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Digital Image Watermarking Using 3-Level DWT-SVD And Median Filter

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ABSTRACT-

In the 21st century, the use of internet and multimedia applications is growing day by day. The demand of online trade and digital content, in the form of audio, video, text, images is increasing. But the problem arises that the digital data can easily be manipulated and duplicated. This increased the demand of securing the digital data for copyright protection, preventing unauthorized distribution, and ownership verification. Digital image watermarking is a powerful tool to secure digital data. An information called ownership identifier is hide in the original data with a suitable algorithm so as not to affect the quality of the original data. Watermarking techniques mainly aims in maintaining the robustness and imperceptibility of the image. Watermark can be embedded in frequency domain or spatial domain. Frequency domain is the mainly used technique due to its robustness against different types of attacks. Watermark can be extracted using blind and non-blind technique. In this paper, 3-level DWT –SVD of the host image is done by Haar wavelet and the technique is used to embed watermark in the host image. Further a median filter is used to improve PSNR at a low value of alpha. Watermark is extracted using blind technique. The experimental results conclude that the extracted watermark with the proposed algorithm is invisible and quality of watermarked image and recovered image is good.

Keywords— Discrete wavelet transform (DWT), Singular value decomposition (SVD), HAAR Wavelet transform, Median Filter, MSE, PSNR.

Introduction

Watermarking of images has recently acquired tremendous curiosity in a range of applications like, identification of image, copyright control, verification of image and data hiding, amongst others. Duplication and distribution of multimedia data have been rendered easy and virtually costless due to tremendous advances in networking and high speed processors. Digitized data can easily be manipulated thus losing its originality [1].Thus it makes copyright protection of digital media a stern challenge. Thus the concept of digital watermarking comes into picture. Digital watermarking is the process that embeds data called a watermark into a multimedia object in such a way that the watermark can be later on detected or extracted for a object assertion purposes. The multimedia objects, in which the watermark is embedded, are usually called the original, cover signal, host signal or simply the work [2] [3].The watermark should be

embedded in such a manner that the originality of the host image should not be distorted [4].A digital watermark is a distinguishing piece of information that is assigned to the data to be protected. One important requirement by this is that the watermark cannot be easily extracted or removed from the watermarked object.

An effective digital watermarking method must satisfy the two main requirements of imperceptibility and robustness to common image attacks like cropping, rotation, Gaussian noise, motion blur, salt and pepper noise, compression and many more signal processing operations. Digital image watermarking techniques are grouped into spatial and frequency domain. Spatial domain is the embedding of watermark by modifying the intensity values or pixel values of the image [11]. Frequency domain is the embedding of watermark in frequency components of the image. To obtain frequency components, any of the frequency transform technique is used [1] [11]. Commonly used frequency domain transforms are Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT) and Discrete Wavelet Transform (DWT)[11][16]. DWT is the mainly used transform due to its excellent multi resolution characteristics and spatial localization [16]. Frequency domain technique is more effective as compared to spatial domain due to its robustness and imperceptibility [11].transform domain of watermark is done in either in full frequency band of image or in specific band such as low frequency band or high frequency band or middle frequency band.

In the proposed algorithm, information is hidden in low frequency band LL of host image. Watermark is extracted from all the sub-bands. The features of SVD are combined with DWT to embed data in host image. Section II covers the review of related works. Section III covers the overview of DWT and SVD. The proposed algorithm is discussed in section IV. Section IV also explains the application of Median filter to further enhance the performance of above algorithm. Results and conclusions are discussed in section V.

