Analysis of Robustness and Invisibility on a Medical Image Watermarking Algorithm

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ABSTRACT
The present paper extends another different diffusing spectrum hinged technique of image-adaptive watermarking. Here discriminative implantation ofwatermark issettled in compactfabricated slabs of the image, contingent alongside the individual entropyof the slabs. The unfamiliarity of this practice lies down in the pliability of its power factor that can be altered comfortably in the interest to procureaintegral level of optical grade of the watermarkedimage. This variable strength factor (VSF) is calculated using standard deviation of Discrete Wavelet Transform (DWT) measure of blocks with elevated entropy. The robustness of this technique is verified by studying the relationship between the imperceptibilityof the watermarked image and recovery of the watermark for different values of VSF. The invisibility of the received watermarked image is determined utilizing Peak Signal to Noise Ratio (PSNR) and recovery of the watermark is calculated as Bit Error Rate (BER). The technique may be used for safeguarding the ownership of medical images.
Keywords:image-adaptive watermarking, PSNR, BER, variable strength factor, telemedicine

1. INTRODUCTION

Nowadays, an unexpected growth in digital technology has brought a significant change in daily life of every person. All data in the current scenario need to be stored in a digital format [1]. This too increases the risk of forging, tampering or copying of data. A robust technique of watermarking provides the much possible and awaited solution to such a problem. This helps to embed an invisible watermark into another image for proving the rights of proprietorship [2].By lodging a strong watermark within an image;rightful ownerevinceshis possessionifnecessary. But whilst a watermarkbeabundantly robust forholding out againstsomewhat hostile ornon-hostile attacks, it should be completely invisible.As durability and undetectability are antagonistic stipulations, a plenty of investigationeffort and tasks are still proceeding to sustain equilibrium between them[3-5]. Image-adaptive watermarking bestows a befitting technique to counter these complications.[6-8]

2. RELATED WORK

Any watermarking technique must possess three desirable features of good imperceptibility, high robustness and capacity, which is indeed a challenge to achieve. Since all the desirable features are difficult to achieve simultaneously, image –adaptive watermarking forms the best approach to solve the problem. [9] used various visual models in image-adaptive watermarking.[10] too proposed a fixed scaling factor formed on the basis of an image-adaptive approach used for inserting the watermark bits in different sized chunks of the host image [11] also presented a sturdy image-adaptive watermarking technique using spirited strength factors in watermark embedding. [12-13]also proposed to insert one and two watermarks in the medical images using adjustable strength factors using Discrete Wavelet Transform (DWT).[14-15] also used Discrete Cosine Transform(DCT) for inserting the bits of the watermark.

The current work proposes the input image to be divided into different pieces of size 8x8, where only those blocks are selected for hiding the watermark which have high value of entropy. DWT is appealed on these blocks to procure the less frequency coefficients.VSF calculation is done usingthe concept of standard deviation from these blocks. Since the proposed technique is half blind in nature, thus important adjacent information comprising of locations of large entropy blocks, means of small frequency measures of DWT and watermark size is also communicated along with the watermarked image. This helps to recover the watermark at the receiver.

The paper is further organized as: The proposed embedding and detection of watermark are presented in Section3. The calculation of VSF is given in Section 4. The next Section discusses the variation of the values of PSNR and BER for natural and medical images. The results are concluded in the last Section.

3. PROPOSED WORK

The proposed scheme for inserting and detecting the watermark is detailed in Section 3.1 and 3.2 correspondingly. The block diagram of the suggested watermarking technique of embedding and recovery of watermark are shown in Figure 1.

ISSN:0975-3583,0976-2833 VOL12,ISSUE02,2021

3.1 Embedding of Watermark

The input image is disintegrated into different blocks of proportions 8x8. The mean value of entropy is calculated to determine the blocks whose entropy is above the mean entropy value. These are known as high entropy blocks, which are selected for hiding the binary watermark bits of 1 and 0. The number of blocks is always equal or greater than the bits of the watermark as each block hides one bit.

DWT is pertained on the selected blocks to achieve the four sub bands. Only the low frequency coefficients (assumed as L) are selected for embedding the watermark, as the changes in this sub band are not easily perceptible to human eye.The modified coefficients are assumed as L'.

