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A New Approach for Roni Based Medical Image Watermarking Using Contourlet Transform

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Abstract

The majority of modern healthcare systems rely their diagnoses on data collected from the internet. The medical imaging and patient health records are transmitted over the network via the internet-enabled healthcare (E-health) applications. In practical medical applications, the primary problem is the security of medical images transmitted over the internet. For the purpose of embedding secret data on medical images without affecting important information, a trustworthy watermarking approach is required. We provide a unique watermarking approach in this research that embeds the watermark data in the medical image's Region of Non- Interest (RONI). The medical image is subjected to a contourlet transform, and RONI is determined using contourlet coefficients. In this work, we demonstrate the embedding and extraction process of medical image watermarking using Contourlet transform. Experiments are carried out on medical images such as MRI and CT images. The performance of the proposed scheme is analyzed using the metric PSNR. The proposed scheme provides an average PSNR value of 47.1604% for MRI images and 57.5452% of PSNR for CT images.

Keywords: *Medical Image, Watermarking, Contourlet Transform, RONI, Image Security*.

1. Introduction

Over the decades, the development of technology is increasing day by day. Thousands of multimedia data is transmitted over internet every day. Data security and quality are the major concerns in data transmission. In the medical field also, transmission of medical images through internet without losing any information is the challenging task. The increasing number of medical images in the medical field needs to be shared among specialists and hospitals. The sharing of medical images through internet among hospitals requires privacy. Security of medical information implies three main qualities. They are (i) Confidentiality, (ii) Reliability and (iii) Availability. In Confidentiality, the information which is transmitted must be accessible by the owners only. (ii) Reliability has two aspects. (a)Integrity and (b) Authentication. Integrity means the information must not be modified by unauthorized users. Authentication means the proof that the information belongs to the correct users. (iii)Availability is the ability of the information to be used by the owners in the normal scheduled condition of access and exercise.

Medical Imaging is the visual representation of the functions of particular organs or tissues of the human body which helps to view the internal organs of the body. Medical Imaging is used to diagnose the problems in the particular organ of the body. MRI (Magnetic Resonance Imaging), CT (Computed Tomography), X-Ray and Ultrasound are some of the types of Medical Images.

In recent days, the hackers are adding harmful effects in the Medical Imaging. This will lead to misguided decision making by the doctors and healthcare professionals. The patient medical record should not be hacked or altered by any hackers or attackers. Medical data are to be transmitted very securely through the internet. For the transmission of medical data in secured way, some techniques are used in the medical field. Watermarking is the best method for handling medical images in a secured manner. Watermarking is the process of embedding a logo or data into the original medical image. By means of watermarking process, the Medical Image is transmitted safely through the Internet.

Watermarking process consists of two phases. They are (i) Embedding Process and (ii) Extraction Process. In Embedding Process, a logo or data is embedded into the Medical Image. In the Extraction process, the embedded data is extracted from the Watermarked Image. Any modification in the significant area must not be accepted. This difficult can be solved by the following technique. Split the medical image into two regions. Region of Interest (ROI) and Non-Region of Interest (RONI). The pixels of the ROI region contain important information. Watermarking process can be done on the RONI region to save the pixel values in the medical images.

In this proposed work, watermarking is done in the RONI by considering Contourlet coefficients. For embedding in the RONI, Significant Binary Mask Generation is used to locate the pixels which are not playing major role in the medical image. Reference image or Hospital Logo can be embedded with the help of Secret key or watermark data which is also used in the extraction process.

Literature Survey

Watermarking in medical images can be carried out by many techniques. This proposed work is implemented based on Region of Non-Interest (RONI) in the medical images using Contourlet Transform. Watermarking of medical images in the RONI region focuses on insignificant regions in the medical images. Poovadi Aparna et al. [19] implemented an image watermarking technique using crypto watermarking system for E-healthcare applications. The authors described the embedding method in which bit streams are compressed and embedded. Jing Liu et al. [10] developed a multi watermarking method using the henon map chaotic encryption technique to strengthen the security of watermark information to resist both conventional and geometric attacks. Xin Zhong and Frank.Y.Shih, Uma Mageswari. A et al. [14]: Umamageswari, A et al. [13] developed a frequency domain reversible watermarking technique to hide the watermark data in ROI and RONI which increases the security.