II LITERATURE REVIEW

Van et al [1], suggest two LSB techniques. First technique works on LSB of the image and replaces it with a pseudo noise sequence while the second technique adds a PN sequence to the LSB of the cover image. Another method called patchwork works on n no. of points (ai,bi) in an image. The embedding is done increasing the brightness of ai by one unit and simultaneously decreasing the brightness of bi by one unit. But the algorithm did not proved to be very successful as it was highly sensitive to the noise and the quality of image degraded due to embedding of watermark. Kundar et al [3], decomposed binary logo watermark through DWT. Host image is DWT decomposed and the watermark is embedded on block by block basis the watermark is scaled by a scalene factor before embedding. The coefficients of different frequency bands of the original image are quantized and the binary watermark is embedded. For watermark recovery, the binary code which is embedded is estimated by analyzing quantization coefficients. After estimation the code is correlated and compared with a threshold value. Results proved to be good and very resistant to various types of attacks. Cox [5], developed his first DCT based watermarking algorithm in which he embedded watermark in DCT domain that uses human visual system properties. In this method all the coefficients or few coefficients of the image are used in watermarking. The amount of embedded information is an important parameter because it influences the watermark transparency. If more the embedded information then lower the watermark transparency. So this method did not proved to be very fruitful. V.santhi and Dr. Arun kumar Thangavelu [11], proposed a new SVD and DWT based technique for hiding watermark in full frequency band of color images (DSFW). The quality of the watermarked image and extracted watermark is measured using peak signal to noise ratio (PSNR) and normalized correlation respectively. The proposed algorithm shows Robustness of watermarked image against various attacks including salt and pepper noise and Gaussian noise, cropping and JPEG compression. Good PSNR value of 36dB is found. Nagwar Pragnya and Aravind naik, [23] proposed a blind image watermarking techniques and watermark is embedded using frequency domain using discrete wavelet transform, singular value decomposition and torus automorphism technique. Results proved that it is robust against different signal and non-signal attacks and watermark can be extracted without cover image. Samreet kaur and Navneet kaur sidhu [24], proposed a digital image watermarking technique SVD-DWT-DCT with Kalman filtering. Peak signal to noise ratio (PSNR) and Mean square error (MSE) has been evaluated and better results have been found in contrast to SVD-DWT-DCT technique.

III OVERVIEW OF DISCRETE WAVELET TRANSFORM AND SINGULAR VALUE DECOMPOSITION

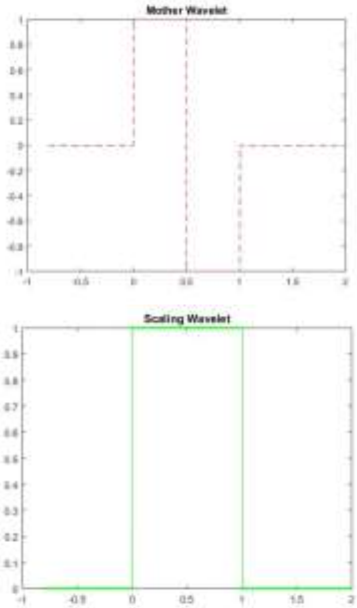
Wavelet is rescaled square shaped functions together forming a basis of family. Wavelet analysis is action to Fourier analysis considering that it allows the orthonormal function representation of the target function over an interval. Haar sequence, proposed in 1909, used these functions as an example of orthonormal system for the space of square function on the unit interval [0, 1]. The study of wavelet came much later and as a special case of Daubechies wavelet. The Haar wavelet is also known D2. The disadvantage of the Haar wavelet lies in the fact that it is not continuous and hence not differentiable. This can however, be an advantage in analysis of signals with sudden transitions like the monitoring of tool failure in machines.

The Haar wavelet's mother wavelet function Ψ (t) can be described as:

$$\Psi(t) = \begin{cases} 1 & 0 \le t < \frac{1}{2}, \\ -1 & 1/2 \le t < 1, \\ 0 & otherwise. \end{cases}$$

Its scaling function Ø (t) can be described as

$$\text{Ø}(t) = \begin{cases} 1 & 0 \le t < 1, \\ 0 & otherwise. \end{cases}$$



Haar Basics

The Haar transform decomposes a discrete signal into 2 sub signals each sub signal is half of s's original length. The first half is the approximation (or average) of the original signals and the second half indicates the detail (or change), d, from the spectrum s. The frequency spectrum of a signal is basically the frequency components (spectral components) of that signal.

