Design and Analysis of Efficient Blind Reversible Watermarking Technique

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ABSTRACT
This paper proposes a blind reversible watermarking techniquewhich incorporates the histogram shifting in wavelet domain. The integer wavelet transform is used to transform the image into wavelet domain. The watermark data is embedded into the sub-band coefficients identified by just noticeable distortion (JND)of the transformed host image. To ensure the prohibition of pixel overflow and underflow in spatial domain property inspired pixel adjustment (PIPA) is also employed, finally wavelet-domain statistical quantity histogram shifting and clustering are used for improving robustness and reducing run-time complexity of the extracting process. The experimental results demonstrate predominance of the proposed approach for different host and watermark images. It also demonstrate the efficient recovery of both watermark and host image.

Keywords
Watermarking, histogram shifting, medical images, reversible, zero-points, integer wavelets

1. INTRODUCTION
Cutting edge digital communication systems encourages simple access to multimedia information and gives simple approach to disseminate and control them. Exchange of multimedia data could effectively provide simple and quick understanding information. The exchange of such information is normally done through non-secure environment, for example, the Internet and hence expands the danger of unapproved access to the important data. To overcome this problem, watermarking is an obvious choice [1, 3, and 4]. Digital image watermarking refers to the methodology of implanting a watermark (e.g. content, sound or a logo image) into the host image which allows validation of the host image. There are some application specific requirements of watermarking technique like if host image is a medical image, then reversibility of the watermarking calculation is a vital necessity to guarantee lossless discovery of both host image and the watermark at destination for right conclusion and verification [1]. To attain to lossless watermarking in wavelet domain, an integer wavelet transform and a reversible watermarking calculation are needed. Integer wavelet transform maps integer image segments (pixels) to integer coefficients in wavelet domain and accordingly offsets overflow when the coefficients are coded into determined number of bits [5, 6]. Because of the expanded exchange of such images, reversible image watermarking technique turned into a complex design problem [2, 5-13]. In [8, 9] histogram shifting in spatial domain is utilized for lossless information covering up. They presented zero-focuses and peak focuses in image histogram for watermark insertion. In [10] histogram density in spatial domain is utilized to make holes for information inserting. It needs additional information to be sent with the watermarked image to have the capacity to recreate the host image and the watermark. In [13] the system presented in [9] was modified for embedding more information in host image by utilizing a lossless information covering up. Since images histogram shift for distinctive images, it is hard to embed high payload of watermark in host image with no noticeable aggravation. To take care of this issue and to expand the capacity of watermarking calculation to be connected to any image, the methodology of watermarking is ideal to be carried out in wavelet domain, or it can be said that histogram of images in spatial domain doesn't fall into a routine pattern; yet in wavelet domain, histogram of the coefficient in high frequency sub-bands has a Laplacian like distribution. Moreover due to low impact of disturbance in high frequency sub-bands of image on human visual system (HVS), wavelet coefficients located in these sub-bands are better candidates for watermark embedding.

In [12] the host image is initially separated to non-covering pieces and after that information to-be-implanted is inserted in high frequency wavelet coefficients of every square. The insertion procedure is carried out by means of LSB-substitution or bit shifting. To accomplish reversible calculation the side data must be implanted in the host image which has negative effect on subtlety of the watermarked image. In [5], the thought presented in [8, 9] for histogram shifting strategy in spatial domain is connected to integer wavelet disintegrated image. A zero-point near to the crest purpose of the histogram is initially made in the histogram and the watermark bits are embedded in this point in light of the thought of histogram shifting. In the event that information to-be-embedded is remained, another zero-point is made and this methodology is proceeded until all watermark bits are embedded. Every one of the zero-focuses are in the center locale of histogram where more coefficients are found around there and subsequently more limit for watermark insertion is given. However this obliges a wide district of the histogram to be moved and thusly has a negative effect on the vagueness of the watermarked image. To beat the vagueness test and give better visual quality to watermarked image, it is obliged that the moved areas of the histogram of the high frequency subbands to be as little as it can be. All the more over the moved parts need to be found before all else and end parts of the histogram where contain higher frequency values that are less delicate to HVS. This paper proposes a calculation which satisfies the aforementioned prerequisites for histogram shifting of the high frequency wavelet subbands. In view of the limit needed for the watermark information, two thresholds, one before all else part (left part) and the other at last part (right part) of the histogram are chosen and the left and right hand side of the histogram is moved to left and right by one unit separately to make two zero-focuses. The watermark information is then legitimately embedded in the position of these thresholds and zero-focuses in the histogram. The center piece of the histogram is kept unaltered.