Asaad.F.Qasim et al. [2]: Singh et al. [27]: Rahman et al.[3] developed a scheme to segment the image into 2 regions as ROI and RONI. The watermark data is embedded into the ROI region using reversible watermarking technique. Jeyanthi et al. [1] implemented a technique for watermarking on RONI. In this work, fuzzy interference rules are used to predict the RONI portion of the image and then watermark data is embedded into the singular values of RONI. Nour AlHoudaGolea et al. [25] developed a ROI based fragile watermarking technique. Atta Ur Rahman et al. [8] developed a fragile watermarking technique in which the medical image is divided into two parts using rectangular region. Two watermarks are used for embedding process. One watermark is used to achieve authenticity of image and other is used to achieve robustness against attacks. Abbasi et al. [21]: Roček et al. [4]: Novamizanti et al. [15] developed a reversible watermarking technique. Anusudha. K et al. [31]: R. Shri raama et al. [32]: Can deset al. [33]: Keshta et al. [24]: Gupta et al. [26]: Ahmed et al. [20] developed a watermarking technique for telemedicine applications using Electronic Health Record (EHR). Zainol et al. [28]: Ayangar et al. [16]: Yasmeen et al. [29]: Zermi et al. [30] developed a watermarking technique based on Singular Value Decomposition (SVD) technique. Yadav et al. [22] implemented a watermarking scheme based on DWT-SVD-WHT in the telemedicine applications. Goyal et al. [17] implemented a watermarking scheme using Curve let transform in ECG signals.

Arda Ustubioglu et al. [6] carried out a watermarking technique in which the watermark data is extracted even when an image was attacked by compression, cropping and noise addition. Xiyao Liu et al. [7] developed a watermarking technique based on Recursive Dither Modulation (RDM) with Slantlet transform and singular value decomposition. In this technique, the image is decomposed into ROI and RONI regions under limited embedding capacity. The watermarks are embedded into the whole image to avoid risks. Rahini et al. [5] developed a dual adaptive watermarking scheme using contourlet transform in the RONI region. Ali Alzahrani et al. [11] developed a watermarking system based on DWT-DCT and SVD technique in which the input medical image is divided into ROI and RONI region and DWT is applied on the RONI region. Priyanka Singh et al. [9] developed a watermarking scheme based on Least Significant Bit (LSB) substitution technique. In this work, the medical image is partitioned into ROI and RONI regions. The watermark data is embedded into the ROI region. Balasamy. K et al. [12] carried out a watermarking scheme using fuzzy based ROI method. Allaf et al. [18]: Tarhouni et al. [23] developed a usage of watermarking scheme in medical field.

Proposed Work

The following contributions are made in this work.

1.A novel algorithm is proposed to identify the Region of Non-Interest (RONI) in the medical image using contour let transform technique to embed the secret data.

2.A framework for watermark embedding and extraction is proposed using contourlet transform based approach formedical images.

Background

Now a days, there are several techniques available for digital image watermarking. According to domain, the watermarking process can be carried out in two ways. They are (i) Spatial Domain and Frequency. In the spatial domain, the pixel of the original image will be altered by the watermarking process. To overcome this problem, frequency domain watermarking techniques were used. In frequency domain, watermarking process can be carried out by (i) Discrete Cosine Transform (DCT) (ii)Discrete Wavelet Transform (DWT) and (iii) Discrete Fourier Transform (DFT) (iv) Curvelet Transform and (v) Contourlet Transform and etc., In the frequency domain the watermarking process is applied on the coefficient's values of the images. Comparing to frequency domain watermarking techniques such as Discrete Wavelet Transform and Curvelet transform, in which Contourlet Transform provides exact reconstruction of the original image. In addition, the stability against attacks, ease of implementation and better computational complexity is also obtained. Compared to Curvelet Transform, the sub- band sin Contour let Transform overlap with each other. This proposed work deals with watermarking using Contourlet transform. Moreover, the watermark data can be embedded into the selected Contourlet coefficients to secure the original image.

The first generation of Contour let Transform was developed by Do and Vetterli in 2002which is a two- dimensional transform method for image representations. Contourlet Transform can capture the smoothness of edge so images with different elongated shapes and in variety of directions. Two filter bank structures namely Laplacian Pyramid (LP) filter and Directional filter Bank (DFB) have been used in Contour let transform.

Laplacian filter is used to capture point discontinuities and then Directional filter bank is used to form those point discontinuities into linear structures. Laplacian Pyramid filter bank coefficients are called approximation band sand Directional filter bank coefficients are called detail bank. Directional filter bank passes high frequency values and drops all the low frequency signal sin its directional sub bands. This is the reason for combining Directional filter with Pyramidal filter. This multi scale resolution combination will remove all the low frequency sub bands. The property of this Contour let Transform is used to constructs the original image clearly.

The Watermarking process consists of two phases. (i) Embedding process and (ii) Extraction process. In embedding and extraction processes, three components are considered. They are (a) Original Medical Image(b) Watermark data (c) Reference Image (Hospital Logo). In this work, the electronic Health Record (EHR) is considered as the watermark data and Hospital logo is considered as the reference image.

In Medical Image Processing the portion of a medical images can be divided into 2 regions. Region Of Interest (ROI) and Region of Non-Interest (RONI). The Region of Interest (ROI) may be the boundaries of an organ or a volume of mass. Any changes in the ROI leads to misinterpretation. The remaining area of an image except the boundaries is called Region of Non-Interest (RONI) of an image. In this work, we propose a methodology to identify the RONI in medical image and embedding is done in the RONI.

