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Maximum Like-hood NON-ROI Position based Image Watermarking for Medical Images

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Abstract— **In this paper, a medical image watermarking technique based on maximum like-hood NROI positions is proposed. It is used to embed the data of patient and ROI into the medical image, provides robustness to the embedded data and ROI as well as recovers the patient data and the ROI. Telemedicine includes transmission of medical images from one place to another for medical diagnosis. These medical images can be changed accidentally or intentionally. In this proposed work, the medical image is divided into two regions namely; region of interest (ROI) and non-region of interest (NROI). The ROI is used for medical diagnosis. Later, the patient data and ROI are compressed using Huffman coding and then embedded into NROI using maximum like-hood detection positions. The results of the experiments conducted on various medical images show that the proposed method maintains the quality of the watermarked medical images, provides robustness to the embedded data and recovers the original patient data and the ROI.**

Index Terms— **DICOM, Huffman, NROI, ROI, Watermarking**

1. INTRODUCTION

Telemedicine makes use of latest technologies for providing medical services in distant rural areas. It allows the patients to get treatment from far away specialists without visiting the specialists. It involves exchange of medical images between the physician and the patient. Medical images play an important role in diagnosis of patients. While sharing of these medical images, they pass through unsecure networks like internet. Hence, these medical images can be changed by the intruders or can be attacked by noise. This can lead to wrong diagnosis. Watermarking is a helpful tool in such cases. The digital Watermarking embeds digital information called watermark into digital multimedia data [5]. The digital watermark can be audio, text, logo and graphics. The third party is unaware regarding the transmission of the hidden data. The watermarking schemes can be categorized based upon the input. It can be audio watermarking, video watermarking and text watermarking. In this proposed work, image watermarking is being considered.

For protecting the digital images, four categories of watermarking schemes have been developed. These are Robust Watermarking, Semi-Fragile Watermarking, Fragile Watermarking and Hybrid watermarking [7]. The robust watermarks are hard to be removed from the digital images, so the robust watermarking methods are generally used for the copyright protection of images. Robustness indicates the ability of accurately extracting the watermark data after tackling different types of attacks. Robust watermarks can tolerate intentional as well as unintentional attacks like compression, cropping, scaling and so on. The Semi-fragile watermarks can withstand only unintentional attacks. The fragile watermarking is used for confirming the authentication of digital images. If any modification takes place, the fragile watermark is eliminated from the watermarked image. The hybrid watermarks combine both fragile and robust watermarks.

Attacks can degrade the medical image as well as the data embedded inside the medical image. Signal processing attacks and geometric attacks are the two types of attacks. The signal processing attacks involve filtering, compression and additive noise. The geometric attacks involve rotation, scaling, cropping, shearing and random bending [2]. A good watermarking method must be robust, imperceptible and secure. The watermarks can be visible and invisible. The visible watermarks can be detected with naked eye whereas the invisible watermarks cannot be seen. The invisible watermarks are such that the third party cannot detect the transmission. In proposed work we use invisible watermarking. The watermarking can be done in spatial domain or frequency domain or multi resolution domain [12]. The frequency domain watermarking method changes the original image into frequency domain by using Fourier, discrete cosine or wavelet transforms and watermark data is added to the values of transform coefficients. The spatial domain watermarking directly changes the intensities of the pixels. For e.g. spread spectrum based, pixel value differencing, LSB embedding. It provides high embedding capacity. The multi-resolution domain watermarking method combines both the spatial and frequency domain watermarking methods.

Section 2 refers to literature review. It gives brief description of various watermarking techniques used in telemedicine. Section 3 gives brief account of experimental setup. Section 4 describes the proposed work. Section 5 predicts the results and Section 6 refers to the conclusion.

