
RONI-based medical image watermarking using DWT and LSB algorithm

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Abstract. In recent years, hiding information in medical images is the largest usage to secure this information or garnet the integrity of the owner. But this embedding can distort the medical image and change the necessary patient information. In this paper, we propose a robust method for medical image watermarking; first of all. The original image is filtered by a sharpening filter for enhanced contrast then separate their two regions using snake segmentation. The embedding mark (an electronic patient record) is added to the frequency domain after applying Discrete Wavelet Transform (DWT) on the region of non-interest (RONI) using the last signification bit (LSB). This region has a predominantly black background where a region of interest (ROI) has the necessary patient information. This method preserves a high-quality watermarked image, and it improves authentication. Our method is evaluated by Pick Signal to Noise Ratio (PSNR = 46.4039 for 512*512 bits image size) SNR, NC, and Histogram analysis.

Keywords: Medical image, region of non interest (RONI), DWT, LSB algorithm, Digital watermarking, Authentication.

1 Introduction

Modern health care's information infrastructure is based on digital information management. While recent developments in information technology provide new ways of accessing, managing, and moving medical information, Because of their ease of manipulation and replication, they also compromise their security. [1] Digital watermarking and steganography are the embedding of secret information methods (bits in general) into a host signal such as an image, video, audio, or database. This approaches are used to ensure the validity, integrity, or identity of the owners. Following that, the embedding mark is identified and extracted to disclose the owner/identity of the digital material. [2]

Steganography of medical images represents a special case of steganography of images because of the sensitivity of the information on the patient's disease exists on

it, to the well the sensitivity of the added patient recode. The medical image is divided into two regions: the first is the region of interest (ROI) which contains important information about the patient's disease, and helps doctors to interpret and diagnose it. The second region is the region of non-interest (RONI) has a predominantly black background with some text content. So that if the RONI of the medical image is distorted or degraded by any modification, this deterioration has no influence on the patient's diagnosis and therapy. [3]

In recent years many papers are published about the different steganography and watermarking algorithms of an image or their enhancement. The use of visible watermarking based on Region of Non Interest (RONI) for medical image authentication is proposed in [3], In [6], DWT-SVD with hamming code is used to build an improved non-blind, resilient, undetectable, and secure watermarking approach for concealing multi watermarks. The suggested method's confidentiality and compression performance are enhanced. Sivaganesan and all [8] proposed innovative image watermark schemes for the protection of copyright protection and authentication, Which are based on DWT, DCT, and LSB algorithms for embedding the watermark into the cover image. Khawatreh, S. and all [7] proposed a method in which they added a message to the color image by using the LSB2 algorithm and they encrypt it by blocking and reordering method to get a secure stego-image. For the medical image and patient's privacy, Ambika and all [9] propose a method based on effective selection of pixels for added an image continent the patient's information to the cover medical image in the frequency domain. This selection of pixels does by Elephant Herding-Monarch Butterfly (EH-MB) algorithm. And Khalil, M.K [10] proposed a method based on the combination of steganography and cryptography of the medical image to analyze the degradation when the watermark was embedded in the frequency domain, and mention the relation between the PSNR value and the location of the secret message.

In this paper we separate the two region using snake segmentation, and transform the RONI to the frequency domain by apply the second level of discrete wavelet transform (DWT). The obtain LL2 sub band are used to added the electronic patient record (EPR) into it using Last Signification Bit (LSB) algorithm. This method's aim is to achieve the security of the information hiding and authenticity without any distortion in RONI.

The remainder of this paper is structured as follows: Section two covers the same ground. Section 3 discusses the suggested approach. Section three displays the obtained results and the discussion; the final section of this paper contains the conclusion

2 Preliminaries

2.1 Sharpening filter

Sharpening is a critical pre-processing technique for bringing out edge details by increasing the contrast between dark and bright areas. It increases edge rigidity and accentuates the subtle characteristics that are already there. [20] Image blurring is a

method of integrating or averaging image pixels in close proximity. This method is used to eliminate noise from images and smooth them down. [21]

