Medical Image Multiple Watermarking Scheme Based on Integer Wavelet Transform and Extraction Using ICA

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Abstract. In this paper, a medical image multiple watermarking technique rely on integer wavelet transform is proposed. Medical image watermarking is a unique division of image watermarking in the intellect that images have particular necessities. Watermarked medical images should not diverge relating to their creative complement because clinical interpretation of images should not be pretentious. Watermarking methods rely on discrete wavelet transform (DWT) are described in numerous writings excluding forcefulness and defense by means of integer wavelet transform is enhanced while equate to DWT. The important confront in traverse angles in images arrives from the discrete environment of the information. In this paper, input image is scaled to two level by means of integer wavelet transform and the two watermarks are embedded in the ensuing coefficients. To extract the watermark, Pearson ICA is applied and it has a novel feature, it does not necessitate the alteration procedure to extract the watermark. Simulation results illustrate that proposed method is robust against attacks such as Gaussian noise, Salt and Pepper noise, rotation and translation. PSNR, Similarity measure and Normalized correlation are the performance measures applied to evaluate and it is compared with Wavelet Packet Transform (WPT). Simulations are conceded in using Matlab.

Keywords: Image watermarking · Independent component analysis
Telemedicine · Integer wavelet transform

1 Introduction

Digital watermarking is the process by which watermark a discrete data stream is hidden inside the input image by impressive invisible changes on the image. To embed and extract the watermark, a secret key is used in many proposed techniques. Copyright protection is one of the main sources of power for research in this area for digital medium. Copy protection code is the main application to protect and to allocate possession. By altering the watermarked image, attacker tries to extract the watermark. Thus, it is struggled to embed the watermark and it is hard to extract without key except the watermarked image is drastically imprecise. A trendy similarity for watermarking is the system of data connections in which the ambition is to efficiently converse the watermark

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information using embedding algorithms. Consequently, it is vital for the outlook progress of associated hypermedia structure that strong procedure are urbanized to look after the logical belongings precise of data in chargers alongside unofficial repetition and redeployment of the substance made obtainable on the system. In addition to the above it is a significant concern to widen a strong watermarking proposal by means of an enhanced swapping between sturdiness and indistinct [1]. From copyright infringement watermarking transpire as an instrument for defensive the multimedia statistics. To identify the ownership watermark is embedded into the input image. After embedding the watermark, perceptual deprivation should not be there. Unauthorized person should not be able to remove the watermark and it is necessary to develop the robust watermarking against intended and unintended attacks [2]. Various watermarking systems are published in the literature. This work contemplates the scrupulous crate of medicinal image watermarking. Watermarking has grown to be a vital matter in medical image safety measures, privacy and veracity. In order to validate and inspect the reliability of medical images, the medical image watermarks are used. Medical image watermarking special requirements is the key problem in watermarking [5]. A stiff obligation is that the image might not endure any deprivation which affects the interpretation of images. Normally, images are necessary to stay behind integral to attain this with no visible modification to their original shape. The three obligatory defense distinctiveness are:

- Privacy is the allowed users have admission to the in sequence.
- Accessibility is the capability of the information arrangement to be used in the typical planned environment of admittance.
- Consistency is based on the aftermath of reliability and validity.

Integer Wavelet Transform is applied to offer a lossless compression. Sub-bands of IWT are identified by restricted exactness information and this used for lossless coding. IWT stress for less data length than the floating point DWT and hence DWT is extra time overwhelming. The image is reconstructed of no loss as the coefficients of IWT are integers and placed devoid of rounding off errors [6]. Here IWT applies lifting scheme. Lifting Scheme is an effectual technique of implementing the wavelet filtering procedure by Sweldens. Lifting scheme is categorized into three stages:

Split: Here the initial signal is separated into two samples of even and odd.

Predict: In this, the odd samples are anticipate from the even samples.

Update: At this stage, the original even samples are added to the predicted odd samples to generate the new even samples. Inverse lifting transform is conceded with the dissimilarity that its signs are upturned. Moreover, the intelligent detection technique, Pearson ICA is applied for extraction devoid of the utilize of preceding information of the watermark and still the conversion procedure. Sturdiness and lucidity of the exceeding technique is established with outcome. This work is prepared like this: 2nd section scrutinizes the IWT; Sect. 3 investigates the watermark implant technique. In 4th section, watermark taking out technique ICA is expressed. The output results are accessible in 5th section and termination are pinched in Sect. 6.