The proposed methodology is totally reversible and could blindly separate both host image and the watermark with no loss. The rest of this paper is composed as: In Section 2 the outline for the proposed watermarking framework is presented. In Section 3Performance Evaluation is presented. In Section 4presents simulation results and lastly Section 5presents the conclusion.

2. PROPOSED TECHNIQUE

The proposed algorithm works on the basis of IWT decomposition structure which arranges the image information into the four different blocks LL (Approximation coefficients), HL (Horizontal detail coefficients), LH (Vertical detail coefficients) and HH (Diagonal detail coefficients) according to the properties of coefficients and the properties of image it is concluded that the HH coefficients contains only the fine information and does not affect the overall image when modified slightly while the LL coefficients contains the most of the information and the rest of the coefficients (HL and LH) contains the information a bit higher than HH but far less than LL. Utilizing the above information we developed the watermarking technique in which can be explained as follows:

Step1: Let the Host image is denoted by 'C' and the watermark image in denoted by 'S'. Now in first step the 'C' and'S' images are decomposed into first level JND and we get the $C_{LL}, C_{HL}, C_{LH}, C_{HH}$ and $S_{LL}, S_{HL}, S_{LH}, S_{HH}$ coefficients respectively for Main and watermark image.

Step2: since it is known that LL coefficients contains most of the information hence only the S_{LL} coefficients are selected from the 'S' decomposition this reduces the information size to be embedded by approximately four times. This reduction in embedding data facilities to properly hide the data into Host image without producing visual artifacts.

Step3: Now all the four coefficients of 'C' and LL coefficients of 'S' are divided into the blocks of nXn (where n can be 2, 3 or any integer less than coefficient matrix size).
Step4: now the embedding procedure can be started for that the first block of S_{LL} is matched with all the blocks of C_{LL} and the index of the C_{LL} block showing the minimum MSE is selected as key while the difference between the block is taken as error block which is then searched on C_{HL} block similarly as done before with C_{LL} and the index is again noted as key the error block coming from this stage is again searched in C_{HH} block in same way finally the error block of this stage is searched in C_{HH} block and the block with minimum MSE is replaced by the error block and index is again noted down.

Step5: the procedure defined in step4 is repeated for all the blocks of theS_{LL}. This ends the embedding procedure and the image with modified C_{HH} coefficients is retransformed to spatial domain using inverse JND (IJND) which is called final image'STG'.

Step6: for the retrieval of the 'S' image firstly the STG is decomposed using JND and the coefficients are divided into the similar block size as used during embedding process. Now the first four digits of key is used to select the blocks from STG_{LL} ,STG_{HL},STG_{LH} and STG_{HH} respectively and then the summation of all four block is performed the procedure is repeated for total key digits and the output blocks are arranged in same way it was during embedding.