2. REVIEW PROCESS

Rayachoti Eswaraiah and Edara Sreenivasa [1] proposed a watermarking technique for medical images based on integer wavelet transform. It accurately detects the tampered areas in the ROI, provides robustness to the embedded data in RONI region and recovers the original region of interest (ROI). The medical image is divided into important region (ROI) and unimportant region (RONI). The watermark data consists of

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patient data, ROI hash value and recovery data of ROI. This data is embedded into RONI region using IWT. The recovery data is generated and compressed. The SHA-1 technique is used to calculate the hash value of ROI. The watermark is encrypted using the secret key and this encrypted watermark data is embedded into RONI. At receiving side, the tampers are checked and if tampers are identified then original ROI is recovered and patient data is extracted.
Tianrui Zong [2] has given a robust image watermarking technique to tackle with the attacks. Histogram-shape-related index is used to deal with geometric attacks like scaling, rotation, cropping, bending, etc. A safe-band that is made between the chosen and non-chosen pixel groups provides robustness.
Seenivasagam [3] presented zero watermarking system against inversion attacks. It uses hybrid contourlet transform for authentication of medical images. The 'inversion attack' is a class of threats which lead to ambiguities in generating right ownership. This technique provides good robustness against inversion attacks.
Lavanya [8] presented method to hide data by histogram modification of medical images and by using differences depending on block division.
Osamah M. Al-Qershi [9] proposed a hybrid watermarking technique for DICOM images. This technique hides the patient data into ROI by using reversible technique and hides the recovery data into RONI by using robust technique based on discrete wavelet transform.

3. EXPERIMENTAL SETUP

The experimental setup for the proposed work is shown in Fig.1.The various steps have been summarized as follow:

Step 1: Input the host image: Input the medical grayscale scale images of different modalities like CT scan, MRI scan, ultrasound and PET scan.
Step 2: Pre-processing of image: The image is pre-processed using k-means quantization. This is used to form the clusters and remove the noise in the background.
Step 3: Image segmentation: The ROI is concluded from the image and image is segmented into ROI and NROI.
Step 4: Compression: The patient data and ROI are compressed using Huffman coding. It uses lowest number of bits for encoding the data that appears most frequently.
Step 5: Predicting the encryption key: The encryption key is predicted based on the maximum like-hood ratio.
Step 6: Embedding: The watermark data is embedded into the NROI using the encryption key based on maximum like-hood ratio.
Step 7: Distribution: The watermarked image is transmitted to the specialists in the far away cities so as to provide required diagnosis.
Step 8: Extraction: The data and ROI are extracted from the watermarked image.
Step 9: Decompression: The extracted data is decompressed using the Huffman codes.
Step 10: Parameter Evaluation: The various parameters like PSNR, WPSNR, MSSIM and TPE are evaluated to measure the performance of the proposed work. The Normalized correlation is calculated to check the robustness of the proposed technique.

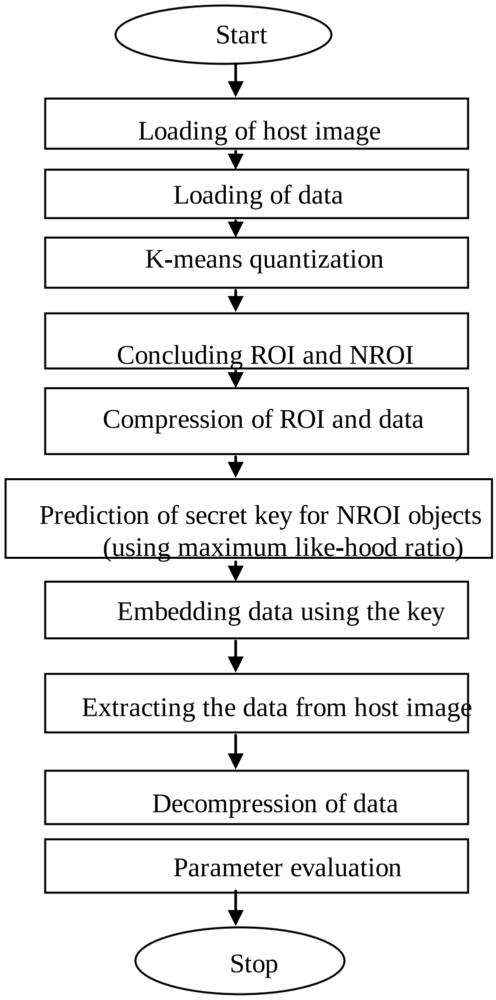

Fig.1 Experimental Setup

4. PROPOSED WORK

The proposed work makes the use of maximum like-hood locations to predict the hash key. The present work comprises of search procedure to find the pixel values in the NROI region having minimum Euclidian distance with respect to pixel values of compressed ROI and the ASCII patient data. The secret key is then produced depending upon the location map of pixels in NROI region. As the embedding process makes use of minimum Euclidian distance, this algorithm is named as maximum like-hood algorithm.