2.2 Snake Segmentation

Snakes or active contour models, meaning that they lock on to adjacent edges and properly localize them. To increase the capture zone encircling a feature, utilize scale-space continuation. Snakes active contour provides a unified explanation of a variety of visual issues, including as edge recognition, line detection, and subjective contour detection; motion tracking; and so on. [18] A snake is an energy-minimization spline whose energy is proportional to its form and position within the image. Internal and external factors work together to regulate the snake's shape. External force directs the snake toward the image's features, while internal force acts as a smoothing restriction. [17] Medical imaging segmentation approaches can provide doctors and patients with an alternative computational tool to help diagnostic and health assessment progress, as well as propose the best therapy option. [19]

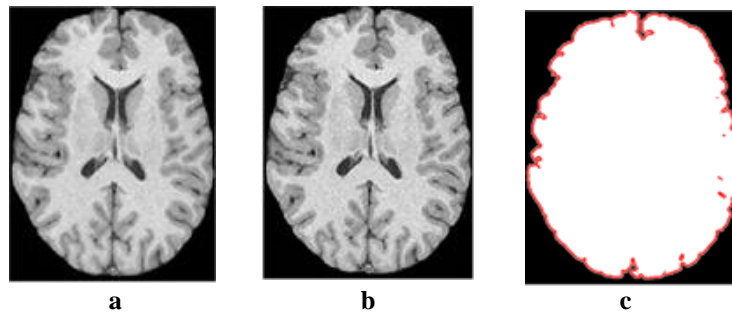


Fig. 1. Processing medical image; a: original image, b: filtered image, c: segmented image.

2.3 Discrete Wavelet Transform (DWT)

DWT is a mathematical technique for decomposing an image hierarchically. The image is decomposed into four sub-bands using DWT: LL1, LH1, HL1, and HH1 (approximation, horizontal, vertical and diagonal). Decompose approximation coefficient or one of the sub bands of level 1 into wavelet coefficients for multi-level. (Figure 3) The multi-resolution feature of the DWT assists in rapidly locating the regions where the watermark is embedding. [11, 1 2]

In this paper, the wavelet type used is Haar wavelet, it proposed by Alfred Haar in 1909, and it is the most basic form of wavelet, presented in discrete form. [14, 15] The Haar transform, like other wavelet transforms, decomposes an image into four sub-bands at the first level (**Fig. 2.a**), we used it in the LL1 sub-band for the second level of the Haar wavelet. (**Fig. 2.b**). In (**Fig 2.c**) the image represents the two-level together.

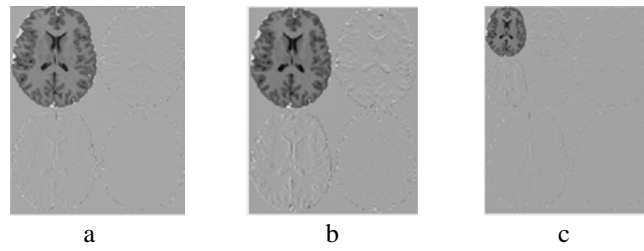


Fig. 2. : Two level DWT decomposition of an image

2.4 Last signification bit (LSB)

One of the most effective methods is LSB replacement, which includes conventional LSB replacement. It was a simple and effective technique for hidden message bits in the cover image's least significant bits, in which the secret message bits exploited the last bit of the image. [16]