Embedding Process using proposed methodology

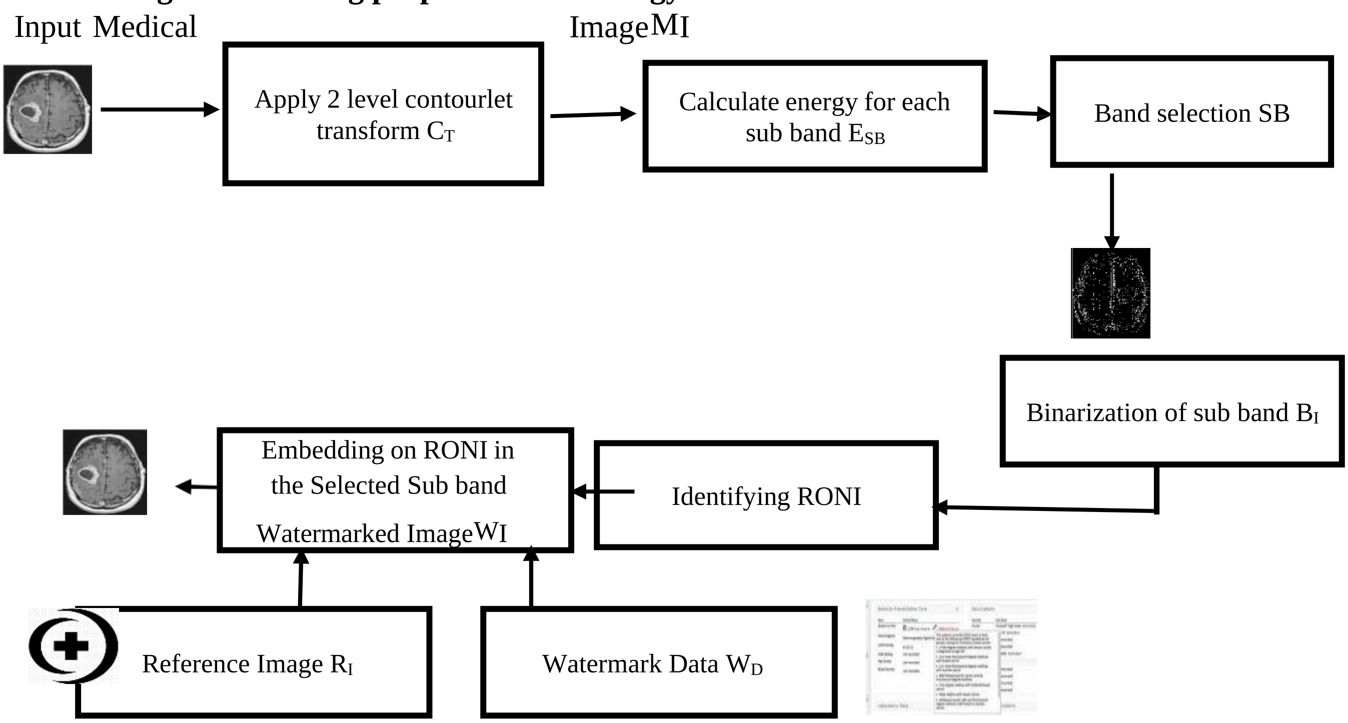


Fig 1. Block Diagram for Embedding Process

For embedding process, the input medical image is subjected to Contour let Transform. In this work the applied two-level Contour let Transform which divides the input medical image into4 sub bands. Then the sub band which has middle energy value is selected for embedding process. The watermark data (i.e., EHR) which available in text format is converted into binary bit streams. The size of the Reference image (i.e., Hospital Logo) is adjusted to match with the sub band. The middle energy sub band is also converted into binary mask image. Finally, the watermark binary streams along with Reference Image are embedded into the selected sub band of the original image. Fig.1 demonstrates the embedding process used in this work. the step-by-step procedure of embedding process is presented below.

Embedding Procedure

Step1: Apply Contourlet Transform

Apply 2-level contour let transform on the input Image MI. It produces approximation sub-band and detail sub-band. This results in following sub bands.

Step2: Calculate energy value

Sub band Coefficients Xi = pdfbdec (MI, p filter, d filter, n levels) (1)

Pdfbdec is the Pyramidal filter and Laplacian filter functions of Contour let transform.

Calculate the energy value of each sub band using the Equation (2).

$$\text{Energy}(E_{SB}) = \frac{X_1^2 + X_2^2 + X_3^2 + X_4^2 \ldots . X_n^2}{\sum X_i}$$

Where X_i refers to coefficient value of ith element (2)

Step3: Identify the middle energy sub band

Arrange the sub band sin ascending order in terms ofenergy value. S1, S2, S3, S4. and select the sub-band which

Step4: Binarization of selected Sub band

Binarization of sub-band is carried out by analyzing the coefficient value and the binary mask is generated from the sub-band using the Equation (3).

