Information Hiding using Image Decomposing

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Abstract: ***With the increasing growth of technology and the entrance into the digital age, we have to handle a vast amount of information every time which often presents difficulties. So, the digital information must be stored and retrieved in an efficient and effective manner, in order for it to be put to practical use. The particular wavelet chosen and used here Haar wavelet. The 2D DWT is applied into the successive zero coefficients of the medium-high frequency components in each reconstructed block for 3-level 2-D DWT of cover image. The procedures of the proposed system mainly include embedding & extracting. The original image can be recovered losslessly when the secret data had been extracted from stego-image. The quality of the compressed images has been evaluated using some factors like Mean squared Error (MSE), Peak Signal to Noise Ratio (PSNR) etc.***

Keywords: Information hiding, Haar Wavelet Transform, DWT, PSNR.

1. Introduction

The rapid evolution of multimedia systems and the wide distribution of digital data over the World Wide Web address the copyright protection of digital information. The aim is to embed copyright information, which is called watermark, on digital data (audio or Visual, Image) in order to protect ownership. In general, a digital watermarking technique must satisfy two requirements. First, the watermark should be transparent or perceptually invisible for image data. The second requirement is that the watermark should be resistant to attacks that may remove it or replace it with another watermark. This implies that the watermark should be robust to common signal processing operations, such as compression, filtering, enhancements, rotation, cropping.

The digital image watermarking techniques in the literature are typically grouped in two classes: the spatial domain techniques [1]-[10] which embed the watermark by modifying the pixel values of the original image and the transform domain techniques which embed the watermark in the domain of an invertible transform. The discrete cosine transforms (DCT) and the discrete wavelet transform (DWT) are commonly used for watermarking purposes [4].This paper, an additive watermarking algorithm embeds the signature data to selected groups of wavelet transform coefficients, varying the watermark strength according to the sub band level and the group where the corresponding coefficients reside. The rest of the paper is organized as follows. Embedding and extraction algorithms are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

2. Background

Before we go into details of the method, we present some background topic of DWT and wavelet of image decomposing, Hui-Yu Huang [2] proposes a technique lossless data-hiding method for a DWT. Using the quantization factors for DWT, our proposed approach can offer high hiding capacity and preserve the image quality of stego-images. The original image can be recovered losslessly when the secret data had been extracted from stego-images.

2.1 Discrete Wavelet Transforms (DWT)

The basic idea of discrete wavelet transform (DWT) in image process is to multi-differentiated decompose the image into sub-image of different spatial domain and independent frequency district [13][14]. Then transform the coefficient of sub-image. After the original image has been DWT transformed, it is decomposed into 4 frequency districts which is one low-frequency district(LL) and three high-frequency districts(LH,HL,HH). If the information of low-frequency district is DWT transformed, the sub-level frequency district information will be obtained. A two-dimensional image after three-times DWT decomposed can be shown as Fig.1.

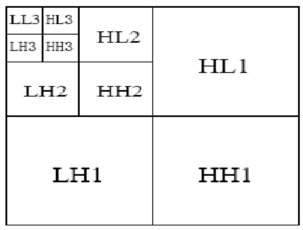

Figure 1: Structure of wavelet decomposition

The information of low frequency district is an image close to the original image. Most signal information of original image is in this frequency district. The frequency districts of LH, HL and HH respectively represents the level detail, the upright detail and the diagonal detail of the original image. The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels as shown in Figure 2. In this figure, the low-pass and high-pass filters are denoted by h and g, respectively. This figure depicts the three levels of the 2D DWT decomposition. At each level, the high-pass filter generates detailed image pixels information, while the low-pass filter produces the coarse approximations of the input image.