4.1 Image segmentation

In this proposed work, the medical image is divided into two regions namely ROI and NROI as shown in Fig.4. A medical image may have more than one regions of interest. This present work considers only one ROI. The ROI is usually claimed by the physician and can be of any irregular shape. In present work, the ROI is indicated by an enclosing rectangle by the physician using morphological operations.The coordinates of the vertices are used to indicate the enclosing rectangle.

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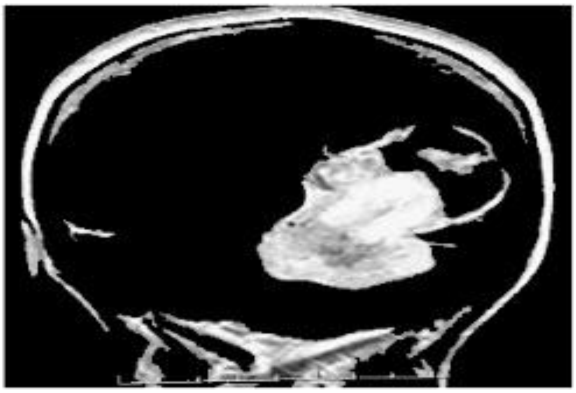

Fig.2 (a): Original image of CT scan of brain

Fig.2(c): Original image of ultrasound of abdomen

4.2 Maximum like-hood Algorithm

The maximum like-hood locations are used for embedding the compressed data into the NROI region of the medical image. This is based upon the minimum cost between the watermark data and the pixel locations of the NROI. The comparison is done between the pixel locations of the NROI and the data. The 8-bit DICOM medical image will have pixel values ranging from 0 to 255 [9]. It searches for the pixel locations in NROI region which have the minimum Euclidian distance from the watermark data. This process is repeated for the patient data and the ROI. Once a pixel location in the NROI region is marked in the location map, it will not be marked again for other values. This will avoid embedding of multiple data on same location in the NROI. Depending upon the location map of pixels in the NROI region, a hash key is generated. At receiving end, the hidden data is extracted using the hash key.

4.3 Embedding Procedure

a) Input the medical images of different modalities as shown in Fig.2.
b) The medical image is pre-processed by using k-means quantization.
c) The medical image is segmented into important region ROI and unimportant region NROI.
d) The patient data is converted from ASCII into binary form.
e) The patient data and ROI are compressed using Huffman coding.
f) The hash key is generated by using the algorithm explained in section 4.4.