Telemedicine removes inconvenience arising from different geographic locations and provides health services at far-away places. In the recent years, use of digital equipment's in health care sector has increased considerably. Modern technology allows

doctors to diagnose their patients using digital parameters. In numerous medical applications, distinct protection and secrecy is needed for patient records, reason being thorough analysis on health pictures is needed for proper diagnosis. Tampering images will lead to surface unwanted consequences as an aftermath of defeat of crucial information.

2 Integer Wavelet Transform

Wavelet construction is a novel technique. Lifting schemes are almost applied in all traditional wavelets. IWT stress for less data length than the floating point DWT and hence DWT is extra time overwhelming. The image is reconstructed of no loss as the coefficients of IWT are integers and placed devoid of rounding off errors. Yet, the lifting strategy in IWT maps integer to integer devoid of rounding misconception (ii) IWT is effortless to comprehend, execute and overturn [4]. During mathematical calculations IWT are performed fast in position, and supplementary reminiscence is not requisite as shown in Fig. 1. The above stuffs of IWT are applied to conserve imperceptibility and increase the robustness. The IWT has three widespread lifting steps:

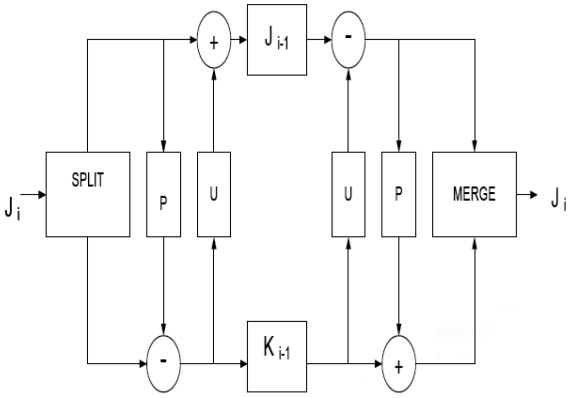

Fig. 1. Integer wavelet transforms decomposition and reconstruction

- Split — It is called as lazy wavelet as the input image is shared into even and odd polyphase mechanism.
- Predict — by finding out the linear combination of trial of even polyphase module, the new odd polyphase modules are calculated. The samples of the odd polyphase constituent are restored by the variation between the odd polyphase component and the anticipate assessment. The envisage procedure is furthermore mentioned as dual lifting step.
- Update — the novel even polyphase modules are shaped rely on a linear combination of various samples prevailed from the predict procedure. This step is also mentioned as the primal lifting step.

Discrete Wavelet Transform (DWT) is appropriate for distinguish the places of the input image and the watermark be able to be invisibly entrenched since of its exceptional time frequency localization belongings. The Integer Wavelet Transform (IWT) is a focused adaptation of universal DWT which maps integers to integers. The benefit of applying IWT is that it can be executed with merely basic arithmetic process. Devoid of deformation is the competent technique to conceal furtive messages [7]. In DWT, the resultant is not consisting of integers when the input consists of integers. So it produces complexity in reinstatement of the input image. But in IWT, integers are present in the output. In IWT, LL coefficients become visible to be secure reproduction of the input image with lesser range while in DWT the resultant LL is indistinct faintly.

3 Watermark Embedding

The input colour medical image is analysis to 2 levels using IWT is revealed. LL2 coefficients which are a low frequency are not selected to embed watermark as it will critically disgrace image eminence [8]. Likewise, the diagonal high frequency sub-bands HH2 are too not measured since safety is underprivileged when watermark is entrenched as shown in Fig. 2.

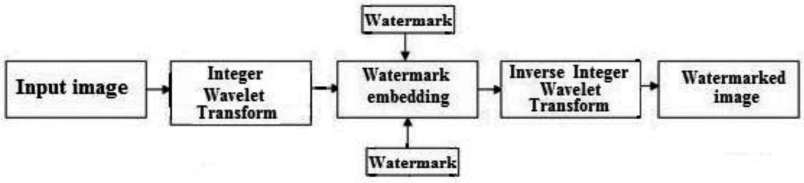

Fig. 2. Proposed block diagram of watermark embedding using IWT

Therefore, the center subband HL2 and LH2 are selected in this paper to entrench multiple watermarks based on the exchange between imperceptibility and robustness. A random replica of the input image is practical to an ability to change watermark by calculating Noise Visibility Function (NVF) with variable variance Gaussian replica. Here, NVF can be uttered by