The watermark bits '1' and'0'0 are embedded using the given multiplicative rule as,

$$L' = L(1 + VSF) \text{ and } L' = L(1 - VSF) \qquad (1)$$

Finally, Inverse DWT is beared upon the blocks to achieve the image after watermarking. The adjacent knowledge is also communicated with the transmitted watermarked figure.

3.2 Detection of Watermark

The watermarked image, unlike the incoming image is also disintegrated into different pieces of proportions 8x8. Again DWT is beared on the blocks with large entropy. The average value of the obtained small frequency measures of the received watermarked images is calculated. Also, the side information is used to provide the value of means of low frequency coefficients of the transmitted input image.

The rule of detection implies the comparison of both mean values. If the mean of the received watermarked image is greater than the mean of the input image, bit 1 is detected. However, bit 0 can be detected if the mean of the received watermarked image is less than that of the mean of the transmitted image.

4. VARIABLE STRENGTH FACTOR (VSF)

The variable strength factor is calculated from standard deviation, which is shown in (2),

$$\sigma = \sqrt{\frac{\sum_{k=1}^{N}(z_i - \bar{Z})}{Q}} \qquad (2)$$

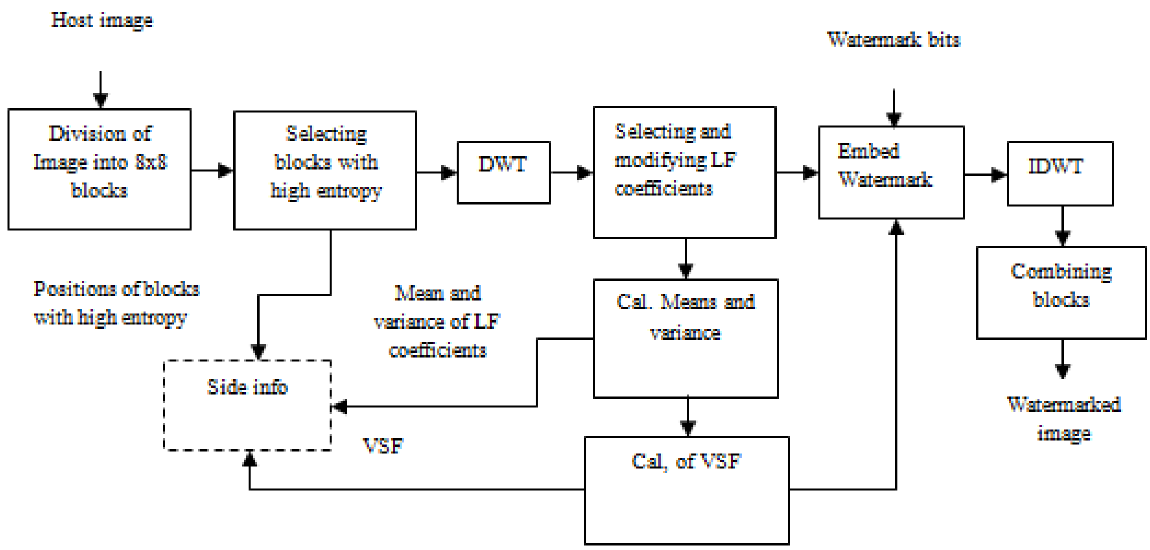
The value of VSF is different for each block and is calculated using (3).

$$\alpha_d = \sigma_i / (\sigma_{max})^{\rho} \qquad (3)$$

Here, σ_i is the standard deviation of small frequency measures of every block in a matrix.

$\sigma_{max}$is the highest value of std. deviation in whole of the blocks and ρ is the multi way framework in the denominator. The merit of ρ is limited between 1 and 2 to preserve the watermark invisibility across minimum BER value of detected watermark.

Plots between PSNR of watermarked image and adjustable parameter ρ are plotted and displayed in Figure 4. Similarly, the plots between BER of detected watermark and adjustable parameter ρ are also displayed in Figure 5.



