Reversible Data Hiding in Encrypted Images for Large Data Size Using DCT

Vimal[1], Mahendra Kumar Patil[2]

[1]ECE Department, M. M. Engineering College, MMU, Mullana, Ambala, Haryana, 133203, India

[2]ECE Department, M. M. Engineering College, MMU, Mullana, Ambala, Haryana, 133203, India

Abstract: ***This letter proposes a method of reversible data hiding method in encrypted images for large data size using DCT. Reversible data hiding is a technique to embed additional message into some cover media with a reversible manner so that the original cover content can be perfectly restored after extraction of the hidden message. The data extraction can be achieved by examining the block smoothness. This letter adopts a scheme for measuring the smoothness of blocks, and uses the closest match scheme to further decrease the error rate of extracted-bits. The experimental results reveal that the proposed method offers good performance for hiding large data size files in an image. It is observed from the method that an image with more details gives better peak signal to noise ratio than image with less detail.***

Keywords: DCT, closest match, image encryption, reversible data hiding, smoothness of blocks.

1. Introduction

Reversible data hiding in images is a technique that hides data in digital images for secret communication. It is a technique to hide additional message into cover media with a reversible manner so that the original cover content can be perfectly restored after extraction of the hidden message. Traditionally, data hiding is used for secret communication. In some applications, the embedded carriers are further encrypted to prevent the carrier from being analyzed to reveal the presence of the embedment. Other applications could be for when the owner of the carrier might not want the other person, including data hider, to know the content of the carrier before data hiding is actually performed, such as military images or confidential medical images. In this case, the content owner has to encrypt the content before passing to the data hider for data embedment. The receiver side can extract the embedded message and recover the original image. Many reversible data hiding methods have been proposed recently [1]–[5]. [1] Embeds data bits by expanding the difference of two consecutive pixels. [2] Uses a lossless compression technique to create extra spaces for carry data bits. [3] Shifts the bins of image histograms to leave an empty bin for data embedment. [4] Adopts the difference expansion and histogram shifting for data embedment. [5] Embeds data by shifting the histogram of prediction errors while considering the local activity of pixels to further enhance the quality of stego image.

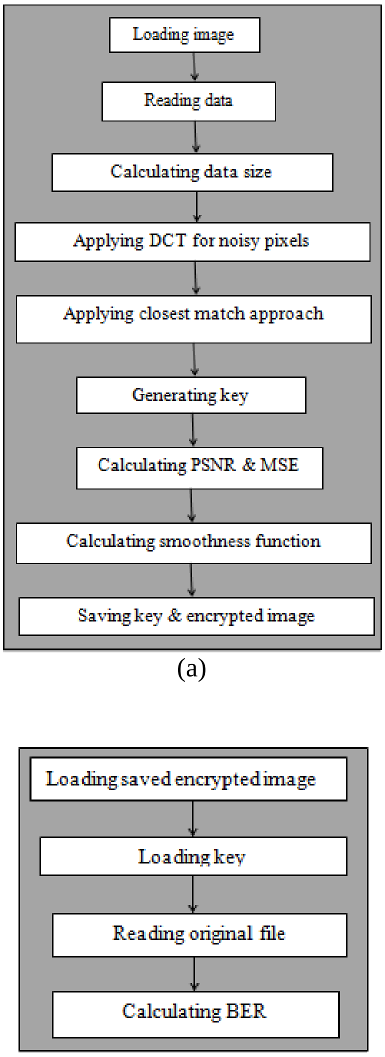
As is well known, encryption is an effective and popular means of privacy protection. In order to securely share a secret image with other person, a content owner may encrypt the image before transmission. In some application scenarios, an inferior assistant or a channel administrator hopes to append some additional message, such as the origin information, image notation or authentication data, within the encrypted image though he does not know the original image content. For example, when medical images have been encrypted for protecting the patient privacy, a database administrator may aim to embed the personal information into the corresponding encrypted images. It may be also hopeful that the original content can be recovered without any error after decryption and retrieve of additional message at receiver side. Traditionally, data hiding is used for secret communication. In some applications, the embedded carriers are further encrypted to prevent the carrier from being analyzed to reveal the presence of the embedment [6]–[8]. Other applications could be for when the owner of the carrier might not want the other person, including data hider, to know the content of the carrier before data hiding is actually performed, such as military images or confidential medical images. In this case, the content owner has to encrypt the content before passing to the data hider for data embedment. The receiver side can extract the embedded message and recover the original image.

