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Comparative Analysis of Wavelet Based Digital Image Watermarking In Low Frequency Band

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Abstract: - In recent years, digitization play a big role in human life as numerous applications. Therefore, authentication, information security and other various issues are raised with multimedia sources and contents. These concerns have triggered significant research to find ways to protect the multimedia contents like image, video, audio, or text etc. To achieve this, we have proposed a hybrid image watermarking technique based on Discrete Wavelet Transforms and Singular Value Decomposition for embedding the watermark in Low frequency band and also compare the performance of the proposed work at different value of SF to satisfy the imperceptibility and robustness.

Keywords — Digital Watermarking; Discrete Wavelet Transform, singular value decomposition (SVD), scaling factor PSNR, NCC etc.

1. Introduction

Due to rapid delivery of digital multimedia data over internet, demand of hiding techniques to secure digital data is required. Data hiding is a very active research areas. Digital watermarking is a branch of Data hiding which is used to hide proprietary information in digital media like photographs, digital music, or digital video [1-2]. Watermarking is the process of embedding the watermark into cover image with the help of embedding algorithm for security and other purposes. Later on, this embedded image can be extracted with the help of extraction algorithm. Generally, the image watermarking can be done in spatial domain or in transform domain [3]. Compared to spatial domain techniques frequency-domain watermarking techniques proved to be more effective with respect to achieving the imperceptibility and robustness requirements of digital watermarking algorithms [4]. Commonly used frequency-domain transforms include the Discrete Wavelet Transform (DWT), the Discrete Cosine Transform (DCT) and Discrete Fourier Transform (DFT) etc. However, DWT has been used in digital image watermarking more frequently due to its excellent spatial localization and multi-resolution characteristics, which are similar to the theoretical models of the human visual system. Further the performance can be improve by using hybridization in digital image watermarking algorithms and by increasing the level of DWT.

2. Methodology

A. Discrete Wavelet transforms (DWT)

Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image. It is a multi-resolution technique that can analyze different frequencies by different resolutions. For 2-D images, filters divide the input image into four no overlapping multi-resolution sub-bands.

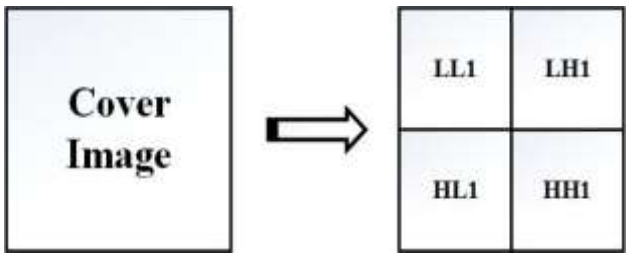


Fig. 1. Decomposition Structure "Single level DWT

Fig. 1 illustrates the DWT decomposition structure for Image, its produce the four different band of image such as LL1, HL1, LH1 and HH1 known as approximation information, horizontal detail information, vertical detail information and diagonal detail information; In wavelet analysis, maximum energy of function or image is centered at LL band means as approximation coefficient. Due to its excellent spatial-frequency localization properties, the DWT is very suitable to identify the areas in the host image where a watermark can be embedded effectively [5].

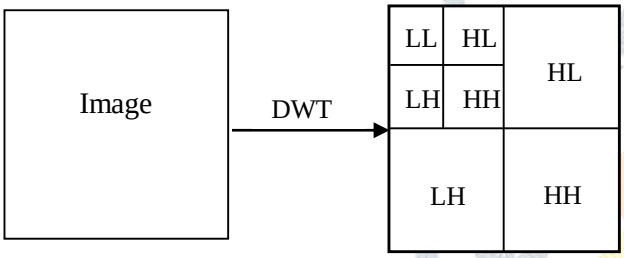


Fig.2 show DWT decomposition of image at level-2

Fig. 2.2(b) represents the two-level DWT decomposition and sub-band of image in two dimensional structure . In wavelet analysis, maximum energy of function or image is centered at LL band means as approximation coefficient.