Fig.2 (b): Original image of MRI scan of lower back

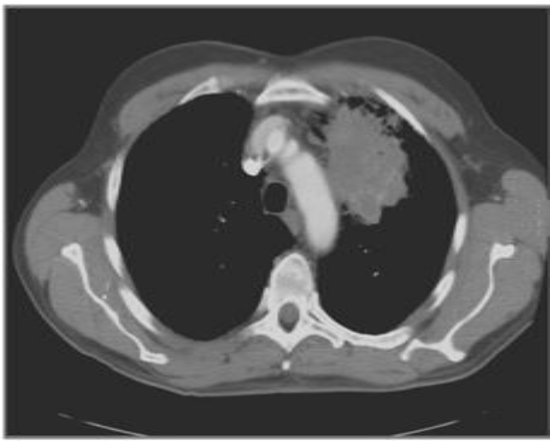

Fig.2 (d): Original image of PET scan of lung

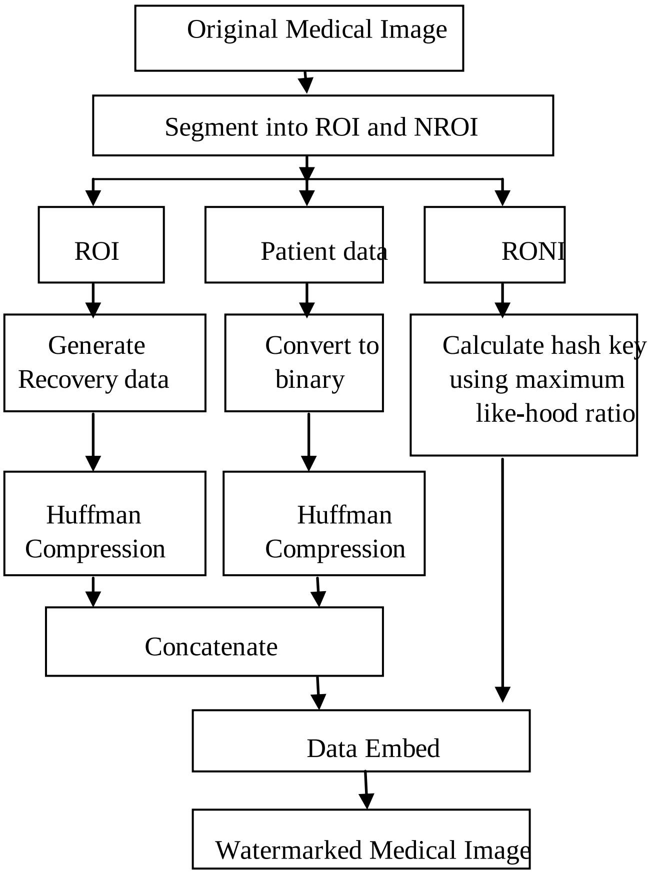

Fig.3 Block diagram of embedding algorithm

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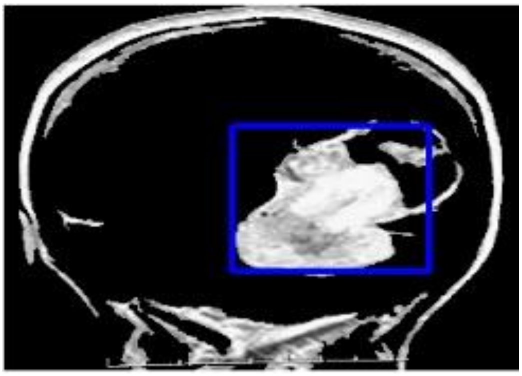

