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A Novel Approach of Image Encoding and Hiding using Spiral Scanning and Wavelet Based Alpha-Blending Technique

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Abstract

This work proposes a DWT based Steganographic technique. Cover image is decomposed into four sub bands using DWT. Encoded Secret image using spiral scanning is hidden by alpha blending technique in HH sub bands. During embedding secret image is dispersed within HH band depending upon alpha value. Encoded secret images are extracted and decoded to recover the original secret image. In this approach the stego image generated is of acceptable level of imperceptibility and distortion compared to the cover image and the overall security is high.

Keywords- Spiral Scanning, Encoding, DWT, Alpha Blending.

1. Introduction

Steganography [1, 2, 3] is the process of hiding of a secret message within an ordinary message and extracting it at its destination. Anyone else viewing the message will fail to know it contains secret/encrypted data. The word comes from the Greek word “steganos” meaning “covered” and “graphei” meaning “writing”.

LSB [4] insertion is a very simple and common approach to embedding information in an image in special domain. The limitation of this approach is vulnerable to every slight image manipulation.

Converting image from one format to another format and back could destroy information secret in LSBs. Stego-images can be easily detected by statistical analysis like histogram analysis. This technique involves replacing N least significant bit of each pixel of a container image with the data of a secret message. Stego-image gets destroyed as N increases. In frequency domain data can be secret by using Discrete Cosine Transformation (DCT) [5, 8]. Main limitation of this approach is blocking artifact. Grouping the pixel into 8x8 blocks and transforming the pixel blocks into 64 DCT co-efficient each. A modification of a single DCT co-efficient will affect all 64 image pixels in that block. One of the modern techniques of Steganography is Discrete Wavelet Transformation (DWT) approach [6, 7]. In this approach the imperceptibility and distortion of the Stego image is acceptable and it is resistant to several attacks.

Image encoding enhanced the security remarkably. We tried to propose a new methodology to encode an image using spiral based scanning. The encoded image is hiding in the HH component of the cover image using alpha-blending technique for the purpose of two fold security.

2. Discrete Wavelet Transformation

The wavelet transform describes a multi-resolution decomposition process in terms of expansion of an Image onto a set of wavelet basis function. The wavelet transform describes a multi-resolution decomposition process in terms of expansion of an Image onto a set of wavelet basis functions. Discrete Wavelet Transformation having its own excellent space frequency localization properly. Applying DWT in 2D images corresponds to 2D filter image processing in each dimension. The input image is divided into 4 non-overlapping multi-resolution sub-bands by the filters, namely (LL1), (LH1), (HL1) and (HH1). The sub-band (LL1) is processed further to obtain the next coarser scale of wavelet coefficients, until some final scale "N" is reached. When "N" is reached, we'll have 3N+1 sub-bands consisting of the multi-resolution sub-bands (LLN) and (LHX), (HLX) and (HHX) where "X" ranges from 1 until "N". Generally most of the Image energy is stored in these sub-bands.

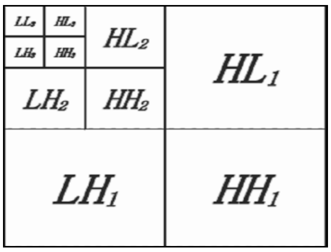

Figure 1. Three phase decomposition using DWT.

The Forward Discrete Wavelet Transform is very suitable to identify the areas in the cover image where a secret image can be embedded effectively due to its excellent space-frequency localization properties. In particular, this property allows the exploitation of the masking effect of the human visual system such that if a DWT co-efficient is modified, it modifies only the region corresponding to that coefficient. The embedding secret image in the lower frequency sub-bands (LLX) may degrade the image significantly, as generally most of the Image energy is stored in these sub-bands. Embedding in the low-frequency sub-bands, however, could increase robustness significantly. In contrast, the edges and textures of the image and the human eye are not generally sensitive to changes in the high frequency sub-bands (HHX). This allows the stego-image to be embedded without being perceived by the human eye. The compromise adopted by many DWT based algorithms, to achieve acceptable performance of imperceptibility and robustness, is to embed the secret image in the middle frequency sub-bands (LHX) or (HLX) and (HHX). The Haar wavelet is also the simplest possible wavelet. Haar wavelet is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions.

