DWT-SVD Based Robust Image Watermarking Scheme

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Abstract

Recent development in digital image and internet technology help the common users to easily produce illegal copies of the images. This article presents a robust watermarking technique using bi-orthogonal wavelet transform. In proposed method the blue channel of the color host image is selected for embedding watermark because it is more resistant to changes compared to red and green channels. The selected blue channel is decomposed into n levels using bi-orthogonal wavelet transform is an invertible transform and has the property of exact reconstruction and smoothness of the embedded image. The singular values of different sub-band coefficients of blue channel are modified using different scaling factors to embed the singular values of the watermark. The copy of the watermark is embedded into four sub-band coefficients which are very difficult to remove or destroy. The combination of DWT and SVD increases the security, robustness and imperceptibility of the scheme.

Keywords:

1. Introduction

The security and authenticity issues of digital images are becoming popular than ever due to the rapid growth of multimedia and internet technology. On internet, digital images are easily and widely shared among the different users at different geographical places. Issues related to digital media are copyright protected, content authentication proof of ownership, etc. The watermarking technique provides the best result of these problems. This technique embeds information so that it is not easily perceptible, Human Visual System (HVS) not able to see any information embedded in the contents. The other important issues in the watermarking system are must be robust enough to resist common image processing attacks, geometric attacks. Based on the domain of processing the watermarking scheme are classified into two categories one is spatial domain and second one is frequency domain. In spatial domain schemes embed the watermark by directly modifying the pixel values of the cover image and the schemes are less complex in computation. The second one is transformed domain schemes embed the watermark by modifying the frequency coefficients in a transform domain such as Discrete Cosine Transform (DCT), Discrete Fourier
Transform (DFT), and Discrete Wavelet Transform (DWT). So I observed Transformed domain schemes are more robust when compared to spatial domain schemes.

2. Related Work

Recently a DCT based watermarking technique is proposed by Huang, but the robustness of the scheme was not so satisfactory. By combining the visual secret sharing scheme with Torus-automorphism, Chang proposed an image intellectual property protection scheme for gray-level images. However as Heieh and Huang mentioned in Chang’s scheme may be vulnerable to JPEG Compression. With the Use of DWT, Heieh scheme is robust against JPEG compression and does not modify the original image so hardly can it causes any loss of the image details. To achieve high robustness against attacks like Gaussian noise, compression and cropping the combination of SVD and DWT are used. In proposed scheme where the two level DWT is applied on the cover image to produce the different sub-bands of frequency. The selected frequency sub-band is converted into blocks of each size 4x4. The SVD is applied on each of these blocks and the watermark is hidden into diagonal matrix of the block. The combination of DWT-SVD was proposed to insert the watermark into the high frequency sub-bands of cover image. The main objective of this article is to present a novel watermarking technique that uses the bi-orthogonal wavelet transform. The technique makes use of DWT-SVD it aims to improve the robustness of existing watermarking techniques. The important goal is to keep the watermarked image imperceptible.

3. 2D Discrete Wavelet Transform and Singular Value Decomposition

In this section we discuss in brief the Discrete Wavelet Transform and Singular Value Decomposition of images.

a) 2D Discrete Wavelet Transform

The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels as shown in figure 1. In other words a 2D DWT can be performed by first performing a 1D DWT on each row, which is referred to as horizontal filtering of the image followed by a 1D DWT on each column, which is called vertical filtering as shown in figure 1 shows the structure of II level 2D wavelet decomposition.
Mathematically the wavelet transform is convolution operation, which is equivalent to pass the pixel values of an image through a low-pass and high-pass filters. A separable filter bank to the image is represented as follows:

\[ L_n(b) = [H_x * [H_y * L_{n-1}]]_{1,2}(b) \]
\[ D_{n1}(b) = [H_x * [G_y * L_{n-1}]]_{1,2}(b) \]
\[ D_{n2}(b) = [G_x * [H_y * L_{n-1}]]_{1,2}(b) \]
\[ D_{n3}(b) = [G_x * [G_y * L_{n-1}]]_{1,2}(b) \]  \( (1) \)

Where * represents the convolution operator, 2,1\(_{1,2}\) represents sub sampling along the rows and \( L_0 = I(x) \) is the original image. \( H \) and \( G \) is the low-pass and band-pass filter respectively. The original image \( I \) is thus represented by set of sub images at several scales: \( \{ [L_d, D_n] | l = 1, 2, 3, n = 1, 2, 3, \ldots d \} \), which is multi-scale representing which depth \( d \) of the image \( I \).