Host Image

Joker as a Watermark

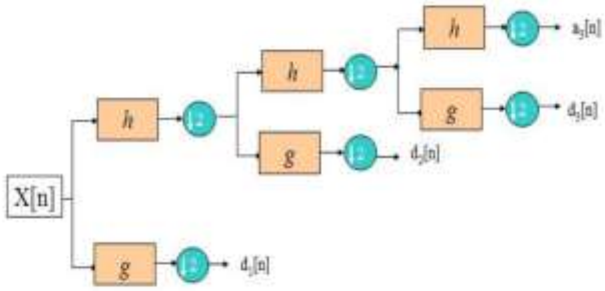


Figure 1: 1-D DWT Analysis or Decomposition Tree

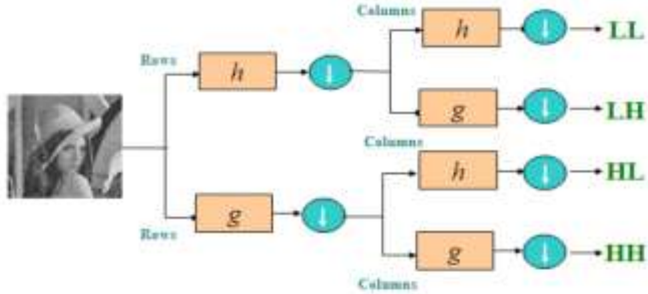


Figure 2: 2-D DWT Analysis or Decomposition Tree

Reconstruction

Signals can be decomposed or analyzed by DWT. However since there is no loss of any piece of info or components the same can be used to assemble original signal while suffering no loss in the process.

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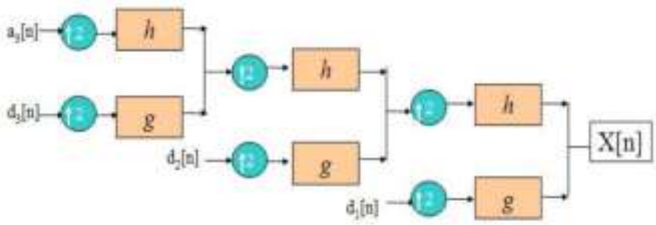

Figure 3: 2-D IDWT Synthesis or Reconstruction Tree

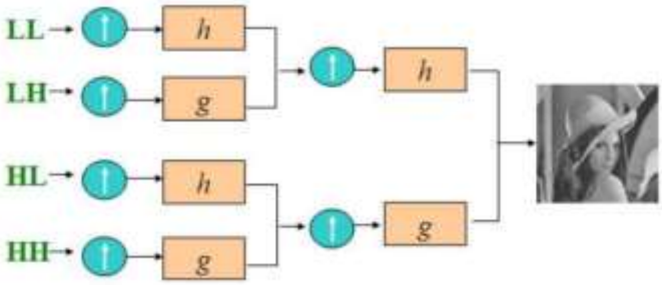

Figure 4: 2-D IDWT Synthesis or Reconstruction Tree

Once the 2-D DWT is applied to the image, it results in four quadrants. Each quadrant is a quarter the size of the original image. It produces the two matrices of coefficients the horizontal details (HL) and vertical details (LH). Using secret key as seed, a pseudo random noise pattern is generated. Using this pattern, the bits of the watermark are embedded in the horizontal (HL) and vertical (LH) coefficient sub-bands. The equation from which is used embed one of the three watermarks is as given below:

W ′i = Wi + α Wixi, for all pixels in sub band LH, HL

W ′i = Wi for all pixels in sub band HH, LL.