$$\mathrm{N}VF(\mathrm{i},\mathrm{j}) = \frac{1}{1+\sigma_x^2(i,j)} \tag{1}$$

where $\sigma_x^2(i, j)$ indicate inconsistency of the input image in a transom middled on the pixel with interrelate (i, j). By implementing NVF, the surface and corners get powerful than in smooth regions in the watermark. Embedding the watermark in HL2 by means of the subsequent equation:

$$I'HL_2(i,j) = HL_2(i,j) + E(HL_2)\alpha_1(1 - NVF(i,j))W(i,j) + \frac{E(HL_2)}{10}.\alpha_1.NVF(i,j).W(i,j) \tag{2}$$

Where $I'HL_2(i,j)$ is watermarked renovate sub-bands, $E(HL_2)\alpha_1$ signify the watermark power of surface and $\frac{E(HL_2)}{10}.\alpha_1$ designate the watermark potency of corner area for HL coefficients. α_1 is the embedding strength issue on the grain areas and plane areas and E represents the mean and watermark $W(i,j)$. Watermarked image is obtained by inversing IWT.

4 Independent Component Analysis

It is an arithmetical method that procures autonomous sources S from even combination X. The input sources and the real addition A are recognized. It is attained by capitalizing superior regulate sign information and optimization methods. Pearson ICA technique applied here for extraction of watermark is explained underneath:

4.1 Pearson ICA

The Pearson ICA algorithm is a blind severance technique of statistically autonomous cause signals for mutual information based system. The minimization of mutual information guides to iterative use of score functions. The elasticity of the Pearson classification makes it probable to replica an extensive variety of basis distributions including asymmetric distributions [3]. The statistics matrix X is measured the same blend of demographically autonomous apparatus as

$$\mathrm{X} = \mathrm{AS} \tag{3}$$

where mixing matrix is A and the values of S enclose the independent constituents has Gaussian allotment. The ambition of ICA is to locate a matrix W that the yield,

$$\hat{S} = WX \tag{4}$$

is an approximation of perhaps covered and sequence basis matrix S. In order to take out the autonomous component sources for a demixing matrix W, this reduces the shared in sequence of the origin

$$W_{k+1} = W_k + D\left(E\left\{\phi(y)y^T\right\} - diag(E\left\{\phi(y_i)y_i\right\})\right) \tag{5}$$

5 Simulation Results

The future watermarking technique is applied on input Medical image (Patient) of size 256 × 256. Integer wavelet transform for two levels is accomplished on the input image. The two middle coefficients HL2 and LH2 are chosen to embed watermarks. Watermark1 (EEG) of size 64 × 64 and watermark2 (Prescription) are used and α is set to 0.3 by frequent replication to make sure the imperceptibility of the watermark. Figure 3 shows the colour Input image (Patient), and it is converted into YUV components. Y component is shown in Fig. 4. Patient Input image is decomposed to one level using IWT to obtain 4 sub-bands LL1, HL1, LH1 and HH1 as shown in Fig. 5 and LL1 is further decomposed to second level to obtain another 4 sub-bands LL2, HL2, LH2 and HH2 as shown in Fig. 6. Watermark 1(EEG) colour image of size 64 × 64 as shown in Fig. 7 is taken and it is converted to Y, U, V components and Y component is shown in Fig. 8. Arnold Transform is applied for Y component of watermark 1 as shown in Fig. 9. Watermark 2 (Prescription) colour image of size 64 × 64 as shown in Fig. 10 is taken and it is converted to Y, U, V components and Y component is shown in Fig. 11. Fibonacci Transform is applied for Y component of watermark 2 as shown in Fig. 12. Two watermarks are embedded in two sub-bands HL2 and LH2. Inverse IWT is done to obtain the Y component of watermarked image as shown in Fig. 13. U and V components are concatenated to obtain colour watermarked image as shown in Fig. 14. The toughness of the over watermarking method is authorized beside various assault similar to Gaussian noise addition, Salt and Pepper noise, Rotation and Translation done on watermarked image. Figures 15 and 16 show Gaussian noise added and Salt & Pepper noise, respectively. Similarly, Figs. 17 and 18 show Rotation and Translation attacks performed on watermarked image respectively. Besides executing a variety of ambush, integer wavelet transform acquire an elevated PSNR rate while contrast to wavelet packet transform. Watermarks 1 and 2 are extracted from Translation attack is shown in Figs. 19 and 20 using Pearson ICA. Comparing the values of PSNR, Similarity Measure and Normalized Correlation intended for integer wavelet and wavelet packet transform is tabulated in Table 1.

