Medical Image Watermarking for Tamper Detection in ROI Using LWT and Hashing

Dr. Chaitanya *Konda*[1], Dr. U. Sathish *Kumar*[2], and Arun *Kodirekka*[3]

[1]Assistant Professor, Department of Computer Science & Engineering, Dr. Y.S.R. ANU College of Engineering & Technology, Acharya Nagarjuna University, Guntur, Andhra Pradesh, India.
[2] Assistant Professor, Department of Computer Science & Engineering, Dr. Y.S.R. ANU College of Engineering & Technology, Acharya Nagarjuna University, Guntur, Andhra Pradesh, India
[3] Assistant Professor, Department of Artificial Intelligence & Machine Learning, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad

Abstract. Security is one of the important characteristics while transmitting the data particularly medical images and patient information over cyberspace without any loss of information. In the proposed method LWT, DCT and SHA-256 hashing techniques are used to provide security to the patient data and to detect tampers in ROI of the medical images. In this paper, medical image is segmented into three regions, region of interest (ROI), region of non interest (RONI) and BORDER regions. ROI is an area that has an important impact on diagnosis, whereas RONI has less or no significance in diagnosis. This paper proposed ROI based tamper detection that embeds hash value of ROI into RONI for authentication and also embed the patient information into RONI for providing security. The experimental results of the proposed method on various medical image databases proved to identify the tampers in medical images. Compared with the existing technique, the proposed method offered high Peak Signal to Noise Ratio (PSNR) approximately 59db for watermarked medical images.

1 Introduction

In the previous few periods, telemedicine is one of the improvements in communication innovative technologies [1]. Hospitals and other research centres using digital data like medical images and patient data for diagnosis and treatment purpose. Now the digital data can be easily transmitted through communication channels. Hence there is a chance to modifying the medical images by noise and by unauthorised persons. Medical data tampering may lead to erroneous diagnosis [2]. medical images of dissimilar modalities like MRI, X-ray, Ultrasound, ECG etc. are used for medical imagine [3,4]. As per diagnosis view, the medical image can be divided into two regions, ROI and RONI [5,6,7]. The ROI holds significant information for diagnosis. Therefore, RONI used for strong watermark insertion.

[1] Corresponding author: anu.konda.chaitanya@gmail.com

Watermark embedding is done either in spatial domain or in transform domain. In spatial domain, the watermark is embedding into the least significant bits of the image directly [8]. In transform domain the watermark is embedding into the image after applying transformation techniques [9,10]. Transform techniques are more robust compared to spatial domain techniques [11].

In this paper, we proposed a new medical image watermarking technique using LWT, DCT and SHA-256. The proposed method divided the medical image into two regions region of interest and region of non interest. Hash value for ROI is calculated and embedded into RONI for authenticity purpose. Patient data is also embedded into RONI for providing security to patient data.

Organization of the paper is, section 2 consists of literature review, section 3 describes the proposed method, section 4 contains performance analysis, section 5 contains experimental results and conclusion in section 6.

2 Literature review

Lalan kumar [12] proposed DCT, DWT and FDCT-based reversible watermarking technique for medical image authentication to solve highly complex problems that have been faced while trying to secure the medical images Rohith thanki [13] have proposed the medical watermarking technique based on FDCT and Block wise DCT to get different frequency coefficients. Mid band frequency coefficients of the DCT block are modified using White Gaussian Noise (WGN) sequences. Yuch-peng chen [14] shows that a deep learning model for detecting distortion watermarks called WMNet, is proposed. WMNet is designed based on the convolutional Neural Networks, used to generate WMNet for subsequent detection of the watermark ownership.

Sultan kiran [15] proposed a reversible watermarking for medical images using RNS, CRC and double chaotic key and the scheme is highly fragile against any kind of tampering. Malay Kumar Kundu [16] proposed a combined spatial watermarking technique with lossless data compression and encryption technique that can be helpful in maintaining originality and security of the medical data. Bouslimi and Gouenou [17] proposed a scheme using the watermarking based on QIM JWD to ensure the confidentiality and reliability of the medical image by using the encryption.