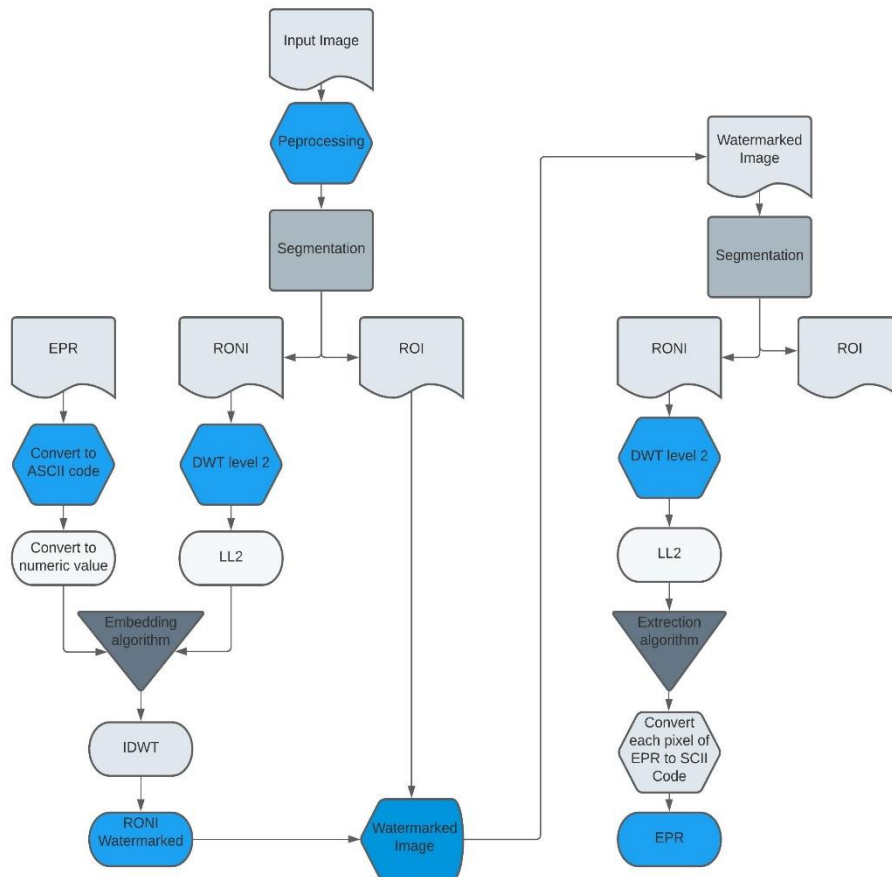


Fig.3: block diagram of the proposed method, embedding and extraction algorithm

3 The proposed method

The proposed method is based on the embedding of the EPR like a watermark in the frequency domain of the RONI. For the embedding algorithm section; the original medical image is processed and filtered to enhanced, before the separation of two regions. The application of DWT in level 2 can decompose the RONI to 4 sub-band and use the LL2 sub-band to limit the location of the watermark. The EPR character is converted to the ASCII code than to binary and it is embedded by the LSB algorithm. After the embedding of the watermark is done, apply the DWT inverse to get RONI watermarked then the medical image is watermarked by combining the two regions. (Figure 3a) The steps of the watermark embedding are represented as follows:

Step 1: read the medical image and apply the sharpen filter to enhance it

Step 2: apply the Snack segmentation on the image and separate the ROI and RONI

Step 3:

- apply the second level of DWT on RONI for obtain LL2 sub bond
- read the EPR character and convert it to ASCII code then to binary

Step 4: calculate the LSB of each pixel of LL2 sub bond and replace it by each bits of EPR one by one

Step 5: apply the inverse of DWT on the RONI by replacing the LL2 by the LL2 obtained in step 4

Step 6: get the watermarked image by combining the two image areas ROI and RONI obtained in step 5

For the extraction algorithm section, get the watermarked image and separate the two regions, apply the DWT in the second level to obtain the LL2 sub-band which the watermark is excited and extract and convert it to the ASCII code than to character like it mention in (figure 3b). The steps of the watermark extraction are represented as follows:

Step 1: read the watermarked image then separate the ROI and RONI

Step 2: apply the second level of DWT on RONI for obtain LL2 sub bond

Step 3: calculate the LSB of each pixel of LL2 sub bond

Step 4: retrieve bits and convert each 8 pixel into character and obtain the EPR

3.1 Measurements metrics

For performance evaluation, the proposed approach is examined on grayscale medical images in different modalities like IRM (images 1,2 and 4), PET (image 3), and OCT (image 5) images of various sizes, then we resize the small size image to be 512*512 pixels for more evaluation and comparison. The watermark tested has 12 characters, and the results are performed on the platform of Core i3, 1.70GHz CPU, 4 GB RAM, MATLAB R2020a. For evaluating the watermarked image perceptibility, use some quality metrics like:

- **Peak-Signal-to-Noise Ratio (PSNR):** The quality of the original and watermarked images is compared using this ration, which is measured in decibels. To compare picture compression quality, the PSNR and the mean-square error (MSE) are employed. The MSE is the difference in cumulative squared errors between the watermarked and original images, whereas the PSNR is the proportion of the original picture that is watermarked.

$$PSNR(I, Iw) = 10 * \log_{10} \frac{(MAX_I^2)}{MSE} \quad (1)$$

Where: $I(i, j)$, $Iw(i, j)$: Is represent the original image and the watermarked image respectively.