Fig. 3. Input image (Patient)

Fig. 4. Y component of input image

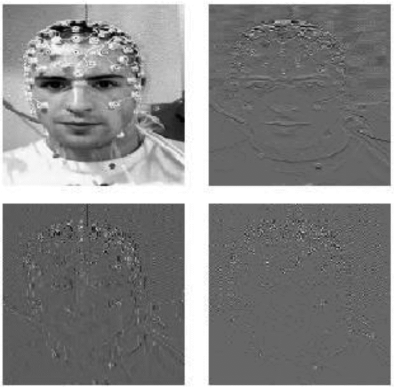

Fig. 5. One level IWT decomposition

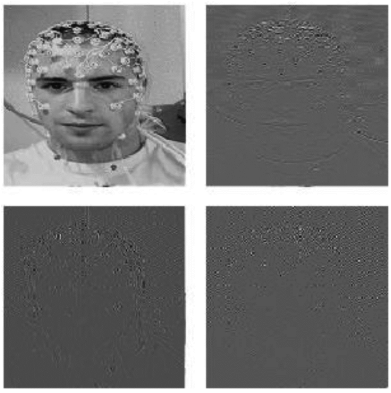

Fig. 6. Two level IWT decomposition

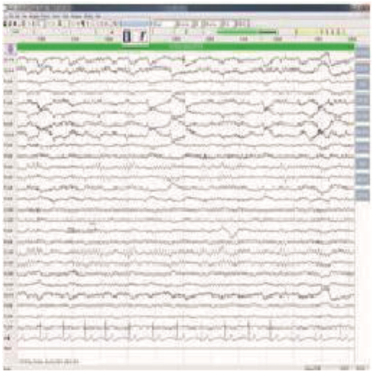

Fig. 7. Watermark1 (EEG)

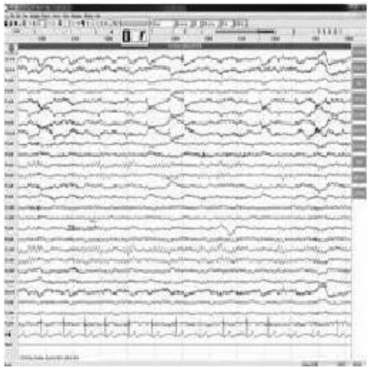

Fig. 8. Y component of watermark1

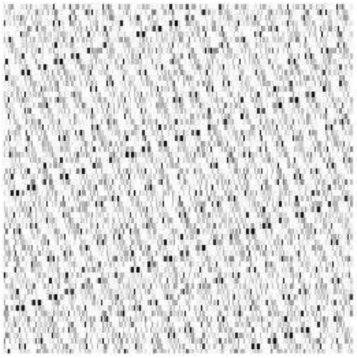

Fig. 9. Arnold transform of watermark1

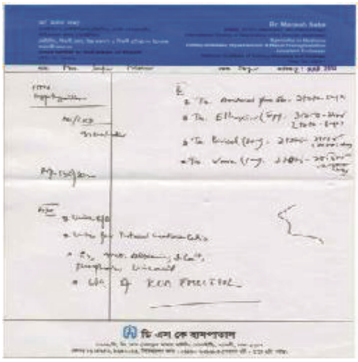

Fig. 10. Watermark2 (Prescription)