3 Proposed method

In the suggested method, the medical image is divided into ROI, RONI and BORDER regions. The ROI region is chosen by the physician. To provide security to the patient information, the patient information is embedded into RONI. To provide authenticity to ROI, hash value of ROI is calculated and embedded into RONI. For embedding, LWT, DCT are applied to the RONI region.

3.1 Watermark Embedding Procedure:

The embedding procedure is given below:

1. Divide original medical image into three regions ROI, RONI and BORDER. ROI region is selected by the physician.
2. Calculate SHA-256 for the ROI region to get hash value and convert the hash value into binary code.
3. Divide the RONI region into 8× 8 non-overlapping blocks and apply LWT to each block then get four sub bands LL, LH, HL and HH. The sub-bands LL, LH, HL and

HH represent approximation, horizontal, vertical and diagonal detail sub-bands of one level LWT decomposition.

[LL, LH, HL, HH] = lwt2(fk) (1)

Where f k represents the 8× 8 sub block of RONI.

4. Select LH sub-band, apply DCT and embed the patient information into the mid frequency coefficients of the DCT block. The equation for DCT is given below.

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \Lambda(i).\Lambda(j).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] cos\left[\frac{\pi.v}{2.M}(2j+1)\right].f(i,j) \quad (2)$$

5. Select HL sub-band, apply DCT to it and embed binary form of ROI hash value into the mid frequency coefficients of the DCT block.
6. Also embed the binary hash value of ROI into the Least Significant Bits of the BORDER region.
7. After embedding, apply inverse DCT to LH and HL sub-bands.
8. Apply inverse LWT to four sub bands to get 8× 8 non-overlapping blocks.
9. Combine 8× 8 non-overlapping blocks to get a modified RONI region.
10. Combine the ROI, modified RONI and modified BORDER regions to acquire watermarked medical images.

3.2 Extracting Patient Information and tamper Detection in ROI:

The following procedure is used for extracting:

1. Divide the watermarked medical image into three regions : ROI, RONI and BORDER. Divide RONI region into 8× 8 non overlapping blocks.
2. Apply LWT to each block then get four sub bands LL, LH, HL and HH.
3. Select HL sub-band apply DCT, then extract patient data from mid frequency coefficients of the DCT block.
4. Select LH sub-band apply DCT, then extract ROI hash value from mid frequency coefficients of the DCT block.
5. Calculate SHA-256 for the ROI region to get hash value.
6. Compare hash value of ROI with the extracted hash value from RONI region.
7. If these two hash values are same then no tampering is done in ROI region. Exit.
8. If two hash values are different then extract the hash value from BORDER region and compare it with the hash value of ROI.
9. If these two hash values are same then tampering done in RONI region. Exit.
10. If two hash values are different and extracted hash value of RONI region and extracted hash value of BORDER region are same then tampering done in ROI region. Exit.

4 Performance analysis

In the proposed method performance is evaluated by the PSNR.

4.1 Peak signal to noise ratio (PSNR)

The measures of PSNR error between the original medical images and watermarked medical images and affects the quality of its representation. If value of PSNR is high then quality of the watermarked medical image also high.

The PSNR equation is given in eq.3.

$$\text{PSNR} = 10\log10\left(\frac{R2}{MSE}\right) \quad (3)$$

R represents the number of maximum possible intensity levels in an image.