Binary Mask B_I=1: if Xi> γ

Binary Mask B_I =0: if Xi<γ (3)

has middle energy value. In this work, the sub band which isat second position is selected as the middle energy sub-band.

The RONI is localized by identifying the non- significant region of the Binary Mask B_I. In order to identify the non- significant region, the Binary Mask B_I is divided into sub blocks of size2X2and the number of ones and zeros are counted for each sub block. The subblock SB is marked asRONI in which the average numberof1's is less than the threshold value β. The Avg-ones is calculated using Equation (4).

Xi–Coefficient Value

γ =10 is chosen to calculate the correct RONI region of theMedical Image.

Avg-ones= $\frac{Number\ of\ 1's\ in\ the\ block}{Total\ number\ of\ elements\ in\ the\ block}$

If Avg-ones >= β ; Sub block SB is ROI (4)

Step 5: Localization of RONI in Binary Mask.

If Avg-ones<β; Sub block SB is RONI ; β = 0.5 .

Step 6: Embedding Process

After identifying the RONI, the embedding process is carried out as follows.

The watermark data (i.e., EHR) is converted into binary form based on the watermark data, the embedding processcalculated as given below.

If Watermark data W_D=0,

Watermarked Image W_I= {α×R_I} (5)

If Watermark data W_D=1,

Watermarked Image W_I=-{α×R_I} (6)

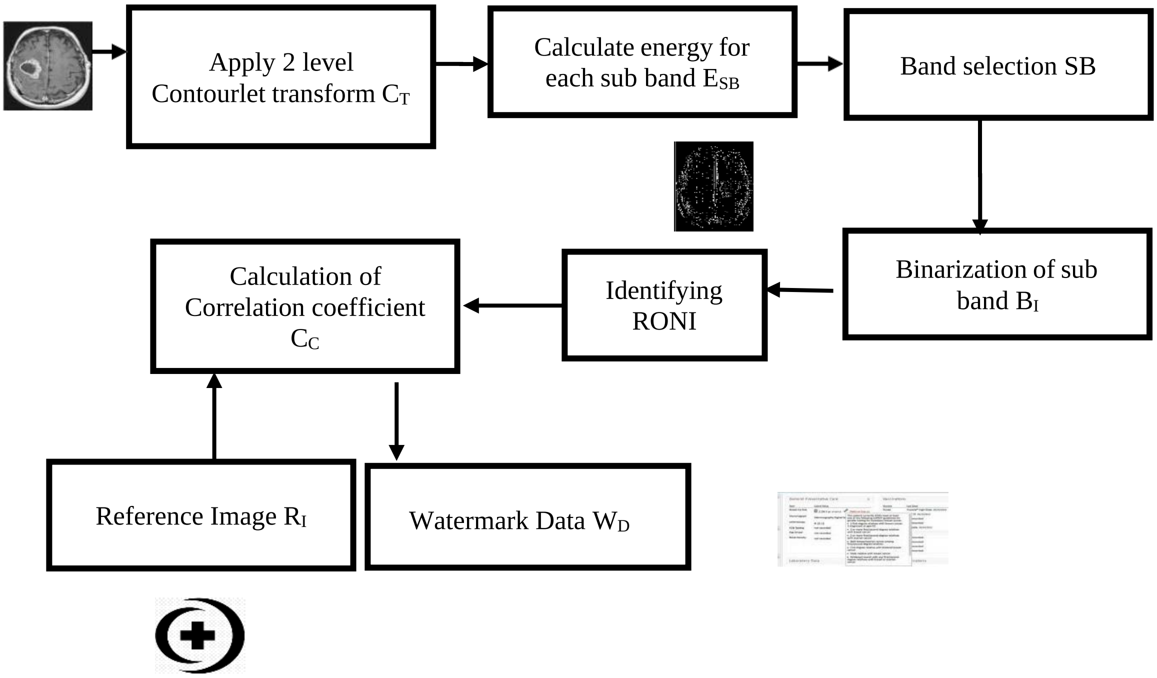
After embedding, Inverse Contourlet Transform is appliedand transmitted to the recipient.

Based on the analysis α value is chosen as 0.9. Inverse transform can be applied by using equation (7) Coefficients = pdfbrec (sub band-inv, p filter, d filter) (7)

Extraction Procedure

In the extraction process, the input is Watermarked Image, Reference Image (Hospital Logo), and the output is Extracted Watermark data. The embedded watermark data is extracted without any loss from the watermarked image.

Watermarked Image WI



Extracted Watermark Data WD

Fig 2. Block Diagram for Extraction Process

The extraction process is demonstrated inFig2. In this extraction process, calculation of Correlation Coefficient of sub-band of the Watermarked Image and Reference Image is used to retrieve the Watermark data.