Where α = Transparency factor

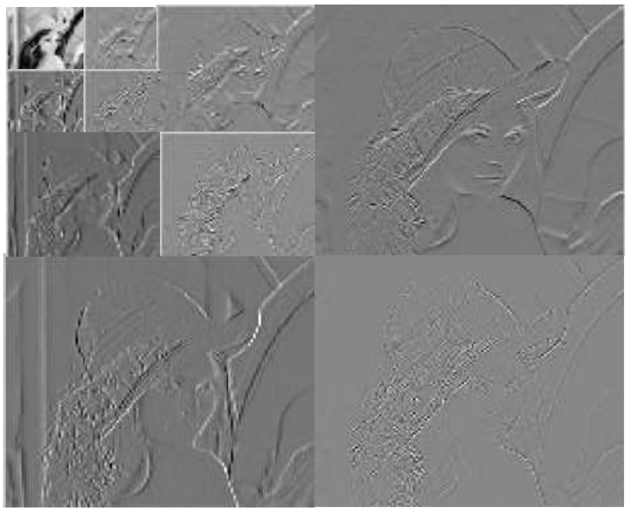

Figure 5: Discrete Wavelet Transform Level 3

Singular value Decomposition (SVD)

To solve several mathematical problems, a linear algebra technique is used. Without compromising the quality of image, a small value is added. This technique is referred as Singular Value Decomposition.

(a) The Singular Values of an image contain good stability due to small value is added to an image, this affect the quality with very minute variation.

(b) SVD is proficient to effectively show the essential algebraic properties of an image, where singular values and singular vectors represent the brightness of the image and geometric characteristics of the image respectively. Image matrix contains several tiny singular values, which is compared with the first singular value. In the reconstruction of the image does not affect the quality of the image if these tiny singular values ignored. That's why without the loss of generality any image can be considered as square matrix. So this technique can be applied to any type of image.

Matrix values are considered as intensity values if it is a gray scale image.

The quality of the image that is reconstructed does not get affected even by ignoring the small singular values. Without any loss of generality any image may be considered as a square matrix. The technique involving SVD can be successfully applied to any kind of image. The matrix values, if it is a grey scale image, are considered as intensity values. This could be modified directly or changes could be affected after changing images into frequency domain. The SVD that decomposes matrix into three matrix of the same size belongs to orthogonal transform .It is not mandatory for the matrix to be a square one for the purpose of decomposing it using SVD technique. Let us denote the image as matrix A and the SVD decomposition of matrix A is denoted using

$A = USV^T$ U and V are known to be unitary matrices such that

$UU^T = I$, $VV^T = I$, where I is an Identity matrix.

$$U = [u_1, u_2, u_3 \ldots\ldots u_n],$$

$$V = [v_1, v_2, v_3, \ldots\ldots v_n],$$

U matrix is referred to as left singular values and V matrix is accordingly referred to as right singular values. The decomposition of matrix A is obtained using.

$$SVD(A) = U\,S\,V^T = U\,[D\ 0;\ 0,\ 0]\,V^T$$

$$S = [D\ 0;\ 0,\ 0]$$

Such that all the elements in main diagonal are in decreasing order like $\sigma 1 \geq \sigma 2 \geq \sigma 3 \geq \ldots\ \sigma n \geq 0$ .Here S that has its main diagonal all positive singular values of A, is a diagonal matrix. The rank of the matrix is equal to the number of non-zero values. Number of nonzero values equals the rank of the matrix. To embed watermark these singular values can be used. Since the order of singular matrix is same as A, and hence the resultant matrix is also square. Hence images of equal size can be taken as cover object.

IV PROPOSED ALGORITHM

Algorithm for Embedding Watermark

1 .In this method, the watermark in all the channels of the YUV space is hidden by selecting the full band frequency. The energy of the watermark is controlled using the embedding factor. It is represented by α and varies from 0 to 1 ($0 \leq \alpha \leq 1$).