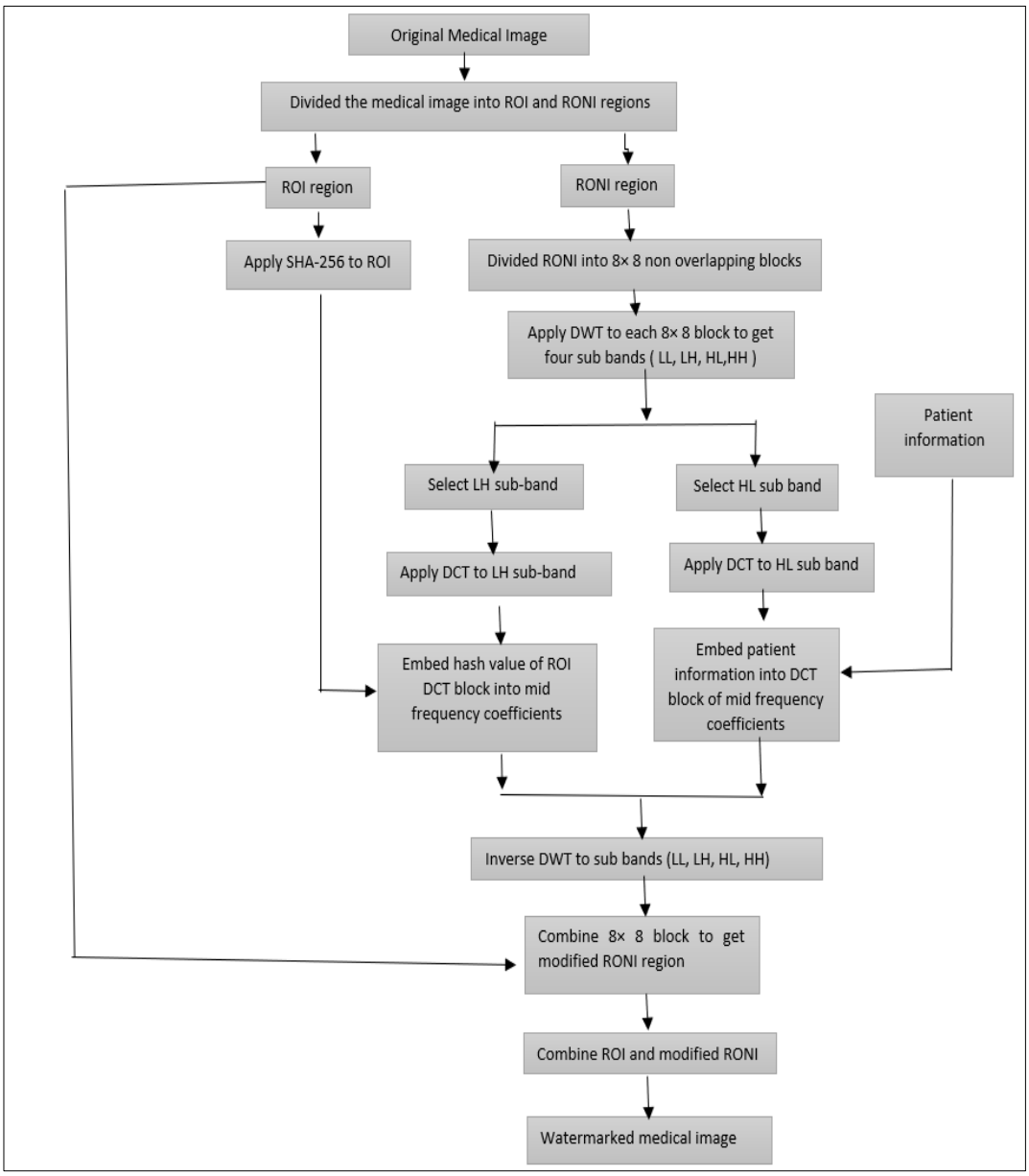


Fig. 1. Flow chat for watermark embedding procedure.