A major recent trend is to minimize the computational requirements for secure multimedia distribution by "*selective encryption*" where only parts of the data are encrypted. There are two levels of security for digital image encryption: low level and high-level security encryption. In low-level security encryption, the encrypted image has degraded visual quality compared to that of the original one, but the content of the image is still visible and understandable to the viewers. In the high-level security case, the content is completely scrambled and the image just looks like random noise. In this case, the image is not understandable to the viewers at all. Selective encryption aims at avoiding the encryption of all bits of a digital image and yet ensuring a secure encryption.

2. Proposed Method

To enhance the quality of image after hiding some amount of data in it, here is to hide data in images using reversible data hiding algorithm with the use of DCT. A sketch of the proposed scheme is given in Figure. 1

Encryption


Loading image
Reading data
Calculating data size
Applying DCT for noisy pixels
Applying closest match approach
Generating key
Calculating PSNR & MSE
Calculating smoothness function
Saving key & encrypted image
Loading saved encrypted image
Loading key
Reading original file
Calculating BER

(a)

Decryption

(b)

Figure 1: Sketch of proposed scheme (a) Encryption. (b) Decryption.

This technique is based on encryption as well as decryption. Encryption is the process of encoding messages (or information) shown in fig. 1(a) in such a way that eavesdroppers or hackers cannot read it, but that authorized parties can. In an encryption scheme, the message or information (referred to as plaintext) is encrypted using an encryption algorithm, turning it into an unreadable cipher text. This is usually done with the use of an encryption key, which specifies how the message is to be encoded. Any adversary that can see the cipher text should not be able to determine anything about the original message. An authorized party, however, is able to decode the cipher text using a decryption algorithm shown in fig. 1(b), which usually requires a secret decryption key that adversaries do not have access to. For technical reasons, an encryption scheme usually needs a key-generation algorithm to randomly produce keys. In this technique, here is to hide data in images using reversible data hiding algorithm with the use of DCT to match the closest data hiding pixel for every symbol to be hide. Basically the purpose of this method is to find out the noisy pixels and then hiding the data in it. This can be done in encryption process and then generating the key for decryption. PSNR and MSE are then calculated to check the changes in quality of image. Then by saving the key and the encrypted image, the decryption process is done. Then calculation of bit error rate is done to check the changes in extracted data.

2.1 Calculation of PSNR and MSE

PSNR is most easily defined via the mean squared error (MSE).Given a noise-free $m\times n$ monochrome image I and its noisy approximation K, MSE is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j)-K(i,j)]^2 \; (1)$$

PSNR is defined as:

$$PSNR = 10.\,log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$
$$= 20.\,log_{10}\left(\frac{MAX_I}{MSE}\right)$$

2.2Calculation of block smoothness

The smoothness of an image block can be evaluated by calculating the absolute difference of neighboring pixels. The larger the summation of absolute differences, the more complex the image blocks is. Therefore, the block smoothness calculated by taking the summation of the vertical absolute differences and horizontal absolute differences of pixels in image blocks using the following equation:

$$f = \sum_{u=1}^{S_2}\sum_{v=1}^{S_1-1}\left|p_{u,v}-p_{u,v+1}\right| + \sum_{u=1}^{S_2-1}\sum_{v=1}^{S_1}\left|p_{u,v}-p_{u+1,v}\right| (2)$$

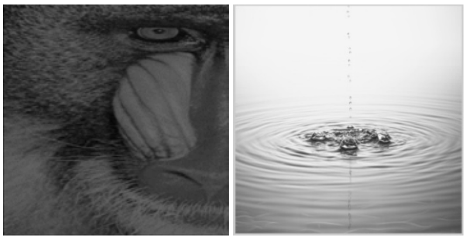
Were $p_{u\,,v}$ represents the pixel values located at position (u,v) of a given image block of size $s_1\times s_2$. This equation fully exploits the absolute difference between two consecutive pixels in both vertical and horizontal directions and thus, the smoothness of blocks can be better estimated.

2.3Bit Error Rate

The number of bit error is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion orbit synchronization errors. Bit error rate can be calculated by taking the difference between the decrypted data and original data.

3. Experimental Results

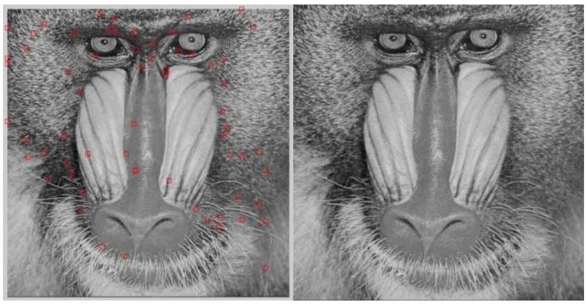
We used two images and then convert these images into gray level images of size 512×512, including Baboon and Splash as the test images, as shown in Figure 2.