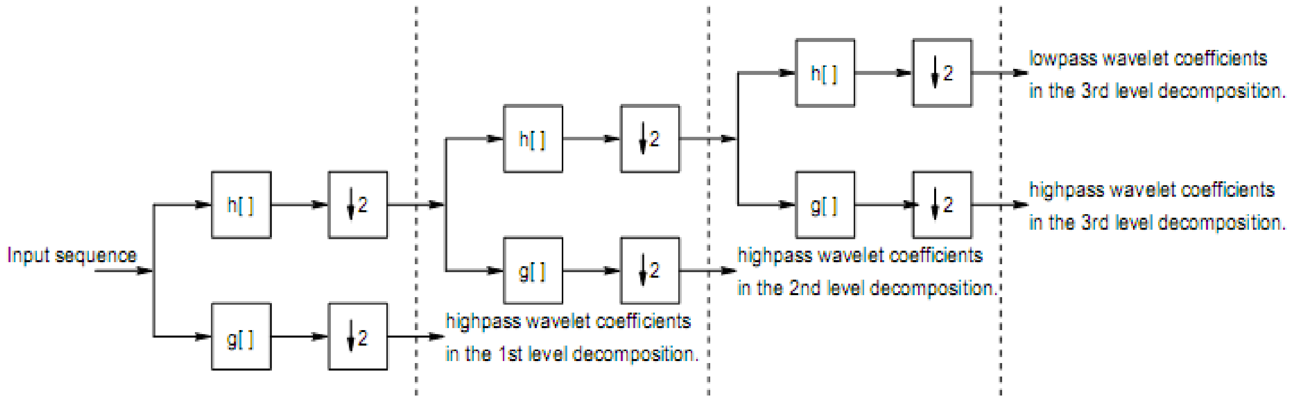

Figure 2: Three level 2D DWT decomposition. The h and g variables denote the low-pass and high-pass filters, respectively. The notation of (↓ 2) refers to down-sapling of the output coefficients by two.

According to the character of HVS, human eyes are sensitive to the change of smooth district of image, but not sensitive to the tiny change of edge, profile and streak. Therefore, it's hard to conscious that putting the watermarking signal into the big amplitude coefficient of high-frequency band of the image DWT transformed. Then it can carry more watermarking signal and has good concealing effect.

This kind of two-dimensional DWT leads to a decomposition of approximation coefficients at level j in four components: the approximation at level j + 1, and the details in three orientations (horizontal, vertical, and diagonal). After getting low frequency component which is equivalent or similar to the original image, so the band has added to the watermark robustness. In such case adding a watermark are much higher than the sensitivity of high frequency components by adding information to the human eye. Beside it, the knowledge of image compression, we know that the adding of watermark in the high frequency image can be easier to lose with lossy compression in the operation. On the basis of such considerations, the algorithm uses a different image multiplied by the weighting coefficients of different ways to solve the visual distortion, and by embedding the watermark, wavelet coefficients of many ways, enhance the robustness of the watermark.

2.2 Haar Wavelet Transform

To understand how wavelets work, let us start with a simple example. Assume we have a 1D image with a resolution of four pixels, having values [9 7 3 5]. Haar wavelet basis can be used to represent this image by computing a wavelet transform. To do this, first the average the pixels together, pair wise, is calculated to get the new lower resolution image with pixel values [8 4]. Clearly, some information is lost in this averaging process. We need to store some detail coefficients to recover the original four pixel values from the two averaged values. In our example, 1 is chosen for the first detail coefficient, since the average computed is 1 less than 9 and 1 more than 7. This single number is used to recover the first two pixels of our original four-pixel image. Similarly, the second detail coefficient is -1, since 4 + (-1) = 3 and 4 -(-1) = 5. Thus, the original image is decomposed into a lower resolution (two-pixel) version and a pair of detail coefficients. Repeating this process recursively on the averages gives the full decomposition shown in Table 1.

Table 1: Decomposition to lower resolution

Resolution	*Averages*	*Details Coefficients*
4	[9 7 3 5]	
2	[8 4]	[1 -1]
1	[6]	[2]

Thus, for the one-dimensional Haar basis, the wavelet transform of the original four-pixel image is given by [6 2 1 -1]. We call the way used to compute the wavelet transform by recursively averaging and differencing coefficients, filter bank. We can reconstruct the image to any resolution by recursively adding and subtracting the detail coefficients from the lower resolution versions.