Fig. 11. Y component of watermark2

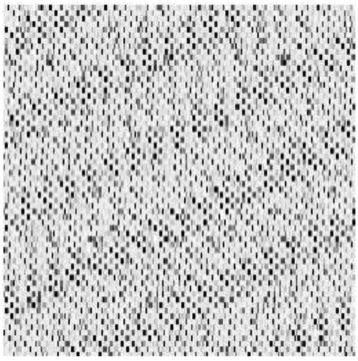

Fig. 12. Fibonacci transform

Fig. 13. Y component of watermarked image

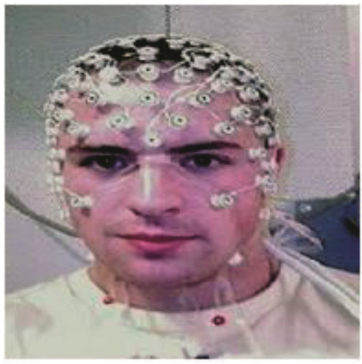

Fig. 14. Watermarked image

Fig. 15. Gaussian Noise attack

Fig. 16. Salt & Pepper noise

Fig. 17. Rotation attack

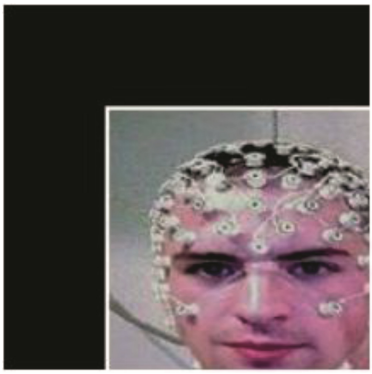

Fig. 18. Translation attack

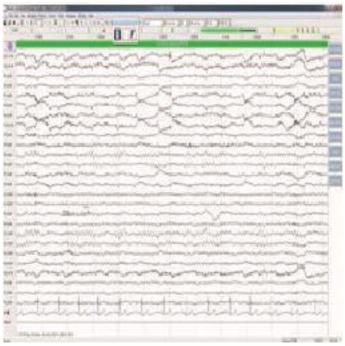

Fig. 19. Extracted watermark1 from translation

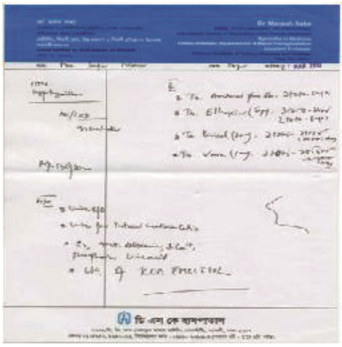

Fig. 20. Extracted watermark2 from translation

Table 1. Evaluation indices of WPT and IWT for various attacks

Input images	PSNR (dB)		Similarity measure		Normalized correlation	
	WPT	IWT	WPT	IWT	WPT	IWT
Watermarked image	45.1768	47.1286	0.9416	0.9617	0.9312	0.9621
Gaussian noise	43.8094	45.8432	0.9267	0.9535	0.9298	0.9592
Salt & pepper noise	43.7863	45.3098	0.9381	0.9582	0.9223	0.9597
Rotation	42.9279	44.9965	0.9316	0.9407	0.9210	0.9492
Translation	42.9987	44.8359	0.9356	0.9485	0.9386	0.9474

6 Conclusion

Healthcare diligence currently requires additional complicated services like transmitting medical images. Improvement in statistics technology made it feasible to clutch such requirements crossways wireless communication. Excluding protection is imperative

issue. In this paper, proposed an impressively robust multiple image Watermarking with higher defense with accurate recovery of watermark for image, providing PSNR equal to 47 and correlation factor equals to 0.96.

References

1. Bender, W., Gruhl, D., Morimoto, N., Lu, A.: Techniques for data hidhing. IBM Syst. J. **35**(3), 313–336 (1996)
2. Mallat, G.: A theory for multiresolution signal decomposition: the wavelet representation. IEEE Trans. Pattern Anal. Mach. Intel. **11**(7), 674–693 (1989)
3. Bounkong, S., Toch, B., Saad, D., Lowe, D.: ICA for watermarking digital images. J. Mach. Learn. Res. **4**, 1471–1498 (2003)
4. Calderbank, A.R., Daubechies, I., Sweldens, W.: Wavelet transform that maps integers to integers. Appl. Comput. Harmonic Anal. **5**(3), 332–369 (1998)
5. Wong, P.H.W., Au, O.C., Yeung, G.Y.M.: A novel blind multiple watermarking technique for images. IEEE Trans. Circuits Syst. Video Tech. **9**, 813–830 (2003)
6. Giakoumaki, A., Pavlopoulos, S., Koutsouris, D.: Multiple image watermarking applied to health information management. IEEE Trans. Inf Technol. Biomed. **10**(4), 267–274 (2006)
7. Lu, L., Sun, X., Cai, L.: A robust image watermarking based on DCT by Arnold transform and spread spectrum. Adv. Comput. Theory Eng. **1**, 254–259 (2010)
8. Swanson, M.D., Kobayashi, M., Tewfik, A.H.: Multimedia data embedding and watermarking technologies. IEEE Trans. Biomed. Inf. **86**, 814–821 (2006)