(a)

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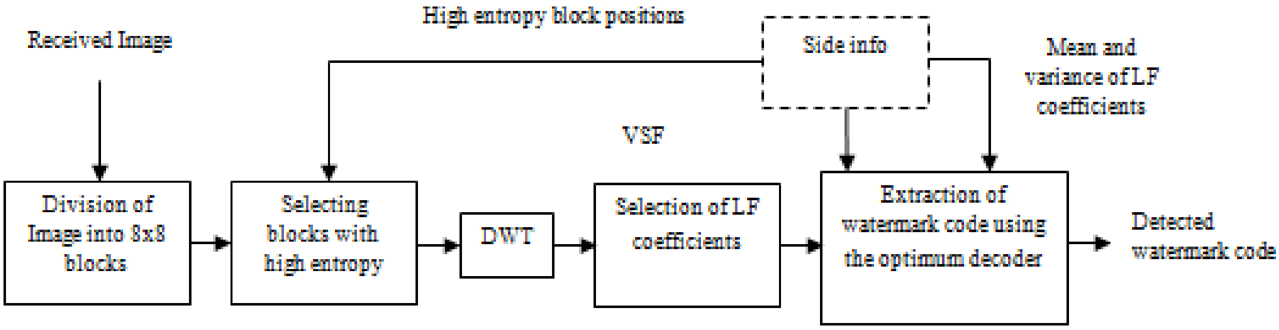


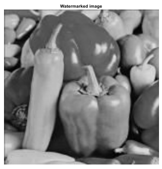
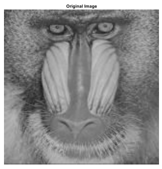
(b)

Fig. 1 Block Drawing of theimage adaptive watermarking technique (i) Inserting watermark. (ii) Detecting Watermark

5. EXPERIMENTAL RESULTS AND DISCUSSION

There is barely a watermarking technique in existing compositions whereindimensions of the image aremalleable option.Nearly entire techniques have utilized images of a distinct proportion only. Nevertheless in the proposed watermarking method, there is a sphere of embracing images of unlike dimensions too. The measurements of the image can be conveyed in along side information which could potentially be utilized during evocation of watermark.

In the proposed work, four standard input images , 'Lena', 'Barbara', 'Peppers' and 'Baboon' of size 512x512 were used for watermarking. Two medical images are also used with watermarks, 'CAMERAMAN' and 'COPYRIGHT" of sizes 18x25 and 32x32.All the standard images use both watermarks for embedding using VSF given in (3). These are shown in Figure 4 and 5 below. The values of ρchosen for the study are (1, 1.5, 2), which are varied between 1 and 2.

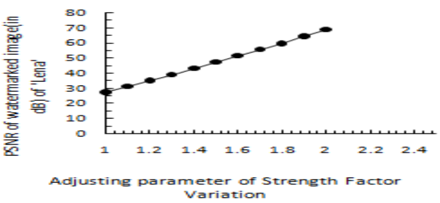
(a)  (b)  (c)  (d) 

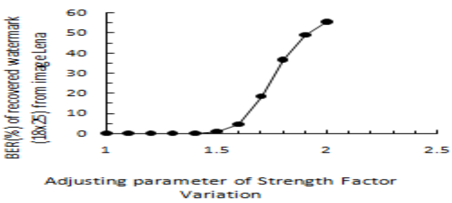
(e)  (f) 

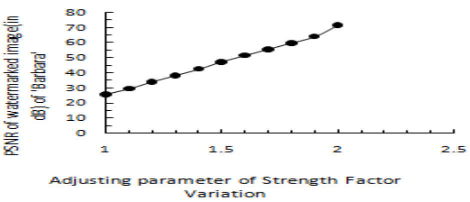
Fig.2: Original input images of size 512x512 used (a) Lena (b) Barbara (c) Peppers (d) Barbara (e) Knee hinge[16] and (f) Lungs X Ray[17]used for medical supplications.

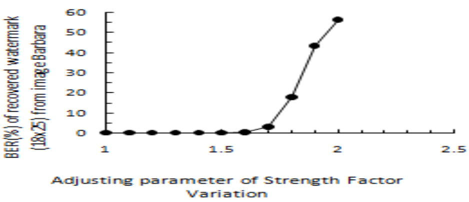
(a)  (b) 

Fig 3: Watermarks Used (a) 'CAMERAMAN' of size 18x25 (b) 'COPYRIGHT' of size 32x32.