- **Signal to noise ratio (SNR):** In contrast to MSE, it may also be computed by the following state,[5]

$$SNR = \frac{X(i,j)}{\sqrt{MSE}} \quad (2)$$

- **Normalized correlation (NC) analysis:** This metrics indicate the resemblance factor between inserted and extracted watermark. [13] It is calculate by following equation:

$$NC(W, W') = \frac{\sum_{i=1}^m \sum_{j=1}^n [W(i,j).W'(i,j)]}{\sum_{i=1}^m \sum_{j=1}^n [W(i,j)]^2} \quad (3)$$

Where: W , W' are original and extracted watermark respectively.

When: $NC=1$, it is the maximum attainable value which specifies that inserted and extracted watermark are impossible to differentiate. $NC=0$, it is the minimum attainable value which specifies that original and extracted watermark are exclusively dissimilar.

3.2 Simulation results

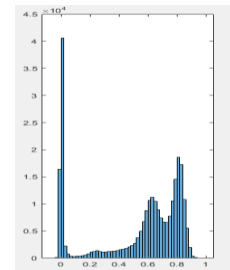
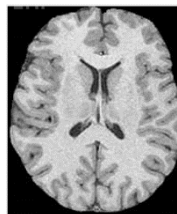
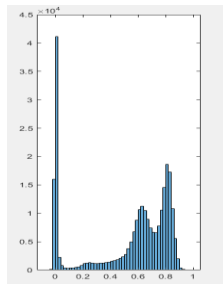
The proposed approach's experimental findings are presented in the table below (**Table. 1**). Where the PSNR value of the 512*512 bits size images are greater than 46 dB and if the PSNR of the watermarked images is more than 30, the human visual system (HVS) will struggle to detect changes between it and the original images. [4] that is clearly shown by the histogram analysis in (Figure 3), where the histograms of the original medical image and the watermarked one are the same. That's mean that

the quality of medical image watermark is high and the necessary information about the patient's illness is not changed. The SNR values are used in image watermarking to assess and evaluate the performance of the proposed method that deals with image distortion and quality. Table 02: is the comparison of our method with existent methods

Table 1. The PSNR and NC values of the proposed method

Image	Image size	PSNR	SNR	NC
Image 01	287x230	40.4146	36.1154	0.9986
	512 x512	46.4039	42.0824	0.9997
Image 02	512*512	46.4039	37.0435	0.9999
Image 03	287x230	40.4146	34.0898	0.9992
	512 x512	46.4039	40.0675	0.9998
Image 04	283x211	39.9792	33.1776	0.9996
	512 x512	46.4039	39.4427	0.9999
Image 05	512 x512	46.4039	35.3562	0.9999