B. Overview of singular value decomposition (SVD)

SVD is an effective numerical analysis tool from linear algebra to decompose a rectangular matrix "A" into an orthogonal matrix U, diagonal matrix S, and the transpose of an orthogonal matrix V . SVD decomposes a given image A of size M×N as

$$A = USV^T \quad (1)$$

U and V are orthogonal matrices of size MxM and NxN, respectively. S is a diagonal matrix of size MxN having singular values .The singular vectors of an image specify the image "geometry" similarly left singular vectors represent horizontal details and right singular vectors represent the vertical details of an image, while the singular values specify the "luminance" (energy) of the image. Slight variations in the singular values do not affect the visual perception of the quality of the image [8-9].

3. Proposed work

The proposed work is divided into two parts, watermark embedding and watermark extraction.

A. Watermark Embedding

The watermark embedding process is described below as following:

Step.1: Load the cover image and watermark image.

Step.2: Decomposed both the images into four sub-bands using DWT.

Step.3: after applying DWT, we decomposed both the images using SVD.

Step.4: Compute new singular matrix using fusion of both singular matrix.

$$S_{wm} = S_i + alpha * S_w \quad (3)$$

where, Swm ,Si and Sw and denote the singular values of watermarked, host and water mark image, respectively.

Step.5: Using new computed singular matrix Snew, New LL band is computed with inverse SVD.

Step.6:Finally, watermarked image is obtained by merging LLnew band and remaining sub band of cover image.

B. Watermark Extraction

The watermark embedding process is described below:

Step.1: Load the cover image, watermark image and watermarked image.

Step.2: Decomposed the images into sub-bands using DWT respectively.

Step.3: after applying DWT, we decomposed images using SVD.

Step.4: The new extracted singular matrix can be calculated by:

$$S_{w_n} = (S_{wm} - S_c) / alpha \quad (4)$$

where, Sw_n denotes new singular value.

Step.5: Using new computed singular matrix, New LL band is computed with inverse SVD.

Step.6: Finally, extracted watermark image obtained using inverse DWT based on LLnew band and reaming sub band.

4. Results and Discussion

In this section, performance analysis of proposed work has been presented. The simulation work using MATLAB illustrate the efficiency and performance of proposed work on the basis of fidelity parameters. For analysis, all the image are gray scale image and obtained from USC-SIPI image database [14] as a standard evaluation database for watermarking algorithms.

A. Fidelity Parameters

The performance of watermarked images is determined by using peak signal-to-noise ratio (PSNR) and Normalized Correlation coefficient (NCC).

- **Peak signal-to-noise ratio (PSNR) :-**

For measurement of imperceptibility, PSNR in dB is given by:

$$MSE = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(f_c(i,j) - f_{wm}(i,j)\right) \quad (5)$$

$$PSNR = 10\log_{10}\frac{f_c^2(i,j)}{MSE} \quad (6)$$

where, fc2 (i, j) indicates the peak brightness value of pixel and fc, fwm represent the brightness of host and watermarked images at different pixels values.

- **Normalized Cross Co-Relation (NCC):-**

To check the robustness and image quality, the value of normalized cross co-relation (NCC) is measured by:

$$NCC = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} g_w(i,j) * g_w'(i,j)}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M} g_w^2(i,j)}\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M} g_w^2(i,j)}} \quad (7)$$

where, gw and gw' are the brightness level of original and extracted watermark at different value of pixel.

Simulated Experimental Results

Simulated results on MATLAB platform using proposed watermarking technique in terms of fidelity parameters have been presented by considering Lena and Butterfly as a host and watermark image respectively [14].