Fig.4 (a): CT scan of brain indicating ROI

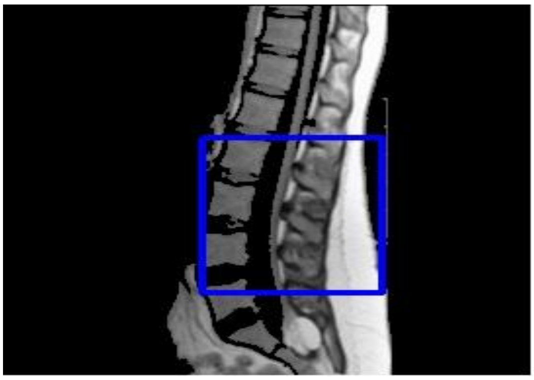

Fig.4 (b): MRI scan indicating ROI

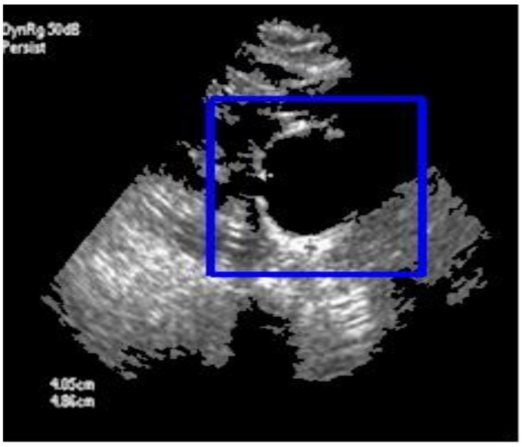

Fig.4 (c): Ultrasound indicating ROI

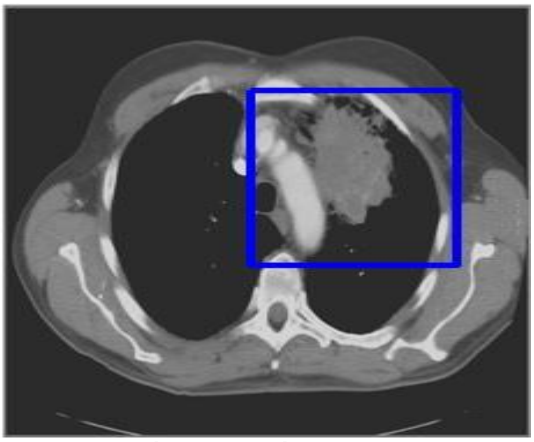

Fig.4 (d): PET scan indicating ROI

g) The compressed ROI and patient data are embedded into the NROI region of medical images.

The fig. 6(a), 6(b), 6(c) and 6(d) indicates the watermarked CT scan of brain, watermarked MRI scan of lower back, watermarked ultrasound of abdomen and watermarked PET scan of lung respectively.

4.4 Algorithm for embedding data

The algorithm for embedding data in NROI of the medical images is given below:

```
for i=1 to j=data
min dist= inf
disloc= 0
for j=1 to j=loc
d= sqrt (NROI [loc j] – data i)
 if (min dis> d)
    min dis= d
    dis loc= j
 end if
end for
key i= disloc
end for
```

where *sqrt* is square root of given value, data is the length of perfect data to be watermarked, loc are the location of NROI image. NROI is the non- region of interest of the medical image, d is the Euclidean distance.

4.5 Extraction procedure

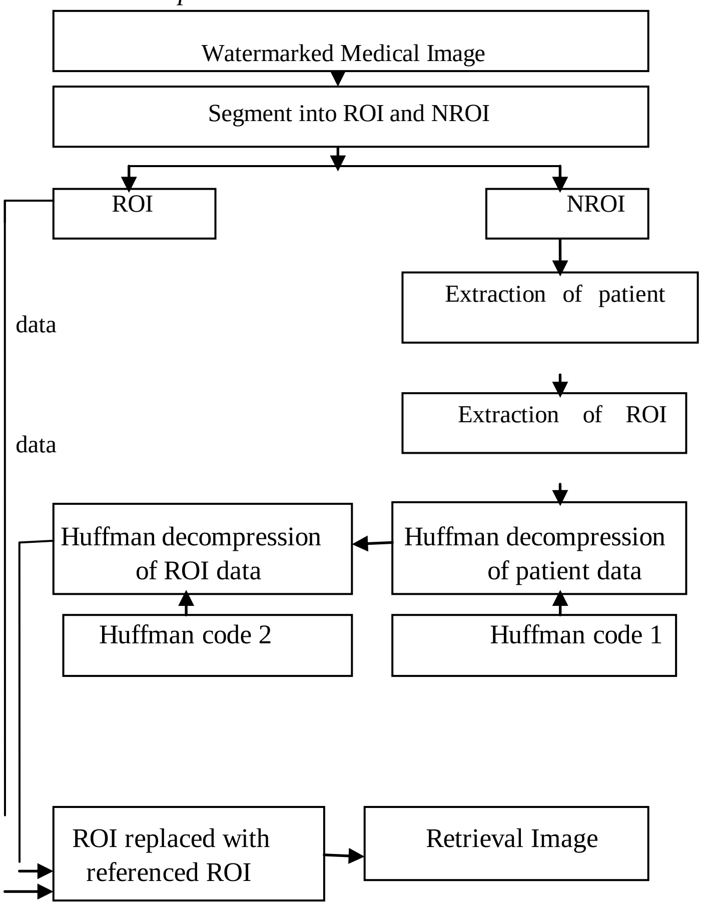

Fig.5 Block diagram of extracting algorithm

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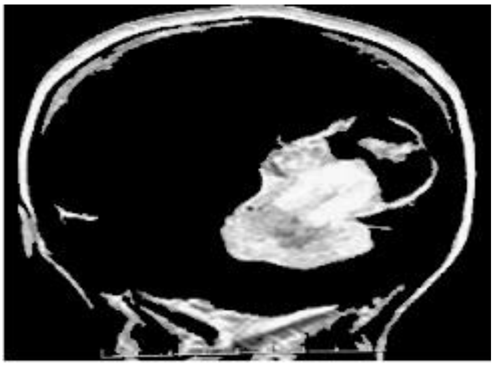