Image 1



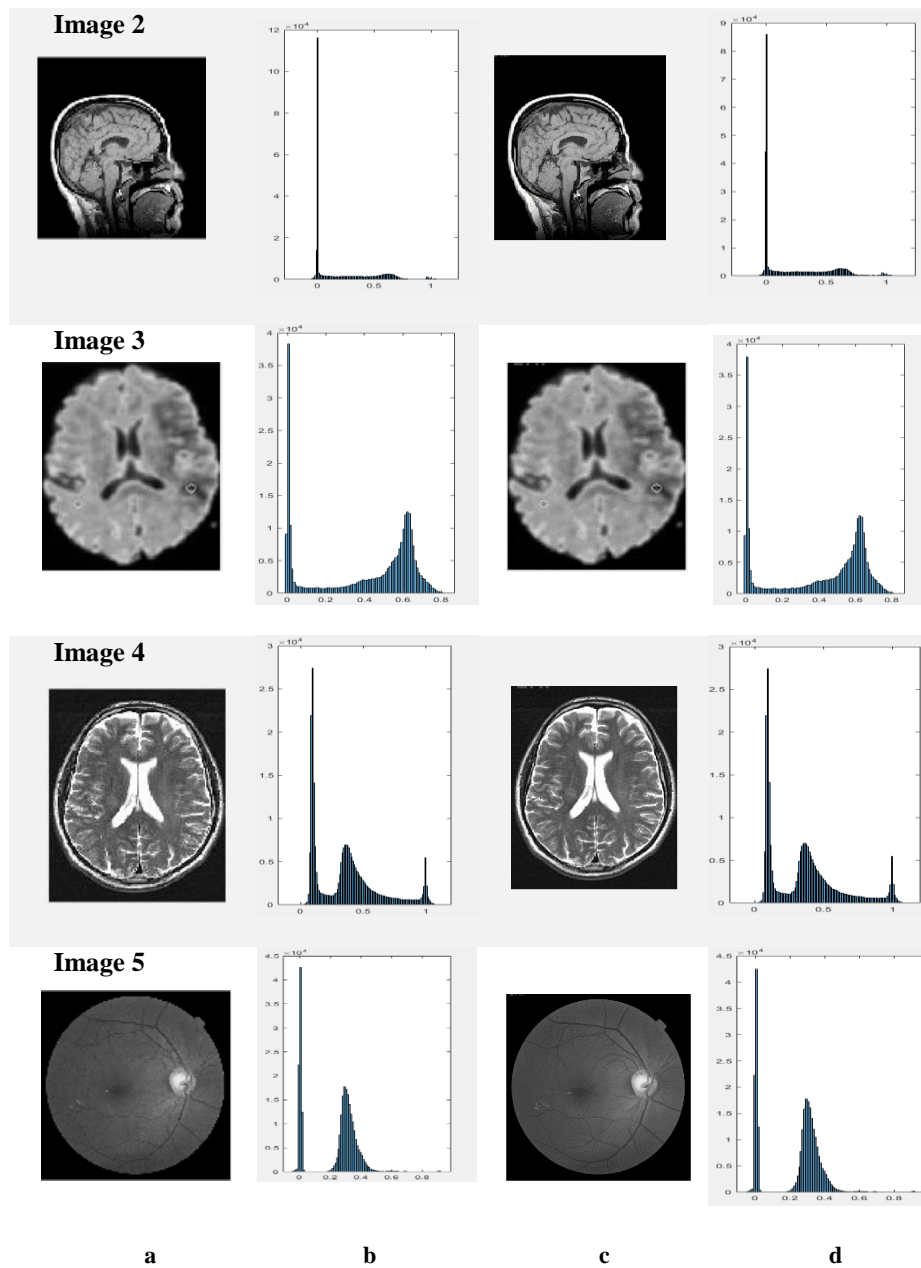


Fig. 3. Histogram analysis of original and watermarked image, a: Original medical image, b: Original medical image Histogram, c: Watermarked medical image, d: Watermarked medical image Histogram

Table 2. Imperceptibility results comparison with literature methods

Paper reference	Technique used	Application domain	Result obtained
Ref. [6] (2020)	DWT-SVD ECC, Chaotic-LZW	Medical and Non medical image	PSNR = 44.1944
Ref. [3] (2017)	Human visual system (HVS) model Image processing operations	Medical image	PSNR = 38.01
Ref. [9] (2020)	DWT Elephant Herding-Monarch Butterfly (EH-MB) Optimization algorithm	Medical and non-medical image	max PSNR = 42.1776, for medical image max PSNR = 38.01444, for non-medical image (Lena)
Ref. [10] (2017)	RC4 for encryption DFT	Medical image	PSNR = 44
Proposed method	Snake segmentation DWT LSB Algorithm	Medical image	PSNR = 46.4039

4 Conclusion

The proposed work is an embedding of EPR in the frequency domain of the RONI using the last significant bit (LSB) algorithm. The comparison of the PSNR value results in this method with other methods already exist in the literature depicts the high quality of medical image watermarked, without destroying the necessary patient record which is excited in ROI. In future work, we plan to apply different encryption systems on EPR to get secure information hiding in curve images.