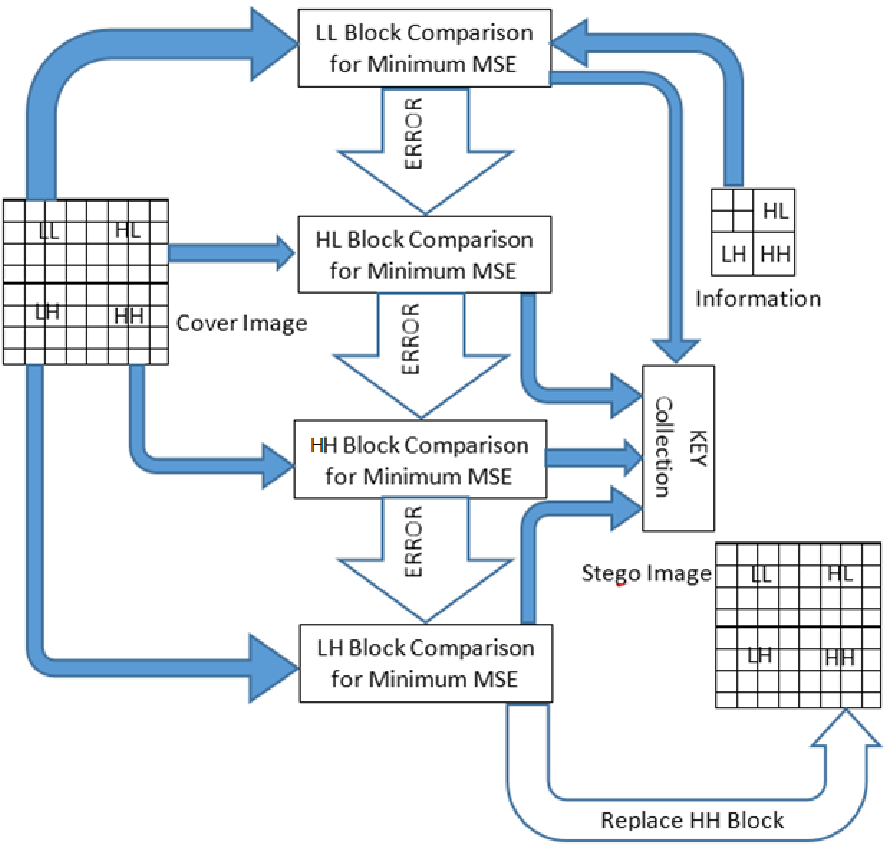


Figure 2: Block Diagram of Proposed Algorithm

3. PERFORMANCE EVALUATION

Peak signal-to-noise ratio (PSNR), is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.

It is most easily defined via the mean squared error (MSE) which for two mXn monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR is defined as:

$$PSNR = 10 \cdot log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

$$= 20 \cdot log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

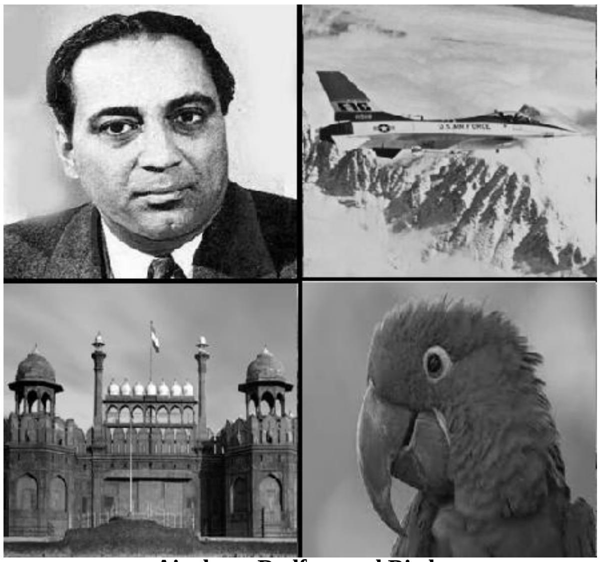
$$= 20 \cdot log_{10}(MAX_I) - 10 \cdot log_{10}(MSE)$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255.

4. SIMULATION RESULTS

The proposed algorithm has been extensively tested on various standard images as presented in figure 3 and 4 and the results are summarized in the tables from 1 to 8.

Cameraman.



Airplane, Redfort and Bird.

