Research Result

Low-Frequency Band DWT-SVD Based Adaptive Second-Level Hybrid Image Watermarking

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ABSTRACT

The ever-growing importance of copyright ownership of multimedia contents is a direct result of the proliferation of various multimedia systems. One such method that has been developed to safeguard digital photos from unauthorized use is digital picture watermarking. In order to accomplish this, we present a hybrid image watermarking algorithm that utilizes both Discrete Wavelet Transforms and Singular Value Decomposition to either hide the watermark image information or make it appear as though the visible image is the cover image and the other is the watermark image, thus establishing ownership of the content. With the help of the scaling factor (), watermark singular values will be incorporated into the singular value. In this experiment, we show that a hybrid picture watermarking approach is superior to a traditional one. Various fidelity metrics, including as peak signal-to-noise ratio (PSNR) and normalized cross correlation, are used to assess the effectiveness of the process (NCC).

KEYWORDS

Image watermarking, discrete wavelet transforms, SVD, PSNR, NCC

1. INTRODUCTION

The quick distribution of digital multimedia data has been facilitated in the modern era thanks to the pervasive network environment. End users are raring to take advantage of the perks and ease that networks have made available. Users, meantime, are eager to disseminate a wide range of media content at low cost and with little regard for the possibility of breaching copyrights in the process. In light of this, a number of covert methods can be employed.

Throughout the fields of information security and multimedia communication, data concealment is a hot topic of study. With the advent of new technologies, modern humans have come to rely heavily on computers. Consequently, there are a wide range of concerns that arise with regards to the authenticity of multimedia sources and content. Computers provide for the convenient, space-saving, and high-quality storage of digital data, as well as its straightforward manipulation. All of these data, whether it be a photograph, a video, an audio file, or a string of text, is kept and delivered digitally. In a digital format, data may be replicated without quality loss and distributed quickly and effectively [1]. Consequently, the digital watermark is implemented to address this issue. Digital watermarking is a subfield of information concealing used to covertly insert text, images, or audio/video clips into digital files [2, 3]. Problems with copyright infringement have arisen as a result of the widespread dissemination of digital content over the Internet. The ease with which copyrighted content can be shared via P2P networks is a major source of anxiety for the companies who create such digital media.

Watermarking an image can be accomplished in either the spatial domain or the transform domain [6]. Distinct from spatial skills specific to a domain [4].

Digital watermarking algorithms need to be imperceptible and robust, and frequency-domain watermarking techniques have been shown to be more effective in accomplishing both of these goals [5]. The Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), and Discrete Fourier Transform (DFT) are all examples of popular frequency-domain transforms. However, DWT has been used more frequently in digital image watermarking because of its excellent spatial localization and multi-resolution characteristics, which are similar to the theoretical models of the human visual system. Increasing the DWT level is one way to improve the performance of DWT-based digital image watermarking algorithms.

Certain factors, such as those listed here, can be used to evaluate a watermarked image's quality. First, the watermark must not detract from the quality of the original image or it will be useless. [5] [6]. For another, image robustness makes it hard to remove the watermark when subjected to various attacks like adding noise, compressing the image, resizing it, etc. [7] [8]. Third, the spatial domain and the transformation domain both contain the bulk of the information relevant to capacity. On the other hand, there are limitations in both the spatial and transformation domains. For example, in the spatial domain, it is vulnerable to attacks based on image processing.

2. DISCRETE WAVELET TRANSFORMS (DWT)

Because it is a multi-resolution method, the DWT can be used to evaluate signals at varying frequencies at varying levels of detail. Here, we'll discuss why DWT works so well for image watermarking, as well as the benefits of adopting it over alternative transforms. Applying DWT to a two-dimensional image is analogous to processing the image with a filter with the same width and height in both dimensions. The filters separate the input image into four distinct multi-resolution LL1, LH1, HL1, and HH1 bands that do not overlap with one another. Coefficients of the discrete wavelet transform (DWT) at the coarse scale are represented by the LL1 sub-band, while those at the fine scale are shown by the LH1, HL1, and HH1 sub-bands. As a result of its superior spatial-frequency localization features, the DWT is well suited to pinpoint the host image regions where a watermark can be successfully implanted. In most cases, the lower frequency sub-bands LLx contain the majority of the image's energy, hence placing watermarks there could drastically damage the image quality. However, embedding in the low frequency sub-bands has the potential to considerably boost robustness. However, the human visual system is rather insensitive to changes in the high frequency sub bands HHx, which contain the image's borders and textures. This makes it possible for the watermark to be permanently incorporated into the media without being visible to the naked eye.