The step-by-step process for the extraction process is given below.

Step1: Apply Contourlet Transform

In this Extraction process, the Watermarked Image is subjected into 2-level Contour let transform. This produces four sub bands.

Sub band Coefficients = pdfbdec (WI, p filter, d filter, nlevels) (8)

Pdfbdec is the Pyramidal filter and Laplacian filterfunctions of Contour let transform.

Step2: Calculate energy value for each Sub band

Calculate the energy value of each sub band usingEquation (9)

Step3: Calculation of middle energy sub band

Arrange the sub band sin ascending order in terms of energy values such asS1, S2, S3, S4 and select the sub band which has the middle energy value. In this work, the sub band which is at second position is selected as the middle energy sub-band. This middle energy sub-band isused for further actions for watermarking process.

Step4: Binarization of selected Sub band

Binarization of sub-band is carried out by analyzing the coefficient value X_i and the binary mask BI is generated from the sub-band using Equation (10).

Binary Mask=1: ifXi>10
Binary Mask =0: ifXi< 10 (10)

Where X refers to coefficient value of i^{th} element.

Energy (E

$$SB) = \frac{X_1^2+X_2^2+X_3^2+X_4^2 \ldots X_n^2}{\sum X_i} \quad (9)$$

Step5: Calculation of Correlation Coefficient

In this extraction process, calculate the number of 1's in the Binary Mask to the total number of elements in the mask will be less than 0.5. Then calculate the correlation coefficient between sub-band of Watermarked Image WI and the Reference Image RI.

$CorrelationCoefficient$ C C $=\sum^{i=m,=n}(Sub$-

Experimental Results and Performanceanalysis

The proposed watermarking schemes are experimented using MRI and CT images. The strength of the proposed scheme is also verified against attacks. Some of the attacks are introduced in the embedded image. The attacks include frequency-based compression, addition of noise, cropping and correction. The noise like

$band*ReferenceImage)$

i=0,=0

salt and pepper, speckle, median filter and bilinear filter are introduced in the embedded image.

If Correlation Coefficient CC>=0; Watermark data=1
If Correlation Coefficient CC<0; Watermark data=0 (11)
The sequence of 1's and 0's is converted from binary intotext.

Dataset

In this work, for experimental purpose, we used some of the data bases of MRI images and CT images whichare available freely. The data bases used in this work are listed in Table1.

Table1. Datasets of MRI and CT Medical Images

SL.NO	DATABASES	Website Link
1	**MRI Images** Brain MRI Knee MRI Fetal MRI	https://www.kaggle.com/navoneel/brain-mri-images-for- brain-tumor-detectionhttps://stanfordmlgroup.github.io/competitions/mrnet/ https://f1000research.com/articles/6-93
2	**CT Images** Lung CT Brain CT	https://wiki.cancerimagingarchive.net/display/Public/4D-Lunghttps://wiki.cancerimagingarchive.net/display/Public/Brain-Tumor-Progression

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Performance Metrics

Performance analysis is significant and quantitative metrics are utilized for assessing the performance of any algorithm in medical image processing. PSNR is the metric used in this work to analyze the performance of the Peak signal to noise ratio is used to find the difference between the original medical MI image and watermarked image WI. The ratio between the maximum possible pixels of an image and the value of corrupting pixels that affects the quality of an image is calculated.
proposed technique.

Peak Signal to Noise Ratio (PSNR)

$PSNR = 10 \log 10 \frac{Maximum\ value}{MSE}$

$MSE = \frac{\sum_{i=m}^{j=n} \sum_{i=p}^{j=q} (M_I * W_I)}{\sum WI}$ (12)
13)

MI= Original Medical Image WI = Watermarked Image

Experimental Results

The proposed watermarking scheme is tested on MRI images and the PSNR value is presented in Table 2. The various attacks such as salt noise, speckle noise and Median filter and Bilinear filter were applied on the MRI medical images and the performance is analyzed by using performance metric PSNR.

Table2. Performance of proposed watermarking scheme for MRI Medical Images with various Attacks(Metric: PSNR)