(a) (b)

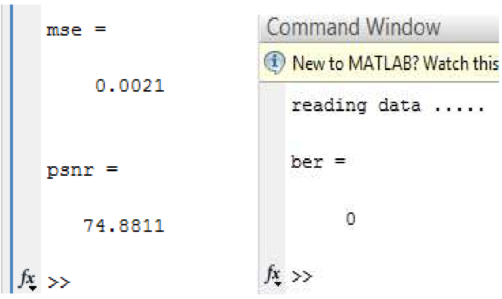
Figure 2: (a) Baboon (b) Splash

This can be explained by taking large data size. For example it can be explained by taking large data size about 2333 bytes. For Baboon image if 2333 bytes of data is embedded in it (shown in Figure 3) then the PSNR comes to be 74.8811 dB and BER is 0% as shown in Figure 4 (a) and Figure 4 (b). Figure 4(b) shows encrypted image of Baboon, from which we conclude that even after hiding large amount of data in Baboon image (contains more details), there is no large difference between the quality of original image and encrypted image.



(a) (b)

Figure 3: (a) Baboon image while hiding data (b) Encrypted image



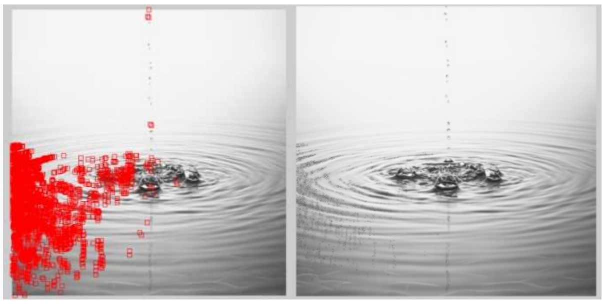
```
mse =

    0.0021


psnr =

   74.8811

fx >>
```

```
reading data .....

ber =

     0

fx >>
```

(a) (b)

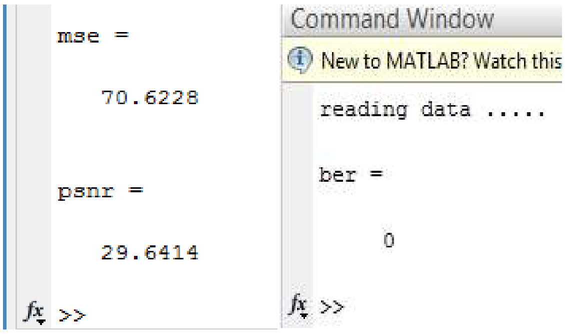
Figure 4: (a) PSNR (b) BER of Baboon image

Now, we take Splash image which contains less detail shown in Figure 2(b). For example, for water splash image (with less details) if 2333 byte of data is embedded in it(shown in Figure 5 (a)) then the PSNR comes to be 29.6414dB and BER is 0% as shown in Figure 6(a) and Fig. 6(b). Encrypted image is blurry where the data is embedded shown in Fig. 5(b).



(a) (b)

Figure 5: (a) Water Splash image while hiding data (b) Encrypted image



```
mse =

   70.6228


psnr =

   29.6414

fx >>
```

```
reading data .....

ber =

     0

fx >>
```

(a) (b)

Figure 6: (a) PSNR (b) BER of Splash image

From the above two results, it is observed that image with more details has PSNR much better than images with less details (i.e. if there is a plain image ,then the PSNR is very low as compare to detailed one).

4. Conclusion

This letter proposes improved data extraction for large size, based on DCT method. We used a new algorithm better estimate the smoothness of image blocks. The extraction of data is performed according to the descending order of the absolute smoothness difference between two candidate blocks. The closest match technique is employed to further reduce the error rate. The experimental result shows that this method is also applicable for large data size. It is observed that image with more details has PSNR much better than images with less details (i.e. if there is a plain image ,then the PSNR is very low as compare to detailed one).

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Author Profile

Vimal is persuing Mtech in Electronics and Communication Engineering at Maharishi Markandeshwar University. Mullana, Ambala, Haryana, India. She was born in 1988 in india. She obtained her bachelor of technology degree in biomedical from Guru Jambeshwar Univeristy Hisar in 2010. Her research area is Image processing.

Mahendra Kumar Patil is Assistant Professor in Electronics and Communication Engineering department at Maharishi Markandeshwar University, Mullana, Ambala, Haryana, India. He was born in 1986 in India. He obtained his Master degree in Signal Processing from Indian Institute of Technology Guwahati, Assam, India in 2011 and Bachelor of Engineering in Electronics and Communication Engineering from UIT RGPV (previously government Engineering College), Bhopal, MP, India, in 2008. His research area is speech processing, image processing and biomedical signal processing. He has significant publication in his short duration carrier.