3. Alpha Blending Technique

The way of mixing the two images together to form a final image. Alpha Blending [9] can be accomplished in computer graphics by blending each pixel from the first source image with the corresponding pixel in the second source image.

The equation for executing alpha blending is as follows,

Final pixel = alpha * (First image's source pixel) +
(1.0-alpha) * (Second image's source pixel)

The blending factor or percentage of colors from the first source image used in the blended image is called the "alpha." The alpha used in algebra is in the range 0.0 to 1.0, instead of 0 to 100%.

Alpha-blending blind Image hiding technique to generate Stego image is given by

Stego Image Embedding:
WMI=alpha*(CI) + (1.0-alpha)*(WM) (1)

Stego Image Extraction:
RW= (WMI - alpha*CI) (2)

where, RW=Recovered Stego Image, WMI=Stego image, CI= selected sub-band (HH) of the cover image, WM= selected corresponding sub-band of the secret image.

4. Spiral Scanning and Encoding Technique

The elements of 2-D array are scanned using spiral scanning method and the elements are stored in a 1-D array.

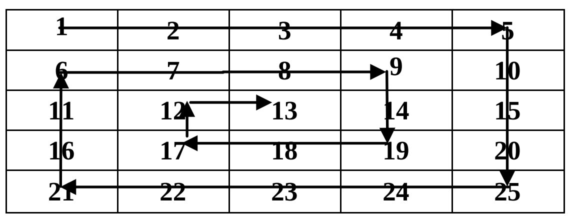

Figure 2.

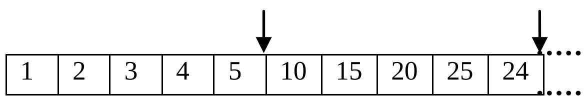

Figure 3.

The generated 1-D array is scanned and the elements are stored in a 2-D array to generate encoded array.

1	2	3	4	5
10	15	20	25	24
23	22	21	16	11
6	7	8	9	14
19	18	17	12	13

Figure 4.

Decoded array is generated by linear scanning of the elements from the above array and the elements are stored in a spiral way in a separate array, as shown below.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Figure 5.

5. Proposed Algorithm

Secret Image Hiding:

1. Cover image is decomposed into four sub bands (LL, LH, HL and HH) using DWT.
2. Secret image is encoded using spiral scanning technique where the size of the image is half of the cover Image.
3. The HH band of the Decomposed cover image is hidden using alpha blending embedding technique.
4. Four sub bands including one modified sub bands are combined to generate the stego image using IDWT

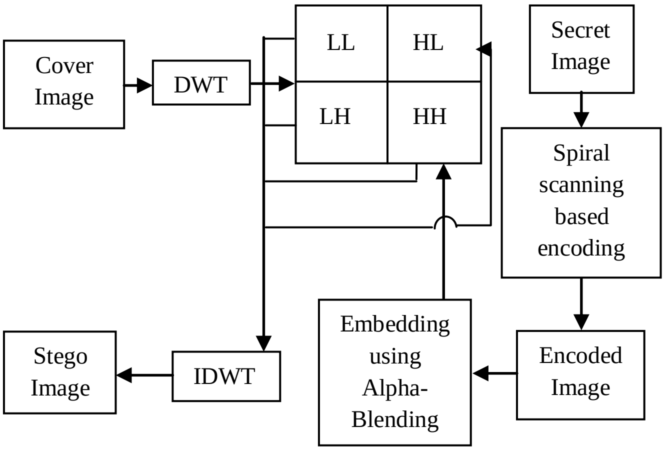

Figure 7

6. Results and Discussion

Encoding and Decoding of the secret image using Spiral scanning:


Figure 8
Secret Image

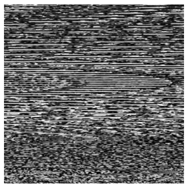
Figure 9
Encoded Image


Figure10
Decoded Image

Histogram Analysis of the above image:

