A Novel Biometrical Image Steganography by Using Wavelet Transform Techniques

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ABSTRACT

The proposed steganography method used in this paper is based on biometrics. And the biometric feature used to implement steganography is skin tone region of images. Here secret data is embedded within skin region of image that will provide an excellent secure location for data hiding. For this skin tone detection is performed using HSV (Hue, Saturation and Value) color space. Additionally secret data embedding is performed using frequency domain approach - DWT (Discrete Wavelet Transform). DWT outperforms than DCT (Discrete Cosine Transform). Secret data is hidden in one of the high frequency sub-band of DWT by tracing skin pixels in that sub-band. Different steps of data hiding are applied by cropping an image interactively. Cropping results into an enhanced security than hiding data without cropping i.e. in whole image, so cropped region works as a key at decoding side. This study shows that by adopting an object oriented steganography mechanism, in the sense that, we track skin tone objects in image, we get a higher security. And also satisfactory PSNR (Peak-Signal-to-Noise Ratio) is obtained.

Keywords: Steganography, DWT, Segmentation, PSNR.

I. 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.

II. 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. In the literature many schemes uses the SVD-DWT based embedding for gray scale image watermarking. The color image is represented by Red (R), Green (G) and Blue (B) channels it is least sensitive to human eyes where for B channel it is least sensitive. Hence in the proposed scheme the blue channel is considered for embedding. 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.

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.

Figure 1. Two Level 2D wavelet based transform.
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:

\[ L_n(b) = [H_y * [H_x * L_{n-1}]]_{2,1,2}(b) \]
\[ D_{n1}(b) = [H_y * [G_x * L_{n-1}]]_{2,1,2}(b) \]
\[ D_{n2}(b) = [G_x * [H_y * L_{n-1}]]_{2,1,2}(b) \]
\[ D_{n3}(b) = [G_x * [G_y * L_{n-1}]]_{2,1,2}(b) \] (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: \( \{ [L_d, D_{nd}] | l =1,2,3, n=1,2,3,....d \} \), 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 figure1.

\[ b) \text{ Singular Value Decomposition} \]

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

\[ I = USV^T \] (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.

\[ \text{III. PROPOSED METHOD} \]

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 contain 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.

Suppose C is original 24-bit color cover image of M×N Size. It is denoted as: \{0,1,...,255\} Let size of cropped image is Mc×Nc where Mc≤M and Nc≤N and Mc=Nc. i.e. Cropped region must be exact square as we have to apply DWT later on this region. Let S is secret data.

Perform embedding of secret data in one of sub-band that we obtained earlier by tracing skin pixels in that sub-band. Other than the LL, low frequency sub-band any high frequency sub-band can be selected for embedding as LL sub-band contains significant information. Embedding in LL sub-band affects image quality greatly. We have chosen high frequency HH sub-band. While embedding, secret data will not be embedded in all pixels of DWT sub band but to only those pixels that are skin pixels. So here skin pixels are traced using skin mask detected earlier and secret data is embedded. Embedding is performed in G-plane and B-plane but strictly not in R-plane as contribution of R plane in skin colour is more than G or B plane. So if we are modifying R plane pixel values, decoder side doesn’t retrieve data at all as skin detection at decoder side gives different mask than encoder side. Embedding is done as per raster scan order that embeds secret data coefficient by coefficient in selected sub-band if coefficient is skin pixel.

**PERFORM IDWT:**

Perform IDWT to combine 4 sub-bands.

**STEGO IMAGE:**

A cropped stego image of size Mc×Nc is obtained in above step. This should be similar to original image after visual inspection but at this stage it is of size Mc×Nc, So we need to merge the cropped stego image Load Image(M×N)Perform Skin Detection Crop an Image (Mc×Nc).
24 bit colour stego image of size MxN is input to extraction process. We must need value of cropped area to retrieve data. Suppose cropped area value is stored in ‘recto’ variable. That is same as in encoder. So this ‘recto’ will act as a key at decoder side. All steps of Decoder are opposite to Encoder. Care must be taken to crop same size of square as per Encoder. By tracing skin pixels in HHH sub-band of DWT secret data is retrieved. 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.

IV. SIMULATION RESULTS

In this paper we demonstrate the simulation results for proposed scheme. This has been implemented using MATLAB 7.8. A 24 bit color image is employed as cover-image of size 256x256.
The secret message $S$ is gray image of size $32 \times 32$. We use Peak signal to noise ratio (PSNR) to evaluate quality of stego image after embedding the secret message. The performance in terms of capacity and PSNR (in dB) is demonstrated for the method in the following subsections. PSNR is defined as

$$PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right),$$

where $MSE = \frac{1}{(M \times N)} \sum \sum (x_{ij} - y_{ij})^2$

$i=1, j=1$ and $x_{ij}$ and $y_{ij}$ represents pixel values of original cover image and stego image respectively.

The calculated PSNR usually adopts dB value for quality judgement, the larger PSNR is, higher the image quality (which means there is a little difference between cover image and stego image). On the contrary smaller dB value means there is a more distortion.

PSNR values falling below 30dB indicate fairly a low quality. However, high quality strives for 40dB or more.

<table>
<thead>
<tr>
<th>Cover image</th>
<th>Capacity of power image</th>
<th>PSNR</th>
<th>Size of logo</th>
</tr>
</thead>
<tbody>
<tr>
<td>(368X356)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case A</td>
<td>Case B</td>
<td>Case A</td>
<td>Case B</td>
</tr>
<tr>
<td>Image 1</td>
<td>70/173</td>
<td>5294</td>
<td>53.0</td>
</tr>
<tr>
<td>Image 2</td>
<td>1067</td>
<td>1056</td>
<td>51.9</td>
</tr>
<tr>
<td>Image 3</td>
<td>1452</td>
<td>1354</td>
<td>51.2</td>
</tr>
<tr>
<td>Image 4</td>
<td>4850</td>
<td>2572</td>
<td>46.4</td>
</tr>
<tr>
<td>Average PSNR</td>
<td></td>
<td>50.7</td>
<td>48.7</td>
</tr>
</tbody>
</table>

Case A- Without Cropping
Case B- With Cropping
V. CONCLUSION

In this report we have presented a new method of steganography with higher embedding capacity. The embedding capacity of the approach is controlled through the filter cut-off frequency. The approach was analyzed and shown to have a very high confidentiality due to the sharpness of information recovery with the cut-off frequency. In this paper, we have proposed a new steganography scheme to hide secret message in digital images. The proposed scheme embeds the secret message by modifying the wavelet coefficients of the original cover image. Moreover, the modification is based on the patterns of the wavelet coefficients. The experimental results show that the difference between the original image and the embedded image is visually unnoticeable and the embedded message could be extracted properly following the proposed extracting procedure.

REFERENCES