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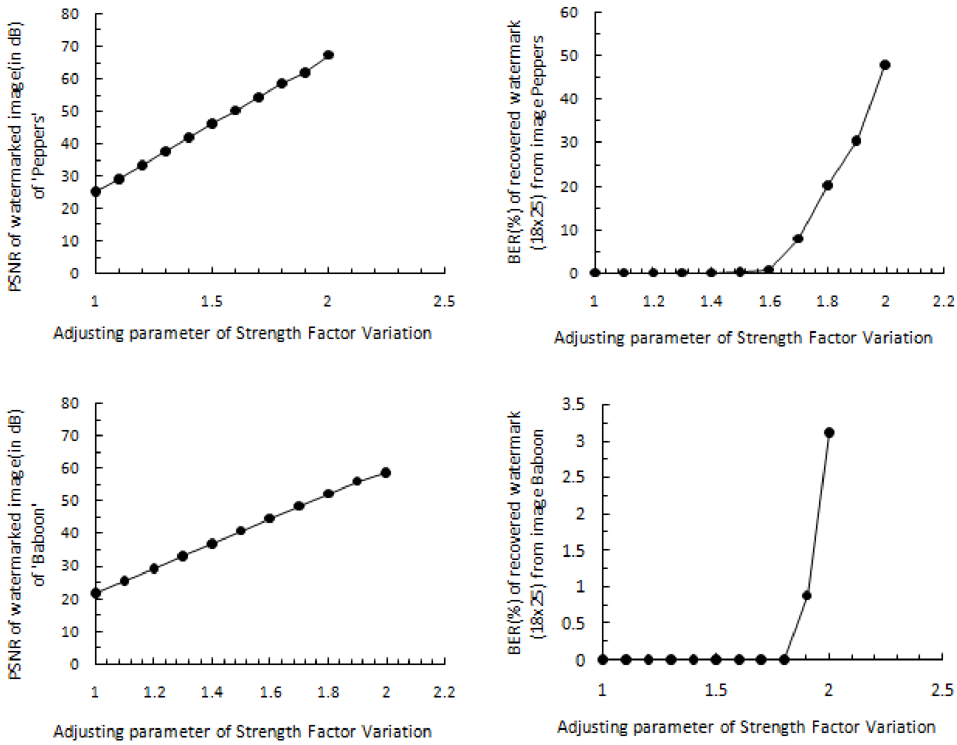
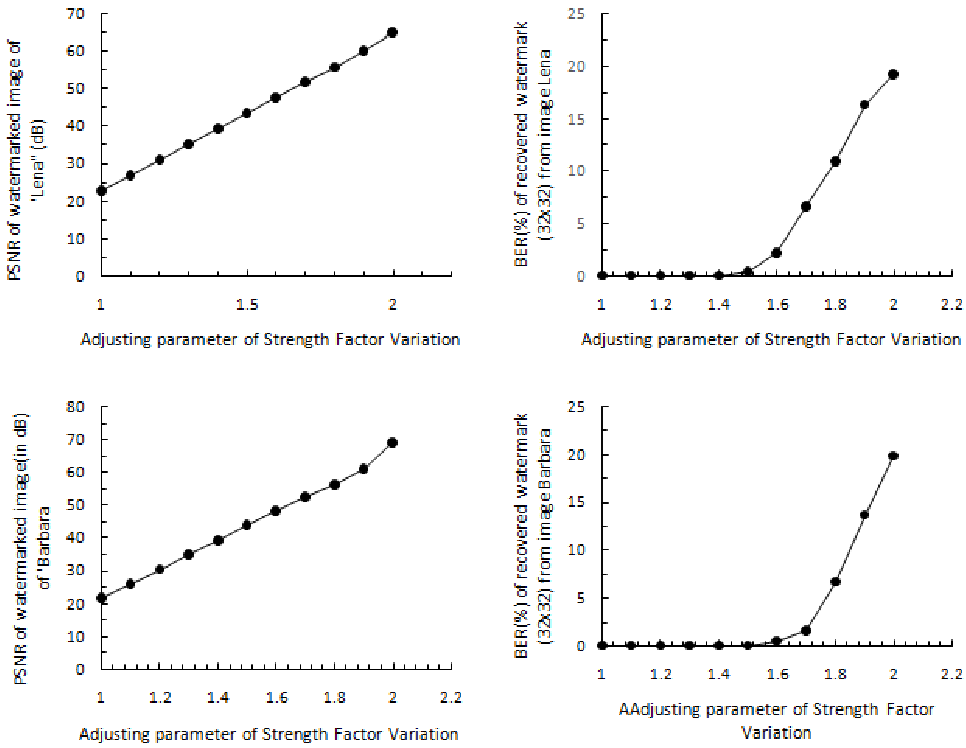