3. Purposed Algorithms

3.1 Watermark Embedding

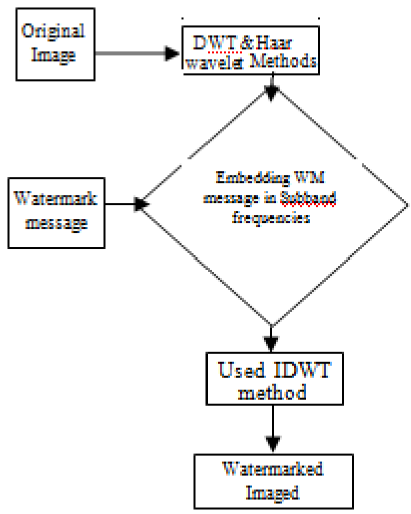

Figure 3: (a) Embedding process

Fig.(a) shown the proposed watermarking technique method to embed the secret message into DWT coefficients in low frequency component. Wavelet transform is used to converts an image from time or spatial domain to frequency domain. The watermark message will be embedding in low frequency components & that will be reconstructed to get original image with watermark message hidden.

3.2 Watermark Embedding

1. Setting image block size and embedding parameters.
2. imread() command is used to read the original and watermark image.
3. The size of image calculated.
4. Compared the watermarked image size is greater than cover image.
5. Determine row & column size of watermark image & reshape it into vector.
6. Decomposed cover image using dwt2 using haar wavelet & display image.
7. Calculated the average value of two wavelet coefficients of the sub-images after wavelet decomposition.
8. Geometric mean of the values of the image, to achieve adaptive embedding strength.
9. After checking the message 0 & 1, add block size to horizontal, vertical & sub bands.
10. Message is embedding and displays the image.
11. Used IDWT to the embedded image.
12. Write watermarked image to file and display.

3.3 Watermark Extraction algorithm

The extraction algorithm process is the inverse of the embedding process. It is assumed that the watermark as well as the see value is available at the receiver end to the authorized users. The operation of channel separation is applied on the watermarked image to generate its sub images, and then 2-level discrete wavelet transform is applied on the sub images to generate the approximate coefficients and detail coefficients. Embedded image decomposed into inverse discrete wavelet transform. IWDT is used to convert frequency domain to spatial domain.

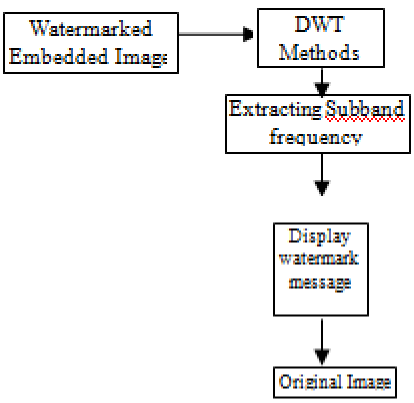

Figure 3: (b) The proposed watermarking technique extracting process

3.4 Extracting Algorithm

1. Define Block size and the threshold wavelet coefficients.
2. Read & display watermarked image.
3. Determine row & column size of watermarked image.
4. Read & display and reshape the size of original watermark image.
5. Finding the 0 value after reshaping it.
6. Decomposed the watermarked image dwt2 using Harr wavelet & display image.
7. Compared the sub graphs wavelet coefficients is less than threshold value means the watermark information determination is 1 else 0.
8. Extracted watermark is reshaped.
9. Write extracted watermark image to file.
10. Show the extracted watermark image and original image.

4. Experiments & Results

The test set for this evaluation experiment watermark image randomly selected from the internet. Matlab R2013b software platform is use to perform the experiment. The Method discussed in the previous section was applied to various test images. An example of embedding results is shown in figure 4, in which a Lena's image is used as the test image and a two binary image is used as the watermark. PSNR is peak signal to noise ratio which is used to define the accuracy so use the PSNR as the objective. The proposed method is tested using MATLAB. For performance evaluation, the visual quality of watermarked image is measured using the Peak Signal to Noise Ratio, which is defined as equation 1. PSNR is the peak signal-to-noise ratio in decibels (dB). The PSNR is only meaningful for data encoded in terms of bits per sample, or bits per pixel.

$$PSNR = 10.\log_{10}\left\{\frac{MAX^2}{MSE}\right\} \quad \ldots\ldots\ldots1$$

```
function out=PSNR (pic1, pic2)
e=MSE (pic1, pic2);
m=max (max (pic1));
Out=10*log (double (m) ^2/e);
end
```