The image is represented by two dimensional signal function wavelet transform decomposes the image into four frequency bands, namely, the \( LL_1 \), \( HL_1 \), \( LH_1 \) and \( HH_1 \) bands. \( H \) and \( L \) denote the high-pass and low-pass filters respectively. The image \( LL \) is obtained by low-pass filtering in both row and column directions. The remains image \( LH, HL \) and \( HH \) contains the high-frequency components. To obtain the next coarse level of wavelet coefficient, the sub-band \( LL_1 \) alone is further decomposed and critically sampled. Similarly \( LL_2 \) will be used to obtain further decomposition. By decomposing the approximated images at each level into four sub-images from the pyramidal images as shown in the figure 1.

b) **Singular Value Decomposition**

The SVD of image \( I \) of size \( m \times n \) is obtained by the operation

\[ I = U S V^T \]  \( (2) \)

Where \( U \) is column orthogonal matrix of size \( m \times n \). The diagonal entries of matrix \( S \) are known as the singular values of \( I \). The columns of \( U \) matrix are known as left singular vector and the columns of the matrix \( V \) are known as the right singular vector of \( I \). The SVD-based images watermarking several approaches are possible. A common method is apply SVD to the entire cover image and modify all the singular values to embed the watermark. The important property of SVD based watermarking is that the large of the modified singular values of image will change by very small.

### 4. Proposed Watermarking Method

In embedding processes, first we separate the R, G and B channels of the color image and the blue channel is selected for the
embedding because this channel is more resistant to changes compared to red and green channels and the human eye is less sensitive to the blue channel, so it is a perceptually invisible watermark embedded in the blue channel and it contains more energy than a perceptually invisible watermark embedded in the luminance channel of a color image. The blue channel is decomposed into n-level using bi-orthogonal wavelet transform using singular value decomposition.

Let select an image of size 64 x 64 as watermark and to convert it into a 1-D vector. In that select two PN sequences for embedding watermark bit 0 and 1 in mid frequency sub-band of higher level decomposition of the channel.

\[
LH'_2 = LH_2 + \alpha \cdot PN(0) \quad (4)
\]

\[
HL'_2 = HL_2 + \alpha \cdot PN(1) \quad (5)
\]

Where LH'_2 and HL'_2 watermarked, LH_2 and HL_2 watermarked sub-bands and alpha is the embedding strength. Finally we reconstruct the watermarked image using inverse bi-orthogonal wavelet transform. To calculate the Mean Squared Error and Peak Signal to Noise Ratio between original image and watermarked image to evaluate the perceptual similarity between these two images by estimating equations (6) and (7).

\[
MSE = \frac{1}{M \times N} \sum \sum ||I(i, j) - K(i, j)||^2 \quad (6)
\]

\[
PSNR(db) = 10 \log_{10} \left( \frac{255^2}{MSE} \right) \quad (7)
\]

In Extraction process the end user separates the R, G and B channels of the watermarked image. The blue channel is decomposed into n-level using Bi-orthogonal wavelet transform.

Then to generate the PN (0) and PN (1) signal similarly to the embedding processes and select the threshold value. By using these signals extracts the original watermark data from HL'_2 and LH'_2 sub-bands.

5. Simulation results

The series of experiments are conducted to analyze the effect of embedding and extraction algorithm on the color image. In this experiment the color image of size 256 x 256 and monochrome watermark of size 64 x 64 are considered as a watermark. Figure 4 shows the embedding process of one level singular value decomposed blue channel using Discrete Wavelet Transform.
In Figure 5 shows extracted watermark on the receiver side are shown.

Figure 4. Host image and 1-level Singular value decomposed blue channel using DWT.

Figure 5. Original Host image, original watermark image DWT decomposed blue channel, Extracted watermark image.

In this we are used one secured key before embedding process, if you want to move the embedding process the same key you enter then only the embedding processes is continued other it gives warning like your “entered key is invalid”. The same procedure also continued in receiver side if the person known the key then only the extraction processes is continued otherwise it’s not possible to extraction in this experiment.

The after completion of extraction we find the peak signal to noise ratio and mean square values obtained from original host images with two different watermark images at different embedding strength are studied and experimentally obtained.

6. Conclusion

In this article watermark is embedded into n level sub-band of DWT decomposition. The results shows that when the embedding factor value increases then distortion in the
watermarked image increases and quality of the extracted watermark also improves. The SVD is an efficient tool for watermarking in the DWT domain. If we use Bi-orthogonal wavelets for decomposition then distortion in the watermarked image is less compared with Haar wavelet transform. The technique makes use of DWT-SVD it aims to improve the robustness of other watermarking techniques. The rigidity of the proposed scheme is analyzed by considering various types of image processing attacks.

References