SL.NO	MRI Image	(Without any attacks)	Proposed scheme with various attacks			
		Proposed Scheme	Salt Attack	Speckle Attack	Median Filter	Bilinear Filter
1	MRI 1	47.3853	43.2137	45.0904	45.2123	28.3197
2	MRI 2	48.1974	45.1126	43.0305	42.0699	17.9837
3	MRI 3	48.3416	41.8797	43.0380	43.0688	26.1552
4	MRI 4	48.3224	40.2296	44.8155	44.3571	28.2892
5	MRI 5	48.1974	41.1608	43.0221	42.0699	17.9837
6	MRI 6	43.4779	40.0641	40.9022	38.9287	23.4503
7	MRI 7	46.1406	41.3698	43.2832	41.4066	24.7621
8	MRI 8	48.2465	42.5134	42.9706	41.2668	16.7936
9	MRI 9	48.4887	43.3538	43.8977	36.1756	18.9151
10	MRI 10	47.1768	43.6988	48.3497	38.2766	24.9131
11	MRI 11	47.3853	41.9256	45.1032	45.2123	28.3197
12	MRI 12	48.7671	40.8075	45.3201	45.2557	25.9397
13	MRI 13	48.2796	41.8025	46.2737	43.9808	24.7711
14	MRI 14	36.1590	35.4727	35.2834	32.5462	19.7559
15	MRI 15	47.9682	41.7339	43.6443	42.9272	22.5352
16	MRI 16	48.2116	42.2951	43.9828	41.4709	23.5783
17	MRI 17	46.2323	41.1709	43.0030	41.0360	22.5556
18	MRI 18	48.4163	42.9799	45.1506	41.2076	25.4660
19	MRI 19	48.4887	40.7921	43.8989	36.1756	18.9151
20	MRI 20	47.8288	42.1032	43.3743	42.7793	22.1347
21	MRI 21	45.2329	40.1845	42.0495	38.0060	19.0371
22	MRI 22	49.7372	40.3624	44.8750	43.7938	25.1225
23	MRI 23	48.7671	40.4413	45.3029	45.2557	25.9397
24	MRI 24	45.1540	40.2467	43.5421	39.8360	24.8955
25	MRI 25	48.4887	41.5687	43.9059	36,1756	18.9151
Average PSNR		**47.1604**	**41.4593**	**43.7244**	**41.1396**	**23.0178**

The proposed watermarking scheme is tested on various CT medical images and the PSNR value is presented in Table 3. The various attacks such as salt noise, speckle noise and Median filter and Bilinear filter were applied on CT images and performance were computed by using metric PSNR.

SL. NO	CT Image	(Without any attacks)	Proposed scheme with various attacks			
		Proposed Scheme	Salt Attack	Speckle Attack	MedianFilter	BilinearFilter
1	CT1	57.5277	43.0182	40.6913	33.0036	20.5463
2	CT2	57.3619	39.9634	40.6271	33.7881	22.3804
3	CT3	58.4523	40.0270	40.7920	33.5292	20.6762
4	CT4	56.7028	41.1766	40.2023	32.7424	22.4492
5	CT5	56.3604	41.4128	39.8913	33.2997	22.4845
6	CT6	57.2848	40.3337	40.8609	26.7871	21.2674
7	CT7	58.2454	41.1658	40.9755	25.4936	19.3297
8	CT8	57.9463	39.5418	41.5036	32.4855	23.4975
9	CT9	54.5460	41.8659	40.7751	24.9475	19.4446
10	CT10	57.3040	40.5016	36.6729	31.8110	21.4605
11	CT11	57.1033	39.7344	40.7095	30.4163	19.8580
12	CT12	57.1179	41.7937	36.9908	30.1864	19.2929
13	CT13	57.9929	41.4281	40.6218	30.1334	19.6345
14	CT14	58.0310	40.4273	40.5653	30.3794	19.3278
15	CT15	57.9622	40.5882	41.4511	30.0994	20.2650
16	CT16	58.9508	40.8210	41.4202	31.5452	20.7223
17	CT17	58.2816	43.9339	40.8846	30.6199	20.0131
18	CT18	57.9071	40.1167	41.0011	30.9430	21.2113
19	CT19	57.0549	39.9909	40.8605	29.2205	19.6847
20	CT20	57.4488	40.9497	41.0953	31.2192	20.7831
21	CT21	58.1378	41.0865	41.0538	30.9740	20.3097
22	CT22	57.5213	41.5270	41.0927	31.5385	20.7726
23	CT23	57.6719	41.5181	41.0138	30.5314	19.8806
24	CT24	57.6463	39.7366	41.0204	31.0117	20.8202
25	CT25	58.0720	41.7146	40.7262	30.4437	19.8458
Average PSNR		**57.5452**	**40.9749**	**40.5399**	**30.6859**	**20.6383**

Table3.Performance of proposed watermarking scheme for CT Medical Images with various Attacks(Metric: PSNR)

In the above Table 2 and Table 3, proposed work produces best PSNR value. In which Salt and Pepper attack and Speckle attack produces medium PSNR values compared with Median filter and Bilinear filter. In Salt and Pepper attack minimum factor 0.0002 produces best results compared with 0.002 and 0.02. From the results, decrease in attacks value will produces better PSNR results. In which Median filter produces PSNR value nearly 30%. Because the median filter operates by going pixel-by-pixel across the image and replacing each value with the median value of nearby pixels. Because of this property it produces least PSNR value. In the above Bilinear filter produces very least PSNR value compared with other techniques. Because it mainly operates on the average pixel values in each block, so it producesleast PSNR value.