Table 1: Experimental results for non-attacked Image: PSNR of Host image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	23.57	30.46	26.72	33.07	27.67	33.49	29.18	36.55
Goldhill	22.70	27.23	23.59	29.80	25.19	31.24	27.07	34.00
Cameraman	22.47	27.23	26.43	33.15	26.47	32.66	26.41	34.03
Barbara	25.73	29.42	26.78	31.85	26.02	33.34	28.81	36.55

Table 2: Experimental results for non-attacked Image: PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	16.08	16.3353	16.42	18.27	18.83	19.73	18.90	19.94
Goldhill	13.99	16.69	16.40	19.10	18.63	21.33	18.04	20.71

Cameraman	16.20	16.88	16.60	17.50	16.42	19.04	17.43	18.83
Barbara	13.85	16.57	15.15	19.22	17.94	20.28	18.50	19.98

Table 3: Experimental results for Gaussian-Noise (Mean = 0, Variance = 0.001): PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	16.13	16.22	16.42	17.86	18.75	19.35	18.51	19.18
Goldhill	14.04	16.43	16.44	18.51	18.62	20.77	17.69	19.74
Cameraman	16.24	16.75	16.58	17.25	16.51	18.64	17.28	18.17
Barbara	13.92	16.37	15.13	18.67	17.90	19.87	18.33	19.03

Table 4: Experimental results for Gaussian-Filter (Windows Size = 3x3, Variance = 0.5): PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	17.15	14.82	19.25	17.26	21.25	18.91	20.09	18.73
Goldhill	15.49	14.86	20.13	17.12	22.16	19.49	24.16	18.94
Cameraman	15.92	14.27	18.72	16.62	20.15	17.86	22.80	17.18
Barbara	15.63	15.45	18.18	17.51	21.97	19.21	24.50	19.12

Table 5: Experimental results for Average-Filter (Window Size = 3x3): PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	13.90	13.44	16.10	15.51	18.32	17.53	18.67	17.40
Goldhill	13.52	13.31	15.46	15.15	18.28	17.78	18.39	17.37
Cameraman	12.96	12.61	15.58	15.32	17.52	16.76	16.67	15.74
Barbara	14.09	13.99	15.88	15.62	18.31	17.97	18.99	17.91

Table 6: Experimental results for Motion-Bluering (Length = 9, Theta = 0): PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	13.67	13.62	16.08	16.08	18.17	18.06	18.09	17.76
Goldhill	13.28	13.37	15.37	15.38	18.12	18.01	17.92	17.55
Cameraman	12.85	12.85	15.51	15.60	17.16	17.13	16.33	15.97
Barbara	13.93	14.04	15.91	15.98	17.93	18.03	18.04	17.72

Table 7: Experimental results for Histogram-equalization: PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	15.06	15.09	13.48	14.14	16.21	16.88	14.25	15.22
Goldhill	12.72	14.06	11.86	12.36	13.50	14.69	11.75	11.48
Cameraman	14.33	14.79	12.01	12.67	13.99	16.33	12.45	14.88
Barbara	13.27	15.02	12.33	14.00	15.22	17.05	14.06	15.51

Table 8: Experimental results for Sharpness-attack (alpha = 0.2): PSNR of Watermark Image

Host image (256X256)	**Watermark Image Sequence (64X64)**							
	Homi		**Airplane**		**Redfort**		**Bird**	
Technique	Previous	Proposed	Previous	Proposed	Previous	Proposed	Previous	Proposed
Peppers	11.82	12.49	9.77	11.07	10.21	10.68	7.99	11.07
Goldhill	10.70	11.95	9.32	10.52	10.20	12.85	7.19	9.76
Cameraman	11.74	13.27	10.22	11.21	10.83	12.55	7.75	9.51
Barbara	10.21	12.01	8.82	11.37	9.90	12.49	6.87	10.14

5. CONCLUSION

Our study focused on presenting a JND-DWT based digital image watermarking algorithm. Proposed method exploits strength of Wavelet domains transform to obtain further invisibility and robustness. The idea of inserting information in the multiple decomposition components is based on the fact that loss from one band could remain from other band. Implementation results show that the impact on Host image is greatly reduced as compare to previous method. Presented method is also tested for most of the common image processing attack such as Gaussian filtering, Averaging, histogram equalization etc. and the simulation results show that proposed method is more efficient and robust compare to previous method.

6. REFERENCES

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