$$\xrightarrow{\text{DWT}}$$

Fig.1 showDWT decomposition of image at level-2

As pointed out, wavelet-based watermarking methods exploit the frequency information and spatial information of the transformed data in multiple resolutions to gain robustness. Wavelet Transform is computationally efficient and can be implemented by using simple filter. Magnitude of DWT coefficients is larger in the lowest bands (LL) at each level of decomposition and is smaller for other bands (HH, LH and HL). The larger the magnitude of the wavelet coefficient the more significantit is. Watermark detection at lower resolutions is computationally effective because at every successive resolution level there are few frequency bands involved. High resolution sub bands helps to easily locate edge and textures patterns in an image.

Wavelet transforms use wavelet filters to transform the image. There are many available filters, although the most commonly used filters for watermarking are:- HaarWavelet Filter, Daubechies Orthogonal Filters, Daubechies Bi-Orthogonal Filters, Symlet wavelets. Each of the filters decomposes the image into several frequencies. Single level decomposition gives four frequency representations of the images.

3. OVERVIEW OF SINGULAR VALUE DECOMPOSITION (SVD)

From the discernment of image processing an image can be viewed as a matrix with nonnegative scalar entries.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 [3, 4, 7, 10]. SVD decomposesa given image A of size M×N as

$$A = USVT$$

U and V are orthogonal matrices of size MxM and NxN, respectively. S is a diagonal matrix of size MxN having singular values and satisfy the property

$$\sigma 1; 1 > \sigma 2; 2 > \sigma 3; 3$$

$$> .... > \sigma n;$$

n: It is worth noting that, 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. Watermark embedding through slight variations of singular values in the segmented image has been introduced as a choice for robust watermarking through minor modification of the singular values of the original image

4. WATERMARKING TECHNIQUE

Here, we propose an adaptive second level hybrid image Watermarking Technique using DWT-SVD in low frequency band. The proposed algorithm 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 image into four sub-bands using DWT for cover and watermark images respectively.

Step.3: after taking DWT,we decomposed both the image using SVD.

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

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

Step.5: Therefore, watermarked image obtained using inverse DWT based on LLnew band and remaining sub band of cover image.

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

B. Watermark Extraction

Watermark extraction process is also very important process, it gives the hidden information from watermarked image; which are embedded into cover image. The watermark embedding process is described below as following and shown in fig. 3.3:

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 taking DWT, we decomposed images using SVD
Step.4: Compute new sigma matrix using fusion of both sigma matrix using scaling factor work as key in watermark embedding process.
Step.5: Using new computed signal matrix Snew, New LL band is computed with inverse SVD.
Step.6: Therefore, extracted watermark image obtained using inverse DWT based on LLnew band and reaming sub band.

5. RESULTS AND DISCUSSION

Over all analysis has done with 512X512 image and evaluated with consider fidelity parameters. Here, images used which are obtained from USC-SIPI image database as a standard evaluation database for watermarking algorithms. Here, results analysis of proposed technique illustrates the efficiency of proposed watermarking technique

Evaluation Fidelity Parameters

The visual performance of watermarked images is determined by using peak signal-to-noise ratio (PSNR)and Normalized Correlation which are historically adopted in image processing in order to evaluate the performance of the output results as shown in tables.

Here, PSNR considered for good efficiency is close to 35 dB to avoid having a visible watermark but at the same time including the watermark with a large energy to be resistant to attacks.

Simulated Experimental Results

Figure 3(a):(mandrill and Lena), size (512x512)).