The algorithm used for hiding information is given below:

1 RGB components of the image is transformed into Matrix.
2 DWT is used to decompose matrices into frequency bands.
3 SVD techniques is applied on each band of host data as well as on watermark using
[U, S, V] = SVD (Band)
[U', S', V'] = SVD (W)
Let U, V be orthogonal matrices, S is a diagonal matrix. The diagonal matrix S is used to embed watermark in its diagonal elements using (7). Here Band represents any one of the frequency band such as LL, LH, HL and HH
S''=S + alpha*S'
The watermark is embedded into the non-zero elements of the diagonal matrix S to obtain the watermarked diagonal matrix S''
4 Inverse SVD is applied on watermarked matrix to get the modified Image Band using
Band'= [U*S''*V]
Inverse transformation technique is applied to get the watermarked image matrices of R, G, B using
[R', G', B']=DWT (LL', LH', HL', HH')

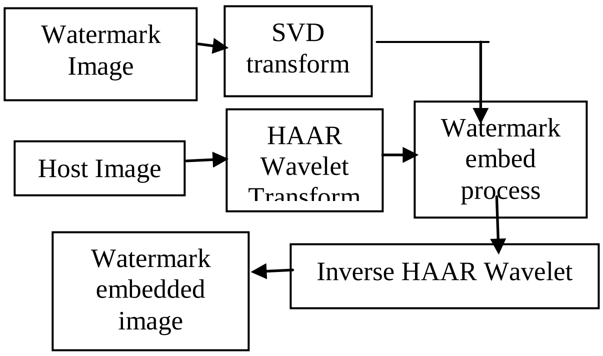

Figure6: Watermark embedding

Algorithm for Extracting Watermark

During Extraction process, the RGB components of the watermarked color image are changed into RGB color spaces that can further be transformed into frequency coefficients of four bands. Each band of frequency is SVD transformed to extract watermark from the diagonal elements.
1 Wavelet transformation Technique is applied to YUV matrices to break it into various range of bands of frequency.
[LL, LH, HL, HH] = DWT (R, G, B)
2 SVD transformation is applied on full band of wavelet transformed YUV matrices
{U, S'', V}= SVD (Band')
3 Watermark is extracted using
S'=(S''-S)/alpha
4 Apply inverse SVD on retrieved watermark using unitary matrices U and V
W'=US'V

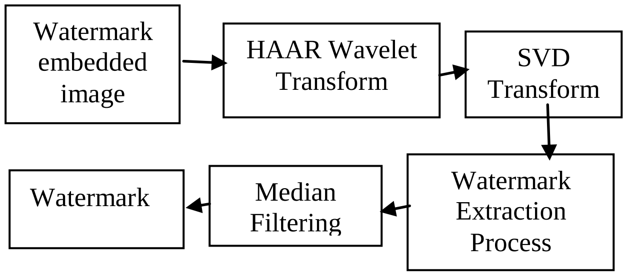

Figure 7: Watermark extraction in host image

To improve the extracted watermark correlation. Nonlinear filter (median filter) is applied
W(i,j)=median(a,b,c,d);
The median filter is applied on first element of LL, LH, HL and HH result of median function is stored in another zero matrix. This is repeated throughout elements of the matrix.The matrix contains the watermark that have good correlation.The extracted watermark is extracted from all sub bands. The median filter is applied on four extracted watermarked image. Because attack in image cause distortion in watermark But attack does not affect all sub bands. But affect depends on the type of attack. So any sub band may affect. The median filter is applied on all extracted watermarked image. The all elements are picked from first element of all matrix. Median filter is applied on these elements throughout the image.

V. Results and Discussions

Performance evaluation is very important part in the any algorithmic designing watermarking. The main task of this is to evaluate the quality matrices of algorithm or method to find out, how much this is effective? Some of the quality matrices an image watermarking method or algorithm.

