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Effectual Data Secrecy using Complexity Segmentation and Differential Expansion on Gray-Scale Image

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ABSTRACT

Image Steganography is a technique to hide secret information in some other medium without leaving any apparent evidence of data alteration. In this paper, we implemented steganography techniques Bit Plane Complexity Segmentation and Tian's Difference Expansion. Here we embed the information in the bit planes of an image, particularly in the noise like region. By using difference expansion method, we also embedded some amount of data in the stego image whose quality can also be maintained. Experimental results showed that the proposed scheme provides higher embedding capacity at the same time image quality can be maintained.

Keywords:- Steganography, CGC, BPCS and Tian's DE.

1. INTRODUCTION

Nowadays the transmission of digitized information has become very convenient due to the generality of Internet. Most organizations and health care systems involve a large amount of data storage and transmission such as administrative documents between governments, military data, medical images along with patient information, and graphs. Among these, the patient information and medical images need to be organized in an appropriate manner in order to facilitate using and retrieving such data and to avoid mishandling and loss of data. On the other hand, the transmission of such a large amount of data when done separately using ordinary commercial information transmitting channels like Internet, it results in excessive memory utilization, an increase in transmission time and cost and also make that data accessible to unauthorized personnel. In order to overcome the capacity problem and to reduce storage and transmission cost, data hiding techniques are used for concealing patient information with medical images[7][8]. Current data hiding techniques can be classified into two groups: spatial domain and transform domain[9]. Transform domain techniques such as Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). Spatial domain techniques, such as least significant bit (LSB) insertion and patch work embeds message by directly modifying the pixel values of the target images. The advantage of spatial domain methods is the lower computational complexity and higher embedding capacity[7]. Recently, reversible data embedding technique has attracted many attentions. It is also called lossless data embedding, that is to say, the original image can be restored after extracting the hidden data. In 2003, Tian proposed a reversible data hiding technique with high-capacity and low-distortion characteristic by utilizing difference expansion of the pixel pairs. He divided the pixel values into pairs then data is embedded into the difference of the pixel pairs. This paper is organized as follows. The theoretical aspects of the implemented techniques that are relevant to this work are introduced in the next section. We then discuss BPCS (Bit Plane Complexity Segmentation) algorithm followed by Tian's Difference Expansion and finally experimental results section.

2. BITPLANE COMPLEXITY SEGMENTATION AND TIAN'S DIFFERENCE EXPANSION

We implemented steganographical algorithm that combines Bit Plane Complexity Segmentation (BPCS)[2][5] and Tian's Difference Expansion (DE)[1] [3] method to hide the data in digital images. Bit plane segmentation decomposes an image into a set of binary images, one for each bit position of the pixel values and we embed secret information in the bit-planes of the cover image by measuring the binary complexity measure. For an 8 bits image (there are 8 bits per pixel), 8 bit planes can be decomposed. After the image is decomposed into its bit planes, we need a binary complexity measure that can be applied to each region of each bit plane. If the complexity is greater than some chosen value we replace the bits of one or more bit planes will be replaced with secret information, and then recompose the bit planes back into an image called stego image. Next, we apply reversible data embedding technique using Tian's

DE method to the image[1]. Reversible data embedding also hides some information in an image in such a way that an authorized party could decode the hidden information and also restore the image to its original, pristine state. After applying the DE method, the stego image is transmitted across the network. At the destination reverse differential method is applied to get the stego image and then BPCS procedure is followed to get the original secrete message from the stego image.

A.Complexity of binary images[2][4]:

The Method of steganography outlined in this paper makes use of the more complex regions of an image to embed data.For an 8x8 pixel size area, the complexity is defined as sum of exclusive-oring of the adjacent bits both in horizontal and vertical direction (k) by maximum possible black and white changes in the image [1][4]. So α = k / max. possible B-W changes Here the value of α lies between 0≤ α ≤ 1.For example the complexity for a typical block can be calculated as shown below in Fig.1

```
1 1 0 0 1 1 1 1    2
0 1 1 1 1 0 1 1    3
1 1 0 0 1 1 0 1    4
1 1 0 1 1 0 0 0    3
0 0 0 1 1 0 0 1    3
1 1 1 1 1 1 1 0    1
1 0 0 0 0 1 1 0    3
1 1 0 0 0 0 0 1    2

4 4 4 4 1 5 3 4    50

Complexity =  50/112 = 0.44
```

Fig. 1 Finding Complexity

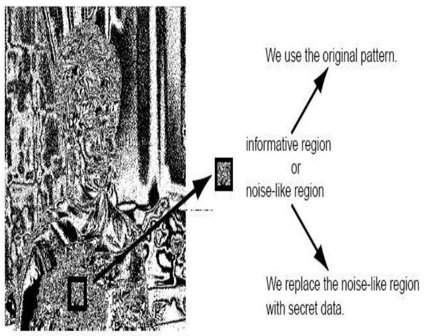

Fig. 2 Example diagram, how we replace noise-like region with secret data.