5 Experimental results

The suggested method is implemented on the medical images with 8 bits per pixel collected from DICOM. The proposed method is executed on Matlab 2019a with intel core2 duo 2.10GHZ processor of 4 GB RAM. Different types of medical images with different sizes and different ROI selected medical images are taken for the embedding process as shown in fig.3. Fig.4 (a), (b), (c), (d) Shows original medical images and (e), (f), (g), (h) Shows watermarked medical images. And in Fig. 5 (a), (b) shows no tampering is done in medical

images (c), (d) Shows tampering is done in medical images either in ROI or in RONI. In Fig.6 (a), (b) are original patient data and extracted patient data. In Table 1. shows the comparison of the proposed method with existing method of PSNR value [4].

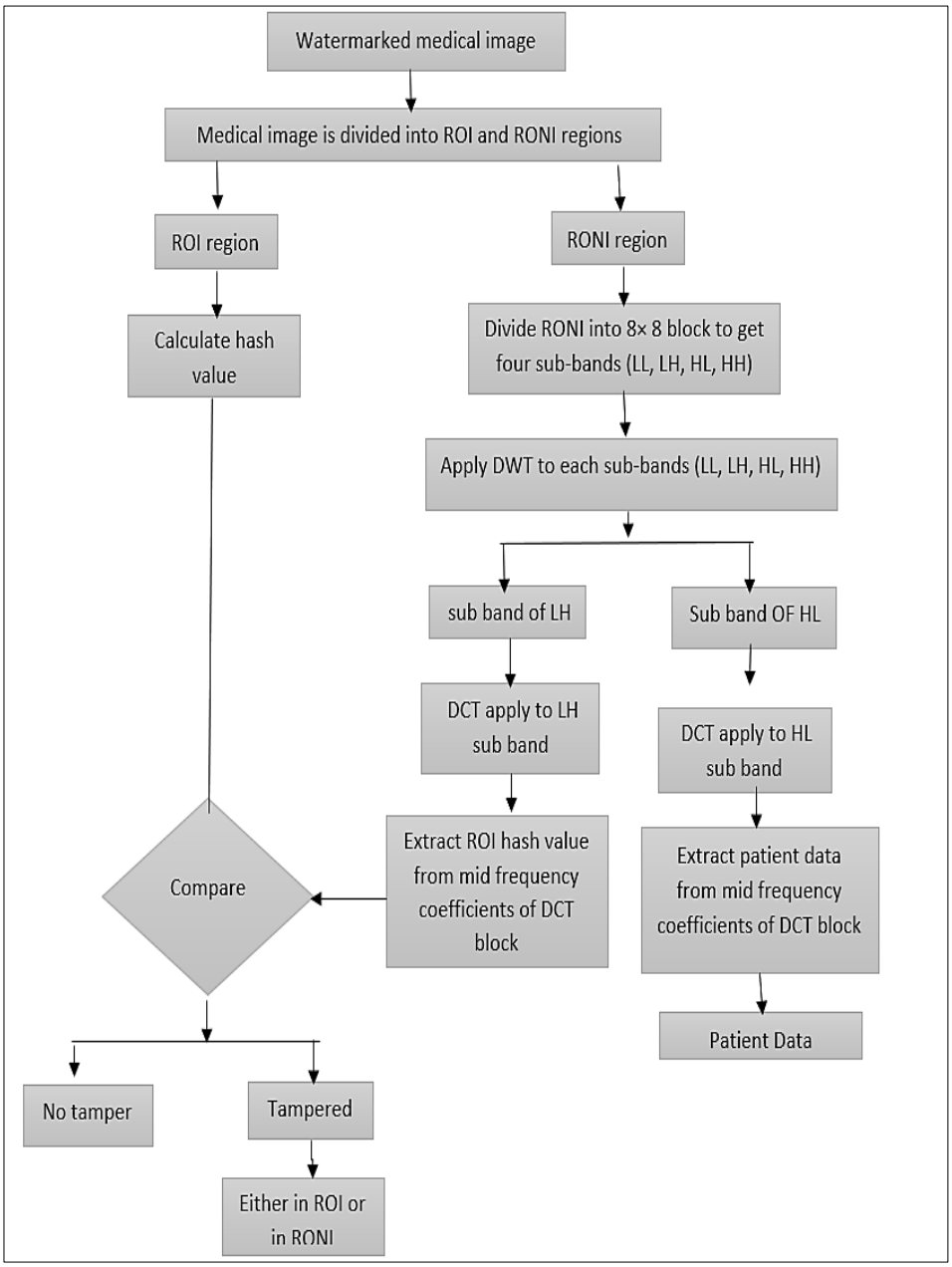


Fig. 2. Extracting patient information and tamper detection in ROI.