The mean squared error (MSE) in an image watermarking is to estimate or measures the average of the squares of the "errors", between host image and watermark image

$$MSE = 1 \div MN \sum_{i}^{M} \sum_{j}^{N} (Wij - Hij)^2$$

Where M, N is pixel values in host image
Wij = Pixel value in Watermarked Image
Hij = Pixel value in Host Image

Attacked images are measured using the Peak Signal to Noise Ratio. The visual quality metrics are made use of as a measure of distortions introduced by the watermarking process. It must be noted that it is distinguishable by visual quality of the data on account of embedding of the watermark and the visual quality of the watermarked data as a result of the attacks performed on it. It must be appreciated that the visual quality of the watermarked data is required to be as high as possible. This aspect means that the degradation of the data due to the watermarking operation is hardly noticeable.

Peak Signal to Noise Ratio (PSNR), defined as:

$$\mathrm{PSNR}(dB) = 10\log_{10}\left(N_1 N_2 \frac{\max\limits_{x_1,x_2} \mathbf{I}^2_{x_1,x_2}}{\sum\limits_{x_1,x_2}(\mathbf{I}_{x_1,x_2} - \mathbf{I}_{W_{x_1,x_2}})^2}\right)$$

Where N1 andN2 are dimensions of the original image I and watermarked image.

$$x_1 = 1,\ldots,N_1,\; x_2 = 1,\ldots,N_2$$

The PSNR shows that Watermarked image is perceptible or watermark is not recognized by naked eyes.

When the watermarked image which in all the sub bands LL,LH ,HL and HH, is tempered by various types of attacks like Gaussian noise, rotation, JPEG compression, crop, rescaling, then the value of correlation parameter defines the correlation of the watermarked image with the original image at various value of alpha. As the results demonstrates, the higher value of correlation parameter from all sub bands at low value of alpha shows the accuracy of the algorithm for embedding and extracting the watermark.

MULTIPLE ATTACK CORRELATION					
ALPHA	LL	LH	HL	HH	Watermark Filtered from all sub bands
0.01	0.483	0.285	0.644	0.509	0.846
0.03	0.475	0.467	0.678	0.601	0.885
0.05	0.474	0.573	0.708	0.702	0.891
0.07	0.476	0.706	0.721	0.834	0.914
0.09	0.478	0.797	0.737	0.894	0.92
0.11	0.483	0.827	0.763	0.898	0.926

Results the value of MSE at various value of Transparency factor alpha

ALPHA	MSE	CONCLUSION
0.01	0.000	Best Results
0.03	0.083	
0.05	0.643	
0.07	2.288	
0.09	5.603	
0.11	10.392	

Results demonstrates the value of PSNR at various value of Transparency factor alpha

ALPHA	PSNR	CONCLUSION
0.03	58.90	Best Results
0.05	50.04	
0.07	44.53	
0.09	40.64	
0.11	37.96	

SECTION – VI CONCLUSION

The concept of robust watermarking is primarily based on geometric invariant domain which is constructed using DWT and SVD algorithm with median filter. Copyright protection is provided by extracted watermark. To the best knowledge this is of first kind of increment in robustness of watermark. Two chief aspects that need to be enhanced are the visual quality of stage image and the effectiveness of content recovery. The diagonal effect caused by SVD is reduced by application median filter application. Embedding watermark in all sub bands of DWT increase in robustness of watermark.

As the watermark is implemented in four sub bands. The multiple attacks reduce watermark correlation. If the value of alpha parameter increased then PSNR of host image get reduces. The quality of watermarked get reduced. To makes good PSNR (peak signal to noise ratio) of watermarked image the alpha parameter is fixed with low value. The low value of alpha reduces watermark's robustness .It is shown that watermark is extracted at various attacks from various band. Have low correlation. Based on this correlation It creates difficulty in automated decision. Thus the applications of median filter make it more robust and make good correlation of watermark.

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