Fig 4: Plots of PSNR for different watermarked received image(s) along with BER of detected watermark 'CAMERAMAN' of size 18x25 for , 'Lena', Barbara', 'Peppers' and 'Baboon' images.



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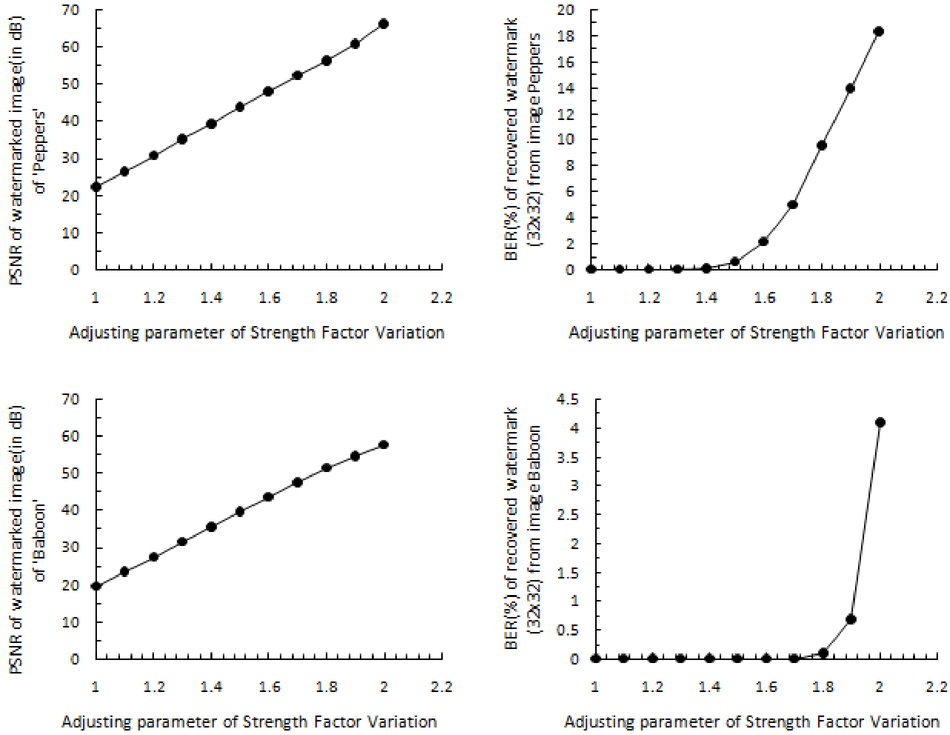
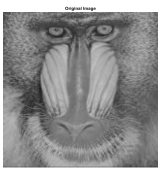
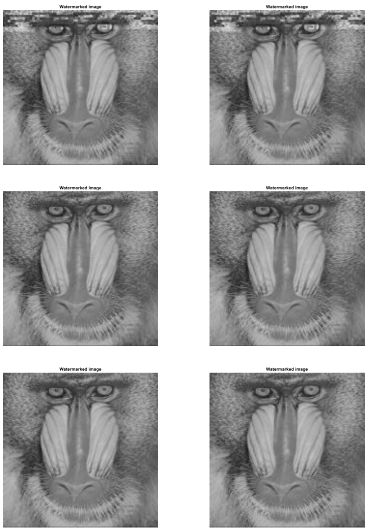
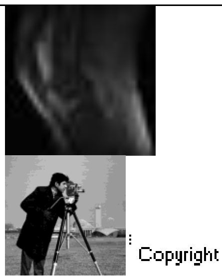
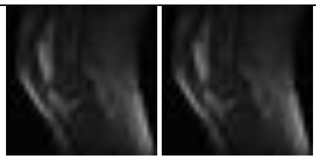