References

1. Assini, I., Badri, A., Safi, KH., Sahel, A., Baghdad, A.: A Robust Hybrid Watermarking Technique for Securing Medical Image. *International Journal of Intelligent Engineering and Systems* 11(3), 169-176 (2018).
2. Singh, P., Chadha, R.S.: A Survey of Digital Watermarking Techniques, Applications and Attacks. *International Journal of Engineering and Innovative Technology* 2, 165-175 (2013).
3. Thank, R., Borra, S., Dwivedi, V., Borisaga, K.: A RONI Based Visible Watermarking Approach for Medical Image Authentication. *Journal of Medical Systems* 41(143), 1-11 (2017).
4. Bamatraf, A., Ibrahim, R., Najib Mohd. Salleh, M.: A New Digital Watermarking Algorithm Using Combination of Least Significant Bit (LSB) and Inverse Bit. *Journal of Computing* 3, 1-8 (2011).

5. Prabu, S., Balamurugan, V., Vengatesan, K.: Design of cognitive image filters for suppression of noise level in medical images. *Measurement* 141, 296–301 (2019).
6. Anand, A., Kumar Singh, S.: An improved DWT-SVD domain watermarking for medical information security. *Computer Communications* 152, 72-80 (2020).
7. Khawatreh, S., Nader, J., Khrisat, M., Eltous, Y., Alqadi, Z.: Securing LSB2 Message Steganography. *International Journal of Computer Science and Mobile Computing* 2, 156-164 (2020).
8. Sivaganesan, S., Geetha, M., Gowthaman, T., Pradeepa, M.: Fingerprint Based Watermarking Using DWT and LSB Algorithm. *International Journal of Pharmacy Research & Technology* 10 (2), 10-14 (2020).
9. Ambika., Rajkumar L.B. : Secure medical image steganography through optimal pixel selection by EH-MB pipelined optimization technique. *Health and Technology* 10, 231–247 (2020).
10. Khalil, M.I.: Medical Image Steganography: Study of Medical Image Quality Degradation when Embedding Data in the Frequency Domain. *International Journal of Computer Network and Information Security* 9(2), 22-28 (2017).
11. Kashyap, N.: Image Watermarking Using 3-Level Discrete Wavelet Transform (DWT). *International Journal of Modern Education and Computer Science* 3, 50-56 (2012).
12. Anand, A., Kumar Singh, A.: An improved DWT-SVD domain watermarking for medical information security. *The International Journal for the Computer and Telecommunications Industry* 152, 72-80 (2020).
13. Singh, A., Dutta, MK.: Lossless and robust digital watermarking scheme for retinal images. In 4th International Conference on Computational Intelligence & Communication Technology (CICT), pp. 1-5; IEEE, India (2018).
14. Walker, J.S.: A Primer on WAVELETS and Their Scientific Applications. 2nd edn. Taylor & Francis Group, USA (2008).
15. Mahmoud, M.I., Dessouky, M. I., Deyab, D., Elfouly, F. H.: Comparison between Haar and Daubechies Wavelet Transformions on FPGA Technology. *Proceedings of World Academy of Science, Engineering and Technolgy* 20, 1307-6884 (2007).
16. Majeed, M.A., Sulaiman, R.: An Improved LSB Image Steganography Technique Using Bit-Inverse in 24 Bit Colour Image. *Journal of Theoretical and Applied Information Technology* 80 (2), 342-384 (2015).
17. Zhou, W., Xie, Y.: Interactive Medical Image Segmentation Using Snake and Multiscale Curve Editing. *Mathematical Methods and Applications in Medical Imaging*, 1-13 (2013).
18. Kass, M., Witkin, A., Terzopoulos, D.: Snakes: Active Contour Models. *International Journal of Computer*. 321-331 (1988).
19. Rebouças Filho, P.P., Silva Barros, A.C., Almeida, J., Rodrigues, J.P.C., de Albuquerque, V.H.C.: A new effective and powerful medical image segmentation algorithm based on optimum path snakes. *Applied Soft Computing Journal* 76, 649–670 (2019).
20. . Jeevakala, S., Therese, A.B.: Sharpening enhancement technique for MR images to enhance the segmentation. *Biomedical Signal Processing and Control* 41, 21-30 (2018).
21. Habeeb, N.j., Omran, S.H., Radih, D.A.: Contrast Enhancement for Visible-Infrared Image Using Image Fusion and Sharpen Filters. *International Conference on Advanced Science and Engineering*, pp. 64-69. IEEE, Iraq,(2018)