(a)

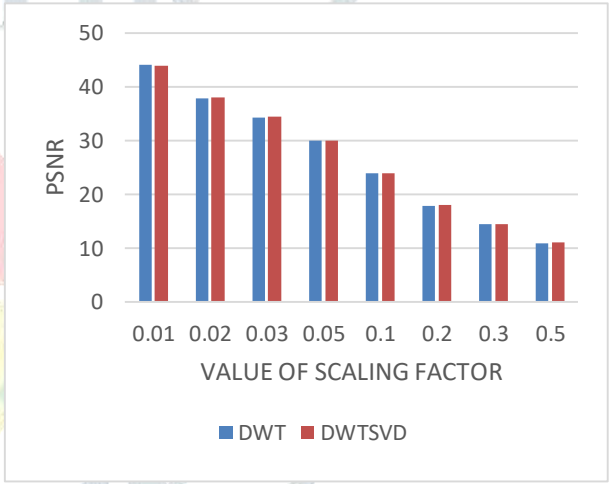


(b)

Figure 3: (a) Lena (b) Butterfly

Table 1 shows the comparison results image watermarking techniques using DWT and DWT-SVD (Lena & Butterfly image size (512x512).

Scaling Factor	Image Watermarking using DWT		Image Watermarking using DWT-SVD	
	PSNR	NCC	PSNR	NCC
0.01	44.02	0.7635	43.61	0.9967
0.02	37.86	0.8964	37.89	0.9992
0.03	34.31	0.9550	34.34	0.9995
0.05	29.94	0.9810	29.94	0.9998
0.1	23.91	0.9944	23.93	0.9998
0.2	17.92	0.9966	18.09	0.9988
0.3	14.55	0.9837	15.00	0.9926
0.5	10.56	0.9188	11.41	0.9761



Bar chart show the value of PSNR at different value of scaling factor Table 1.

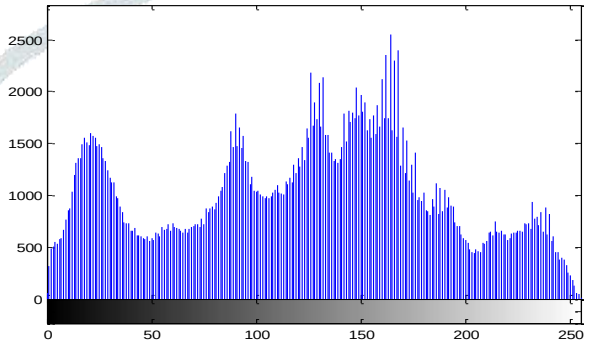


Fig. show the Histogram of Lena watermarked image

Scaling factor	Image Watermark using 2-Level DWT		Image Watermarking using 1-Level DWT	
	PSNR	NCC	PSNR	NCC
0.04	33.18	99.42	33.17	0.9909
0.03	35.43	0.9936	34.41	0.9891
0.025	37.5052	**0.9894**	37.48	**0.9828**
0.02	39.16	0.9842	39.15	0.9764
0.01	*44.40*	0.9581	*44.38*	0.9358
0.005	52.05	0.8581	52.02	0.7873

Table 2 shows the PSNR and NCC Values for different level of DWT based image watermarking techniques.



Watermarked image



Extracted image

Figure show the best result for test images at 0.02 value of scaling factor using DWT-SVD.

Here, performance of wavelet based algorithm is compared with DWT techniques in Tables 1&2. From the Table I, it has been observed that for the same value of scaling factor, DWT SVD based watermarking yields good results in term of PSNR value *and* NCC values. Also the performance of wavelet based techniques are also evaluated on different level of wavelet in table 2 at different values of scaling factor. The simulated experimental results also evaluated with visual representation of watermarked and extracted watermark image for human vision system (HVS). Results are clearly seen that the proposed methodology having robust efficiency of watermarking with data hiding ability to hide data as well as extract the information hidden in the watermarked image.

5. Conclusions

Digital watermarking based on transform domain is at the focus of current research because of their robustness and imperceptibility. Here, comparative performance of wavelet based image watermarking techniques are compared at different level using variable scaling factor On the basis of simulation results, it is concluded that for the same value of scaling factor, DWT SVD based watermarking yields good results in term of PSNR value *and* NCC values . The robustness and effectiveness of this watermarking technique tested both quantitatively and qualitatively.

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