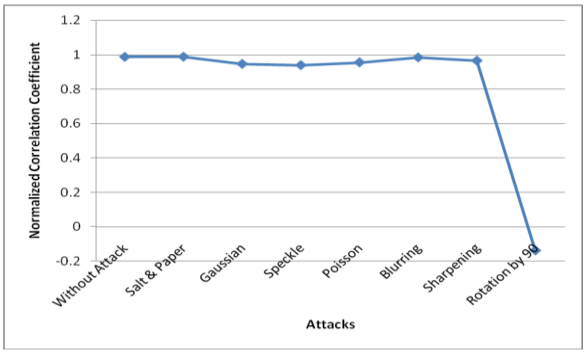

Figure 7 Graphical representation of NCC

From table 6.1 to 6.4, it is clear that percentage of bit per saving is more than 25% so high capacity is achieved with CDCS.

Then the different watermarked images was tested for Gaussian noise, salt & pepper noise, speckle noise, Poisson noise, blurring, sharpening, rotation attacks with same report. The PSNR obtained with the proposed algorithm is more than 54 dB to ensure that the watermarked image closely resembles the input medical image. The acceptable PSNR values are above 40 dB.

It specifies data hiding is effectively done.

NCC is the parameter to assess the correlation between the extracted ROI and the embedded ROI. Achieved a NCC value is 0.98834 which is approximated to 1 implies that extracted ROI and the embedded ROI are same in case of without attack.

Bit error rate is the parameter to measure the number of bits gets distorted at the time of extraction which will change the data. The Bit error rate value is 0 in case of without attack.

5 CONCLUSION

Class dependent coding scheme is useful to save number of bits hiding capacity of data.
DWT Watermarking technique with CDCS are successfully implemented and tested for various attacks. High value PSNR is estimated. Zero bit rate error & approximate correlation is obtained. High capacity and effective medical image data hiding is achieved using CDCS & DWT.

6 ACKNOWLEDGMENT

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