Fig.6 (a): Watermarked CT scan

Fig.6 (b): Watermarked MRI scan

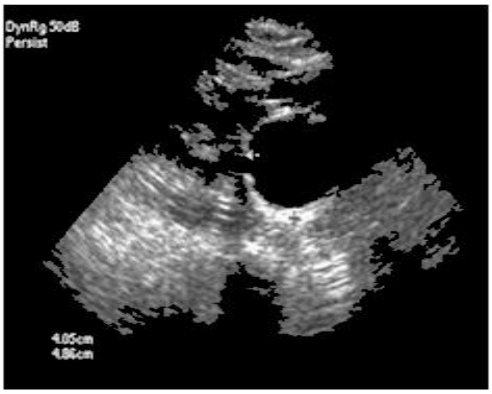

Fig.6 (c): Watermarked ultrasound

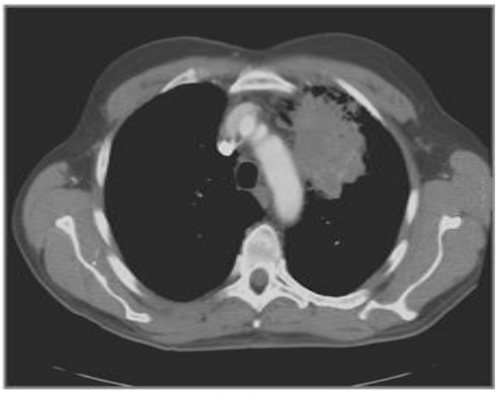

Fig.6 (d): Watermarked PET scan

a) The received watermarked medical image is divided into ROI and NROI.
b) The values are fetched from the NROI pixel locations based on the hash key.
c) The procedure is repeated until complete data is extracted.
d) The patient data and ROI are decompressed using Huffman code 1 and Huffman code 2 respectively.
e) The patient data is generated.
f) The extracted ROI is replaced with the reference ROI to recover the medical image.

5. RESULTS

The parameters used in the experiments are:

(1) Peak Signal to Noise Ratio and weighted PSNR (WPSNR) are used to measure the quality of watermarked medical images.
(2) Mean Structural Similarity Index (MSSIM) is used for measuring the structural similarity between the watermarked medical image and the original medical image.
(3) Total Perceptual error (TPE) is used to indicate the proportion of degradation in the watermarked medical image.

The few medical images used in the experiments are shown in Fig.2. The medical images used are 8 bit grayscale medical images. The computerized tomography (CT) scan of brain, Magnetic resonance imaging (MRI) scan of lower back, ultrasound of the abdomen and Positron emission tomography(PET scan) have been used.

The size of the patient data embedded in the medical image is up to 1kB. The ROI is indicated in the Fig.4 by an enclosed rectangle. The Fig.6 shows the watermarked medical images in which patient data and ROI are embedded in the NROI of the medical images.

The following table shows the values of size of medical images and the ROI taken in this proposed work.

Table1. Sizes of medical images and ROI

MODALITY OF MEDICAL IMAGE	SIZE OF IMAGE	SIZE OF ROI
CT SCAN	199*253	96*117
MRI SCAN	225*225	114*93
ULTRASOUND	259*194	126*96
PET SCAN	265*190	129*90

Table2. Average Performance of proposed method

Modality of medical image	Average PSNR	Average WPSNR	Average MSSIM	Average TPE
CT scan	53.6121	64.5704	0.9960	0.00025
MRI scan	64.2683	74.8193	0.9998	0.00013
Ultrasound	54.3043	65.9903	0.9935	0.00027
PET scan	56.1439	70.2798	0.9955	0.00037