Mean Squared Error (MSE) is one of the earliest tests that were performed to test if two pictures are similar. The mean square error (MSE) is the squared norm of the difference between the data and the approximation divided by the number of elements. A function could be simply written according to equation 2

$$M.S.E = \frac{1}{N}\sum_{i=1}^{n}(X_i - X_i^*)^2 \quad \ldots\ldots\ldots2$$

```
function out = MSE (pic1, pic2)
e=0;
[m,n]=size (pic1);
for i=1:m
for j=1:n
e = e + double((pic1(i,j)-pic2(i,j))^2);
end
end
out = e / (m*n);
end
```

The PSNR value of watermarked image is 38.7737 & MSE is 8.6240, which indicates that there is very little deterioration in the quality of the image.

Table 2: PSNR (db) & MSE of watermarked images under different attack

Cover/ Watermark	*Attacks*	*Original/ Watermarked LenaImage*	*JPEG Compression*	*Gaussian noise*	*Salt & pepper noise*
LENA/BEST	PSNR	38.7737	36.5781	34.9168	33.7290
	MSE	8.6240	14.2980	20.9606	27.5535
LENA/ NepalFlag	PSNR	37.8752	36.0018	34.5350	34.0968
	MSE	10.6063	16.3269	22.8867	25.3162

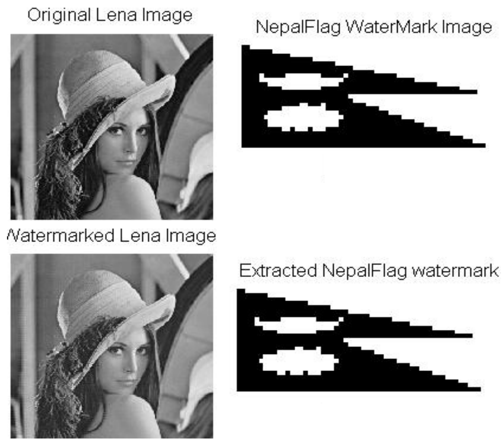

Figure 4(a)

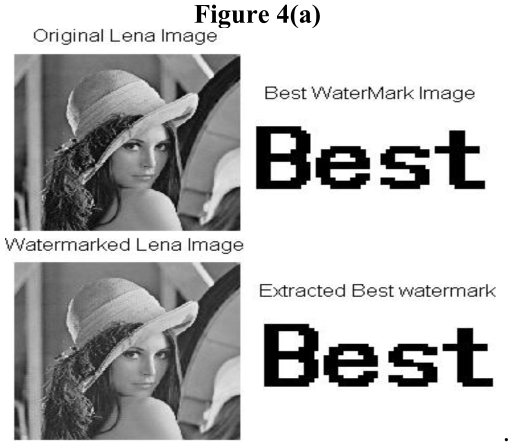

Figure 4(b)

Fig, 4 (a) & (b) Original Lena, watermark Image, watermarked Lena & extracted watermark. The robustness of the proposed watermarking scheme is evaluated against several attacks including adding JPEG compression, salt & pepper noise, Gaussian low pass filter. Above Table shows PSNR & MSE of distorted watermarked images under above distortions. Table 2 show the peak signal to noise ratio (PSNR) & MSE performance of our proposed method of watermarked image and original image with various watermark image, where our watermarked images peak signal to noise ratio has a better performance than others.

5. Conclusion

In our proposed watermarking method, a gray scale visual watermark image is inserted into the host Lena image using the haar wavelet transform, where the copyright of watermark is printed. The experimental results have confirmed that this new technique has two properties high fidelity and robust. The proposed robust watermarking scheme, which provides a complete algorithm that embeds & extracts the watermark information effectively that have degraded through Jpeg compression, pepper & salt noise median, Gaussian filtering. Lossless data embedding using a DWT to improve data hiding capacity & retain good stego image quality. Original image within watermark image Embedded into horizontal & vertical in sub-bands using DWT & harr transform that gave at finally the stegoangraphic image and the hidden message is invisible.

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