Table4.Performance of proposed watermarking scheme for MRI Medical Images in comparison withfew existing techniques (Metric: PSNR)

The performance of Proposed watermarking scheme was tested with existing watermarking techniques and the computed PSNR values for MRI Medical images are shown in Table 4. Few existing techniques such as DWT with SVD, DWT with BS, DCT and Curvelet are some of the existing techniques. The performance of the Proposed scheme and existing watermarking techniques were tested and compared by using Performance metric PSNR.

SL.NO	MRI Image	Proposed Scheme	DWT with SVD Ref [31]	DWT withBS Ref [32]	DCT Ref [33]	CurveletRef [34]
1	MRI 1	47.3853	30.5204	46.8023	11.4994	36.1747
2	MRI 2	48.1974	26.9814	39.9389	8.1180	33.5429
3	MRI 3	48.3416	25.3076	46.4842	8.2774	58.8873
4	MRI 4	48.3224	33.1564	53.2025	11.0759	40.6005
5	MRI 5	48.1974	26.9814	39.9389	8.1180	33.5429
6	MRI 6	43.4779	27.6350	33.3116	7.9356	12.8829
7	MRI 7	46.1406	26.4482	45.8987	9.8715	11.9059
8	MRI 8	48.2465	23.9684	36.1992	8.2632	30.2506
9	MRI 9	48.4887	29.7784	31.7169	9.7528	31.4744
10	MRI 10	47.1768	37.4595	52.7468	15.3721	55.5613
11	MRI 11	47.3853	30.5204	46.8023	11.4994	36.1747
12	MRI 12	48.7671	29.7407	38.1515	11.1139	41.0355
13	MRI 13	48.2796	31.2692	35.7180	12.3046	36.8442
14	MRI 14	36.1590	27.0308	33.7922	6.4644	12.7879
15	MRI 15	47.9682	25.0729	35.6197	9.8381	29.8844
16	MRI 16	48.2116	29.3100	32.6981	9.2923	28.6254
17	MRI 17	46.2323	28.6722	36.1958	9.2067	19.1463
18	MRI 18	48.4163	29.5281	42.5919	11.4296	58.8873
19	MRI 19	48.4887	29.7784	31.7169	9.7528	31.4744
20	MRI 20	47.8288	24.0603	33.3953	9.4960	28.0425
21	MRI 21	45.2329	29.4154	33.5964	8.1496	21.8899
22	MRI 22	49.7372	30.0474	41.7252	11.1435	58.8873
23	MRI 23	48.7671	29.7407	38.1515	11.1139	41.0355

24	MRI 24	45.1640	26.7608	42.9904	11.5379	44.0242
25	MRI 25	48.4887	29.7784	31.7169	9.7528	31.4744
Average PSNR		**47.1604**	**28.5058**	**39.2440**	**10.0151**	**34.6014**

Table5.Performance of proposed watermarking scheme for CT Medical Images in comparison with few existingtechniques (Metric: PSNR)

The performance of Proposed watermarking scheme was tested with existing watermarking techniques and the computed PSNR values for CT Medical images are shown in Table 5. Few existing techniques such as DWT with SVD, DWT with BS, DCT and Curvelet are some of the existing techniques. The performance of the Proposed scheme and existing watermarking techniques were tested and compared by using performance metric PSNR.

Sl.No	CT Image	Proposed Scheme	DWT with SVD Ref [31]	DWT withBS Ref [32]	DCT Ref [33]	CurveletRef [34]
1	CT1	57.5277	28.2467	48.5744	6.7092	58.8873
2	CT2	57.3619	29.8915	48.3034	5.8710	43.6013
3	CT3	58.4523	28.2798	48.7493	6.9670	31.3316
4	CT4	56.7028	28.8383	48.3126	5.8484	33.9525
5	CT5	56.3604	28.2211	48.5423	5.4719	31.3806
6	CT6	57.2848	32.4033	50.7466	6.0455	34.5353
7	CT7	58.2454	29.0949	50.1597	6.8808	58.8873
8	CT8	57.9463	28.0152	54.7041	4.6471	58.8873
9	CT9	54.5460	27.4001	51.4583	5.3365	58.8873
10	CT10	57.3040	28.1460	49.4382	5.1340	58.8873
11	CT11	57.1033	29.0526	45.4435	6.6030	43.5598
12	CT12	57.1179	28.7089	45.3420	6.3874	35.8670
13	CT13	57.9929	28.9079	43.3860	7.0428	24.2991
14	CT14	58.0310	28.4241	49.4586	6.2144	36.8989
15	CT15	57.9622	29.2049	49.8894	7.4915	42.5735
16	CT16	58.9508	32.7534	50.6692	8.8131	40.2265
17	CT17	58.2816	29.3448	50.4897	6.9835	42.4481
18	CT18	57.9071	30.8376	50.1881	6.6556	36.7635
19	CT19	57.0549	29.5783	49.5463	7.0674	39.9279
20	CT20	57.4488	29.6886	50.6569	6.7863	35.3989
21	CT21	58.1378	30.3606	50.3714	8.0822	34.9519
22	CT22	57.5213	29.6115	50.4481	6.8140	38.2248
23	CT23	57.6719	27.9619	50.0366	7.1980	44.5848
24	CT24	57.6463	29.7732	50.1115	6.7857	16.0730
25	CT25	58.0720	28.8637	46.0660	6.5285	43.9138
Average PSNR		**57.5452**	**29.2643**	**49.2436**	**6.5745**	**41.9720**