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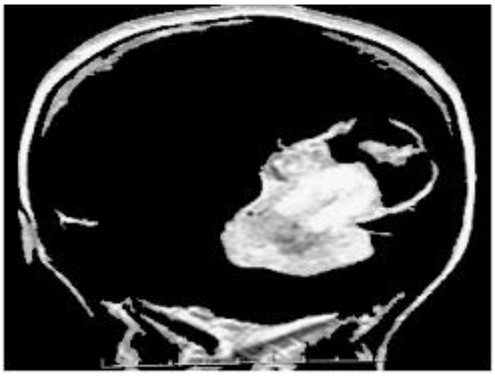

Fig.7 (a): Recovered CT scan

Fig.7(c): Recovered ultrasound

By considering these sizes of medical images and the ROIs in Table1, the average results shown in Table 2 have been obtained by repeating proposed method 50 times. Table 2 indicates the average values of PSNR, WPSNR, MSSIM and TPE of the each watermarked medical image. The above parameters evaluate the efficiency of the proposed technique. The average values are calculated by performing the proposed technique on four medical images about 50 times on each image. If the PSNR of the watermarked medical image is greater than 40 dB then the medical image watermarking method is efficient [1].The PSNR and WPSNR values are above 40db for all the types of medical images taken for the experiment. The recovered medical images are shown in Fig.7. The recovered medical images are obtained after extracting the embedded ROI and patient data from the watermarked medical images. The ROI is extracted even if the tampering has occurred or not.

The attacks are applied on the watermarked medical images to check the robustness of the proposed work that it provides to the data embedded inside the NROI. The attacks like Gaussian noise, low-pass filtering, salt and pepper noise and joint photographic experts group(JPEG) compression are employed on the watermarked medical images. The medical images can suffer from these unintentional attacks during the transmission. The Normalized correlation (NC) measures the similarity between the extracted data and the embedded data.

The NC is calculated using following equation, where *n* indicates the size of data, *w* illustrates the number of bits in

Fig.7 (b): Recovered MRI scan

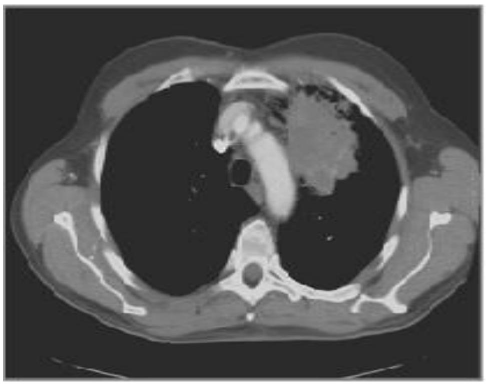

Fig.7 (d): Recovered PET scan

the embedded data and *w*' illustrates the number of bits in the extracted data.

$$NC=\frac{\sum_{i=1}^{n} w(i) \times w'(i)}{\sqrt{\sum_{i=1}^{n} w^2(i)}\ \sqrt{\sum_{i=1}^{n} w'^2(i)}} \qquad (1)$$

The value of NC ranges from 0 to 1. If the value of NC is 1, it means the extracted data matches exactly with the embedded data. The Table 3 shows the values of NC when different types of attacks are applied on the watermarked medical images. The values of NC in Table 3 show that a proximate ROI (almost equal to the original ROI) is extracted when unintentional attacks occur on the watermarked medical images during transmission. The values of NC obtained by using the proposed method are compared with the values of NC achieved by using the previous technique in Table 3. The following values of attacks are considered for each medical image to check the robustness.

a) The Gaussian noise is considered with variance equal to 0.001

b) The Salt and pepper noise is chosen with density equal to 0.005

c) The JPEG compression is taken with compression ratio equal to 90%.

The Fig. 8(a), 8(b) and 8(c) compare the proposed technique with the previously used scheme. The previous work uses integer wavelet transform (IWT) for embedding the data into RONI. Compared to the previous work, the proposed work shows improved results and good robustness towards the attacks.