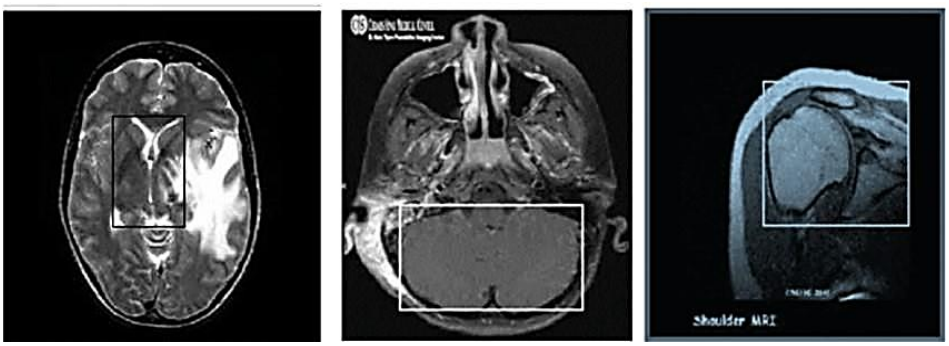
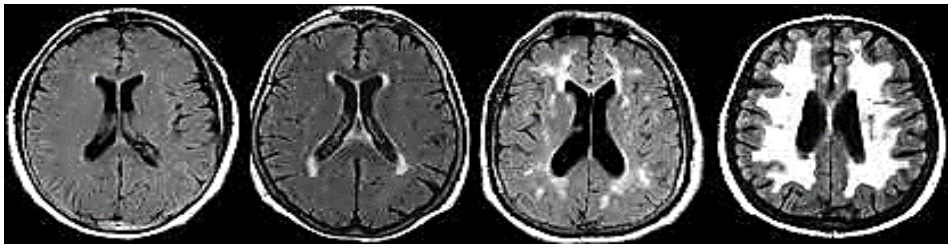


Fig. 3. ROI selected medical image.



(a) (b) (c) (d)

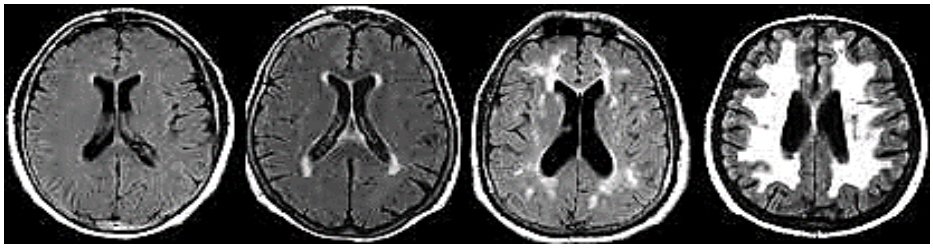
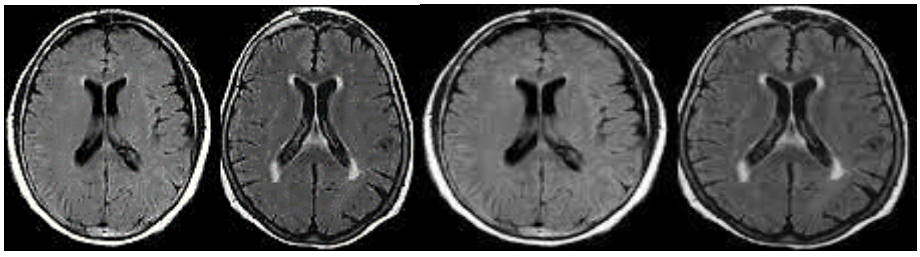