If α is greater than some threshold value, we treat that block as noise like region, and that block is replaced with the secret data.

B.Review of Tian's Difference Expansion [1][3]:

Embed the payload in the difference of pixel values of the stego image. For a pair of pixel values (x, y)in a gray scale image 0<=x, y<=255, define their average m and difference d as

$$m=\left\lfloor \frac{x+y}{2} \right\rfloor \qquad d=x-y \quad \text{---->} \qquad (1)$$

Where $\lfloor z \rfloor$ denotes the floor operation. The inverse transform is defined as

$$x= m+\left\lfloor \frac{d+1}{2} \right\rfloor \quad y=m-\left\lfloor \frac{d}{2} \right\rfloor \quad \text{---->} \qquad (2)$$

As gray scale values are bounded in [0, 255], we have

$$0 \le m + \left\lfloor \frac{d+1}{2} \right\rfloor \le 255, 0 \le \; m - \left\lfloor \frac{d}{2} \right\rfloor \le 255$$

which is equivalent to $|d| \le min(2(255-l), 2l+1)$ ---> (3)

The difference expansion embedding is defined as d' = 2 * d + b where d' is the result of embedding and b is an embeddable bit. To prevent overflow and underflow problems, the difference number d (after embedding) must satisfy the condition (3), then d is embeddable otherwise d is not embeddable.

The implemented algorithm is as follows:

1. Transform the “vessel” from pure binary code to CGC System.
2. Segment each bit plane of the dummy image into informative and noise-like regions by using threshold value (α).
3. Embed each secret block into the noise-like regions of bit planes.
4. Convert the embedded image from CGC to PBC.
5. Apply Tian’s difference expansion method by selecting pixel pairs.

The Decoding algorithm is just the reverse procedure of the Embedding system

3. EXPERIMENTAL RESULTS

We developed bit plane complexity segmentation and Tian’s Difference Expansion program in MATLAB environment. For this we have taken different sizes of images. For example, input image of size 256x256 typically contains 1, 96,608 bytes.

Fig. 3 Input Image

Then input image is divided into bit planes orbit slices.

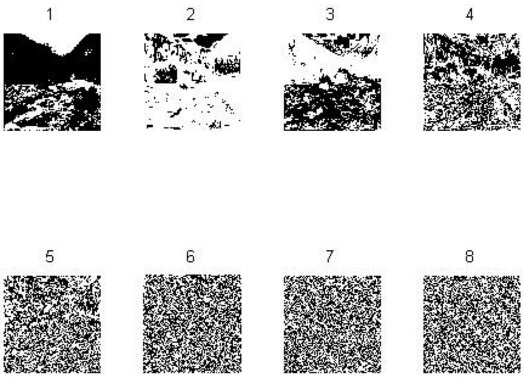

Fig. 4 Bit planes of an input image

We worked on a set of images and estimated the hiding capacity for different threshold values (0 to 1). We observed that, there is a loss in the original informative regions when the threshold value is less than 0.3. If the threshold value lies between above 0.3 there is a possibility of getting additional data blocks other than the secrete data at receiver side. Hence we decided that threshold value of 0.3 is suitable for effective data hiding.

Threshold value	-	0.3
Number of blocks (Noise like regions)	-	3737
Number of bits	-	239168
Capacity	-	45.61%

We replaced all the noisy like regions with some random information then the output image is

Fig. 5 Output image after applying BPCS technique

After, we applied a Tian's difference expansion method to the output of BPCS, in this we embedded 4096 bits of the random information and then the final stego image is

Fig. 6 Stego image

4. PEAK SIGNAL TO NOISE RATIO (PSNR)

Signal-to-noise (SNR) measures are estimates of the quality of the reconstructed image compared with an original image. The actual metric we will compute is the peak signal-to reconstructed image measure which is called PSNR. Assume we are given a source image f(i.j) that contains N by N pixels and stego image F(i.j). First compute the Mean Squared error (MSE) of the stego image as follows $MSE = \sum\{f(i.j) – F(i.j)\}^2/N^2$ The summation is over all pixels. The Root mean Squared Error (RMSE) is the square root of the MSE. PSNR in decibels (dB) is computed by using the formula:

$PSNR = 20\log_{10}(255/RMSE)$

PSNR value for the host image and the stego image is 34.75 dB.

5. CONCLUSIONS

The objective of this paper is to reveal BPCS steganography and Tian's Difference Expansion. We categorized the bit-planes of a natural image as informative areas and noisy regions for the selected threshold value. Then, we can replace the complex noisy regions with secret information in the bit planes of the original image, without changing the quality.

To this we applied difference expansion method again to embed the data. The experimental results show that the presented method provides robustness and high capacity for images during transmission through internet.

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