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Table3. Results of applying various types of attacks on the watermarked medical image of different modalities

Modality of Watermarked Image	Type of Attack	Value of NC using Proposed Work	Value of NC using Previous Scheme
CT Scan	-No Attack	1	1
	-Gaussian Noise	0.99976	0.9858
	-Salt and Pepper Noise	0.98957	0.9813
	-JPEG Compression	0.99960	0.9507
	-Low Pass Filtering	0.99723	0.9616
MRI scan	-No Attack	1	1
	-Gaussian Noise	0.99960	0.9721
	- Salt and Pepper Noise	0.98282	0.9835
	- JPEG Compression	0.99973	0.9539
	-Low Pass Filtering	0.99898	0.9762
Ultrasound	-No Attack	1	1
	-Gaussian Noise	0.99952	0.9822
	-Salt and Pepper Noise	0.98086	0.9782
	-JPEG Compression	0.99951	0.9565
	-Low Pass Filtering	0.99738	0.9651
PET Scan	-No Attack	1	1
	-Gaussian Noise	0.99852	0.9866
	-Salt and Pepper Noise	0.97640	0.9819
	-JPEG Compression	0.99939	0.9623
	-Low Pass Filtering	0.99889	0.9754

The performance parameters of proposed work are compared with that of integer wavelet transform watermarking technique in following figures. The PSNR, WPSNR and MSSIM of the proposed technique and previous scheme are compared in 8(a), 8(b) and 8(c) respectively. The Fig.8 (a) plots the values of PSNR in dB along y-axis and the medical images of different modalities along x-axis. The Fig.8 (b) plots the values of WPSNR in dB along y-axis and the medical images of different modalities along x-axis. The Fig.8 (c) plots the values of MSSIM along y-axis and the medical images of different modalities along x-axis.

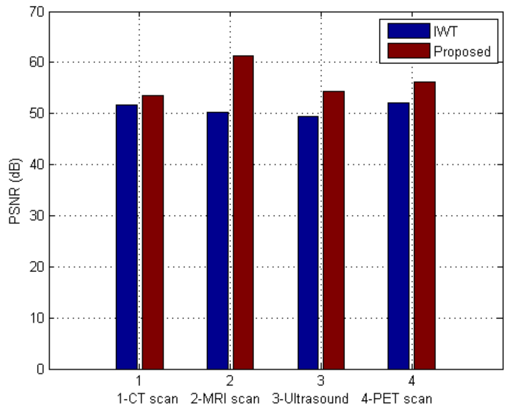

Fig.8 (a) Comparison of PSNR

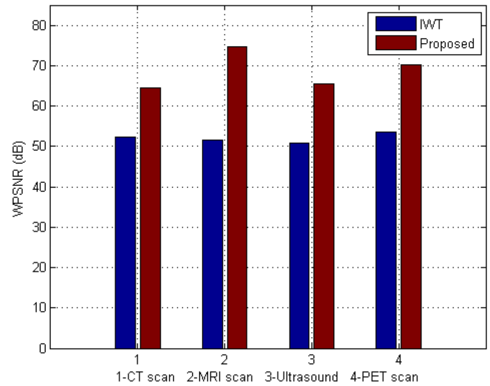

Fig.8 (b) Comparison of WPSNR

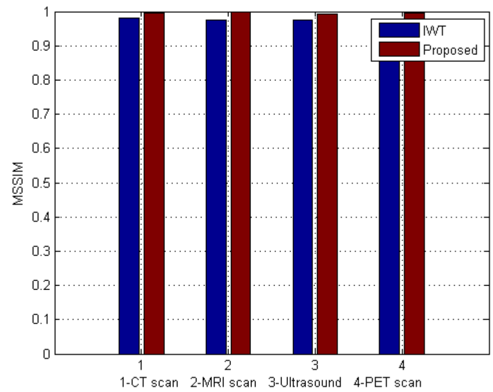

Fig.8 (c) Comparison of MSSIM

6. CONCLUSION

This paper proposed a robust watermarking scheme for recovering the original ROI and the patient data. No embedding distortion is present in the ROI of the generated watermarked images. The presented work accurately extracts the patient data and the original ROI. The experimental results indicate that the proposed work illustrates better results for the medical images with clear boundaries as compared to the medical image with illusion boundaries. The medical images show high robustness to the Gaussian noise and JPEG compression. It provides good robustness to the data embedded inside the RONI. The proposed work gives improved results and robustness to the watermarked medical images. The future work can be done on 12 bit or 16 bit images and with medical images of different sizes having large ROI size.

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