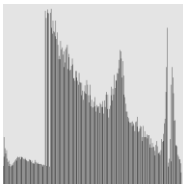
Figure 11
Histogram of Secret Image

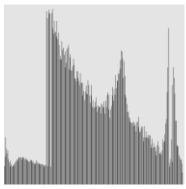
Figure 12
Histogram of Encoded Image

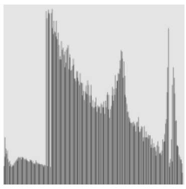
Figure13
Histogram of Decoded Image

Encoded secret Image Hiding using Alpha-blending Technique:


Figure 14
Cover Image


Figure 15
Stego Image

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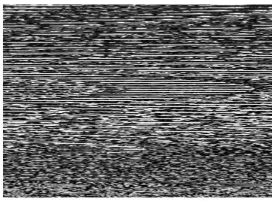


Figure 16
Encoded Image

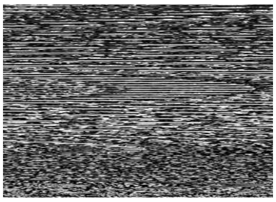


Figure 17
Encoded Extracted Image

Peak Signal to Noise Ratio (PSNR)

It measures the quality of a stego image. This is basically a performance metric and use to determine perceptual transparency of the stego image with respect to host image:

$$PSNR = \frac{MN \max_{x,y} P_{x,y}^2}{\sum_{x,y} (P_{x,y} - \bar{P}_{x,y})^2)} \quad (3)$$

Where, M and N are number of rows and columns in the input image,

$P_{x,y}$ is the original image and

$\bar{P}_{x,y}$ is the Stego Image.

PSNR between Cover Image and Stego Image is 26. 4403 taking alpha as 0.8 shown in Table 1.

Table 1.

Cover Image vs. Stego Image	PSNR
	26.4403

Correlation coefficient

After secret image embedding process, the similarity of original cover image x and stego images x' is measured by the standard correlation coefficient as follows:

$$Correlation = \frac{\sum (x - x')(y - y')}{\sqrt{(x - x')^2}\sqrt{(y - x')^2}} \quad (4)$$

and y' is the discrete wavelet transforms of x and x'

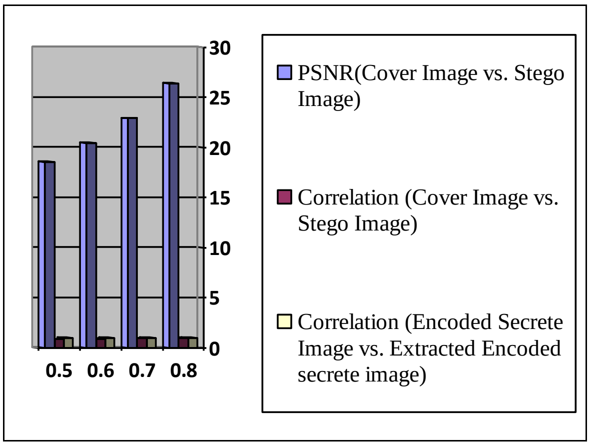
Correlation is done between encoded secret Image and extracted encoded secret image taking alpha value 0.8 shown in Table 2.

Table 2

Correlation between encoded secret image and extracted encoded secret image	0.9989

Table 3

Alpha	PSNR (Cover Image vs. Stego Image)	Correlation (Cover Image vs. Stego Image)	Correlation (Encoded Secret Image vs. Extracted Encoded secret Image)
0.5	18.5628	0.8368	0.9964
0.6	20.4624	0.8865	0.9978
0.7	22.9337	0.9313	0.9986
0.8	26.4403	0.9677	0.9989



6. Conclusion

In the proposed method the encoded image is embedded in the HH sub band of the cover image. So there is a small visual change in between cover image and stego image. But due to strong security aspects this small amount of imperceptibility is acceptable. This approach can be applied for colour images and audio Steganography also, because DWT is applicable for any digital signal.

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