Fig. 4. (a), (b), (c), (d) shows original medical images and (e), (f), (g), (h) shows watermarked medical images**.**



(a) (b) (c) (d)

Fig. 5. (a), (b) shows no tamper and (c), (d) shows tampering is done**.**

Original patient information:
Patient name: Mohan Rao
Decease: Brain Tumour
Age: 52
Gender: M
Location: Guntur
Ph.no: 9000000000
(a)

Extracted patient information:
Patient name: Mohan Rao
Decease: Brain Tumour
Age: 52
Gender: M
Location: Guntur
Ph.no: 9000000000
(b)

Fig. 6. (a) Shows Original patient data and (b) Shows Extracted patient data.

Table 1. Comparison of PSNR values of the existing methods with the proposed method.

S. No	Name of the image	PSNR (proposed)	PSNR (existing) [4]
1	MRI1	58.0756	55.0755
2	MRI2	58.1223	56.0476
3	CTSCAN1	59.7450	53.7450
4	CTSCAN2	59.3277	53.3277
5	CTSCAN3	59.1321	53.5156

6 Conclusion

In the proposed method, DCT and LWT transform techniques are used to embed the patient data in RONI, transform domain is more robust and secure. SHA-256 is used to authenticate ROI, and detect the tampers which is tampering is done or not in ROI. PSNR is used to estimate the suggested method. In the proposed method showed improvement PSNR value compared to the existing techniques.

Reference

1. F. Taher, A. Kunhu, Ahmad. *A new hybrid watermarking algorithm for MRI medical images using DWT and hash functions.* in Proceedings of the 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC, (2016)
2. Singh, Priyanka, and P. Ashok Kumar, *Medical image watermarking for authentication, confidentiality, tamper detection and recovery*. in Proceedings of the 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT), IEEE, (2019)
3. Parah, A. Shabir, Multim. Tool. and Appl. **76**, 8 (2017)
4. Chaitanya, K., and K. Gangadhara Rao. Int J Eng Technol, **7**, 4, (2018)
5. Chaitanya, K., and K. Gangadhara Rao. J. of Theo. & Appl. Infor. Tech. **5**, (2018)
6. Gunjal, Baisa L. and Suresh N. Mali. Int. J. of Comp. and Infor. Eng. **6**, 8 (2012)
7. Liu, Yuling, Xinxin Qu, Guojiang Xin. J. of Vis. Comm. and Imag. Repres. **39** (2016).
8. Eswaraiah, Rayachoti, E. Sreenivasa Reddy, Int. J. of Tele. and Appl. **2**, 12 (2014).

9. Luo, Xuanwen, Qiang Cheng, and Joseph Tan. *A lossless data embedding scheme for medical images in application of e-diagnosis*. In Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society IEEE, (2003)
10. Singh, Amit Kumar. J. of Medi. Imag. and Health Infor. **5**, 3 (2015)
11. Kannammal, A., K. Pavithra, and S. Subha Rani. Europ. J. of Sci. Res. **70**, 1 (2012)
12. Kumar, Lalan, and Kamred Udham Singh. Europ. ean Journal of Molecular & Clinical Medicine, **7**, 4 (2020)
13. Thanki, Rohit, Engineering science and technology, **20**, 4 (2017).
14. Chen, Yueh-Peng, Tzuo-Yau Fan, and Her-Chang Chao. Electronics, **10**, 8 (2021).
15. Sultan, Kiran, Compu. and Math. Metho. in Medic., **12**, (2018).
16. S. Das, K. Malay Kumar, Medic. & Biolo. Eng. & Comp. **50**, 10 (2012).
17. D. Bouslimi, G. Coatrieux. Sign. Proce.: Imag. Comm. **47** (2016).