Sample of watermark image

1. Logo 2 alfabet - W

Figure 3(b): watermark image

Fig. 3(a) shows the original image and Fig. 3(b) shows the watermark image for embedding of watermark in the original image

Table 1. shows the PSNR Value and NCC value for 2 levels of DWT-SVD based image watermarking techniques (mandrill (as cover) &Dell- logo (as watermark)

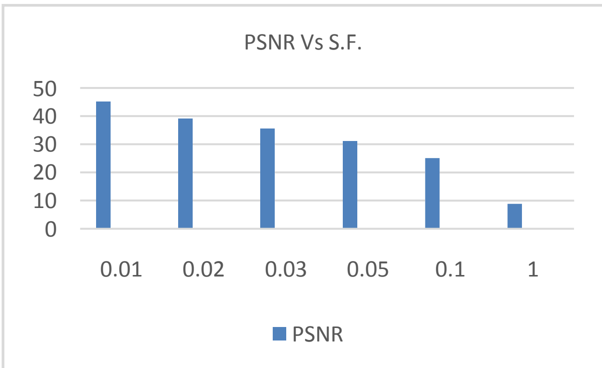
Visibility factor	**Watermarked image**	
	PSNR	NCC
0.01	45.09	0.9978
0.02	39.06	0.9994
0.03	35.58	0.9997
0.05	31.15	0.9999
0.1	25.14	1.0
1	8.81	0.9734

$$MSE = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}(f(i,j)-g(i,j))$$

$$PSNR = 10\log_{10}\frac{L^2}{MSE} \tag{1}$$

From eq. (1), L shows the values of pixel range. As MSEis inversely proportional to PSNR, thus the small mean square error tends to high signal to noise ratio. The quality measurement for image is directly measure from the pixel values. For better image quality the PSNR must be high. The quality of the image is measured using normalized cross co-relation (NCC) and is obtained by using eq. (2) Bar chart show the value of PSNR at different value of scaling factor.

As seen in simulated results, here we proposed 2-level DWT-SVD technique. Here we have used images mandrill as original image and the Dell-logo image as the watermark.

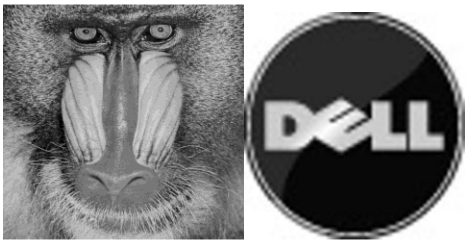


robust efficiency of watermarking with data hiding ability. All experiments are shown the proposed algorithm is efficient in data hiding properties as per HVS.

6. CONCLUSION

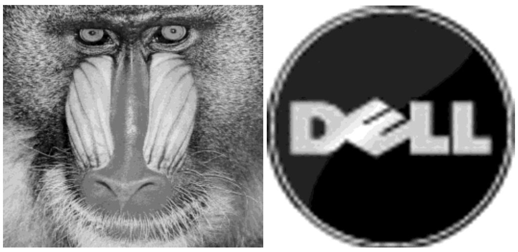
Both the images are of equal size of 512X512.The value of visibility factor k is varied from 0.01 to 0.1and we see thatas we decrease the value of visibility factor, the value of.

In this paper, an image watermarking technique based on a 2-level discrete wavelet transform has been presented and implemented. This technique can embed the invisible watermark into salient features of the image using variable visibility factor. Experiment results shows that the quality of the watermarked image and the recovered watermark are dependent only on the visibility factors and also indicate that the 2- level DWT provide better performance. All the results obtained for the recovered images and the watermark are identical to the original images. Results are PSNR increases but the same time the value of CC decreases hence to get the best result we set the value of visibility factor at 0.02.



Watermarked image& recover water mark image at 0.02using 2-Level DWT

Watermarked image& recover water mark image at 1.0 using 2-Level dwt



Watermarked image& recover water mark image at 0.1 using2 l dwt

Fig. 4 shows the best result of watermarked image and recover watermark image at 0.02

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 clearly seen that the proposed methodology having robust efficiency of watermarking with data hiding ability.

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