In the above Table 4 and Table 5, proposed work produces best PSNR compared with other techniques. In that calculation DCT produces least PSNR value compared with other techniques. Because of its varying magnitude and frequency value in the image pixels, DCT produces least PSNR value.

5. Discussion

The proposed algorithm is tested on nearly 25 Medical images. From which some of the sample medical images is shown for the illustration of the proposed work. As per the Watermarking procedure the above 50 sample medical images are watermarked with the Electronic Health Record with hospital logo as reference Image. The watermark data is embedded into the Region of Non-Interest of the original image. This results in a highly secured data transmission over the Internet. Some of the other Watermarking Techniques such as DWT with SVD technique produces PSNR value as 28.5058 for MRI Images and 29.2643for CT Images and DWT with BS produces PSNR value as 39.2440 for MRI Medical Images and49.2436 for

6. Comparative Analysis

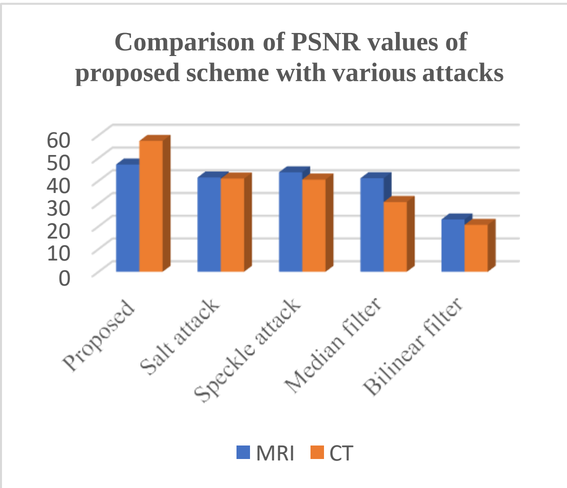

Fig 3. Comparative analysis forPSNR Calculation of Proposed Scheme with various attacks forMRI and CT Medical Images

CT Medical Images and DCT Technique produces PSNR value as 10.0151 for MRI Medical Images and 6.5745 for CT Medical Images and Curvelet Transform produces PSNR value as 34.6014 for MRI Medical Images and 41.9720 for CT Medical Images. But proposed scheme produces PSNR value as 47.1604 for MRI Medical Images and 57.5452 for CT Medical Images and also proposed work compared with some of the attacks namely Salt and Pepper Noise, Median filter, Speckle attack, Bilinear filter. In which proposed work produces best PSNR compared with attacks. When attacks applied in the image, it will normally decrease the quality of an image.

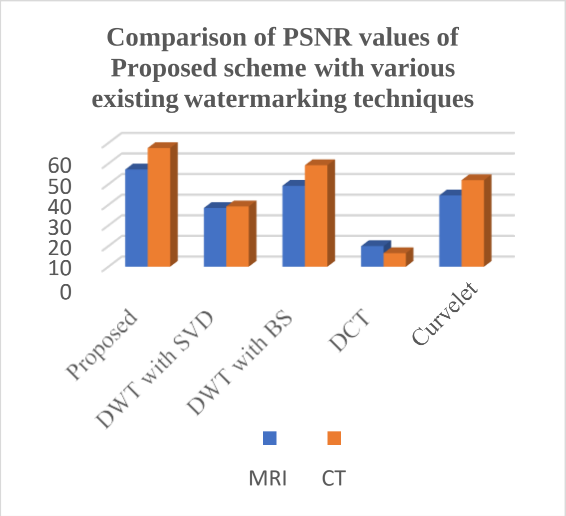

Fig 4. Comparative analysis for PSNR Calculation of Proposed Scheme with existing Watermarking Techniques forMRI and CT Medical Images

7. Conclusion

The proposed scheme is the watermarking process using Contourlet Transform in Medical image in the RONI region. In this comparison side it shows how the best results compared Proposed technique with various attacks such as salt and pepper noise, speckle noise, median filter and bilinear filter applied in the watermarked image to prove the effectiveness of the watermarked image. Large number of characters in HER can be used in proposed scheme. The embedding process be taking place in the binary form with band selection in the RONI region. The proposed scheme uses embedding process in RONI in the selected binary image sub-band. The proposed algorithm shows the secured transmission of medical images over the Internet compared with various attacks applied in the medical image.

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