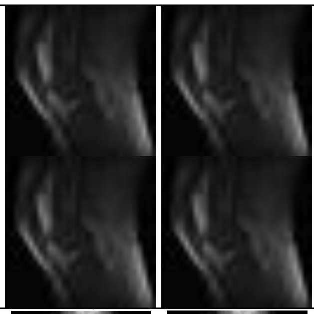
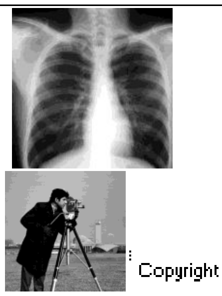
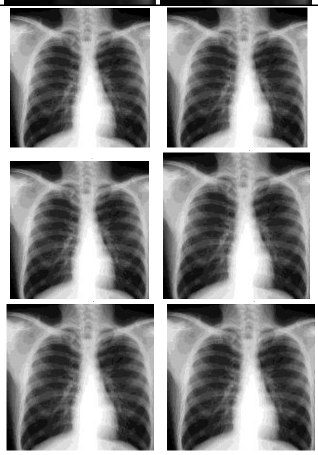
Fig 5: Plots of PSNR for different watermarked received image(s) along with BER of detected watermark 'COPYRIGHT' of size 32x32 for , 'Lena', Barbara', 'Peppers' and 'Baboon' images.

Table 1: Effect of PSNR of watermarked image(s) and BER of detected watermarks(s) upon Imperceptibility

Original Image and watermark(s) used	Watermarked received image	Recovered watermark(s)	PSNR forreceived watermarked image	BER(%) of discovered watermark
			27.29,22.57 43.07,43.45 68.86,65.011	0,0 0,0.3906 55.33,19.23
			25.39,21.61	0,0 0,0.4883

ISSN:0975-3583,0976-2833 VOL12,ISSUE02,2021

			42.47,48.16 71.53,69.004	56.22,19.82
			25.08,22.11 45.91,39.34 67.27,66.12	0,0 0.22,0.097 47.77,18.35
 			21.62.19.48 40.73,47.52 58.64,57.68	0,0 0,0 3.11,4.1
			21.25,23.58 44.09,41.44	0,0 0,0.2705

			58.86,55.011	41.23,15.33
		 	31.29,29.57 40.07,41.15 55.66,58.02	0,0.1 0,0.29 57.53,17.13

From Figures 4 and 5, it is observed that as the value of the adjustable parameter ρ decreases, the PSNR values also become very less. However, the values of BER of detected watermark(s) are also desirably minimum. When the valuesof ρ approach extreme values of 2, the PSNR increases but the BER also rises sharply, which is not desirable. This introduces distortion in the detection of watermark(s). But when the values of ρ lie within the middle of the range, the values of PSNR increase gradually with less or no increase in BER of detected watermarks(s).

The watermarked received images and their detected watermark(s) are shown in Table 1 at different values of ρ. It is observed that the imperceptibility of the watermarked images becomes very poor when the value of the adjustable parameter becomes minimum or approaches high values. Also the detection of the watermark too becomes difficult at high PSNR values.

6. CONCLUSION

The imperceptibility of the watermarked images plays an important role in proving an effective and robust image-adaptive watermarking technique. The high values of PSNR of watermarked image justify the desirable characteristics of imperceptibility. It is observed that the standard of the received watermarked images is desirably maintained and preferred in the range 42dB to 47dB with minimum values of BER of recovered watermark(s). Though the range of PSNR of watermarked images be increased further, but it leads to distortion of recovered watermark(s). However, more robust and hybrid techniques may be proposed to increase the effects of imperceptibility

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ISSN:0975-3583,0976-2833 VOL12,ISSUE02,2021

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