A Comparative Analysis of Image Error Concealment Technique

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Abstract: ***These Image Compression is the solution associated with transmission and storage of large amount of information for digital Image. Image Compression is the method of reducing the image size without corrupting the excellence of the image. And the interest in data hiding has raised with the recent activity in digital copyright security method. To protect the ownership of a digital image is to secretly embed data in the content of the image identifying the owner. In this paper, we proposed an error concealment scheme for protection of compressed image using M-ary quantization index modulation (QIM) with different block loss. The results show that the proposed error concealment scheme presents a stronger error correcting capability and superior visual quality.***

Keywords: Image compression, Data Hiding, error concealment, halftoning, M-ary QIM**.**

1. Introduction

Rapid development in computer and communication technologies and subsequent emergence of the World Wide Web (WWW) altogether make the Internet easily accessible nowadays to everyone. Digitized image is an important component in multimedia communications and requires large storage space and wide bandwidth for transmission. Compression is essential to overcome channel bandwidth limitations in multimedia communications such as high-definition television (HDTV). One of the most important problems is that compressed multimedia signals are extremely sensitive to bit errors in noisy channel. At the same time, imperfect transmission over radio mobile channel further intensifies vast amounts of random and burst bit errors due to fading, signal attenuation, and co-channel interference. In other words, the compressed data are more interdependent than the uncompressed one. As a result, transmission over radio mobile channel causes higher error rate in data that might severely degrade the visual quality of the decoded image compared to uncompressed one.

In order to improve transmission reliability, error concealment (EC) becomes a potential choice of bandwidth preserving approach for transmission of compressed image over fading channel. This compressed form may be JPEG and more newly like JPEG 2000 for digital images.

Error concealment for image and video data can be done either in spatial domain or in transform domain like discrete cosine transforms (DCT) or discrete wavelet transforms (DWT). The use of DCT and DWT becomes alluring as the most common image compression techniques JPEG and JPEG 2000 are based on these two transforms. Usually two schemes, namely data interpolation and data hiding either separately or in combined form are used for error concealment. We classify them as non-data hiding based error concealment methods and data hiding based error concealment methods.

A. Error Concealment Based on Non-data Hiding

Image data interpolation was developed formerly for enhancement of random resolution, registration and reconstruction after rotation and other similar applications in still images. However, this is most seldom the case representing the real scenario. Furthermore, the schemes are complex and time consuming. They are not suitable for real time error concealment.

B. Error Concealment Based on Data Hiding

Data hiding standard was firstly developed for applications like copyright protection, ownership verification, authentication, secure communication and access control [7]. Lately data hiding is also used for some other application such as error concealment in digital data. Liu and Li [8] are the first authors who use data hiding as an error control tool.

2. M-ary Quantization Index Modulation (QIM)

In QIM, characteristic vector X is quantized using a quantizer $Q_\Delta(.)$. Based on the message bit (m), the quantizer is chosen from its family to be embedded . The watermarked characteristic vector $\tilde{X}_i$ is then given by

$\tilde{X}_i = Q_\Delta(X_i + d_i(m)) - d_i(m)$; $m \in \{0,1\}$

where Δ subscript in Q designate a fixed quantization step size, Δ(.) is dither of watermark bit embedded. At the decoder, the signal $\tilde{X}_i$ is requantized by the use of the same family of quantizers to decide the embedded message bit i.e.

$\hat{m} = \arg\min_{m\in\{0,1\}} \sum_{i=1}^{L} \left|\tilde{X}_i - Q_\Delta(X_i + d_i(m)) - d_i(m)\right|$; $m \in \{0,1\}$

Here symbol 'L' indicates the dither's length.

In M-ary modulation, bits are grouped to form asymbol. The relation between the no, of bits (N)and the number of different symbols (M) is $M=2^N$. A special case of an M-ary data transmission system is the binary transmission system is.

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An efficient method to implement an M-ary modulation method is based on near orthogonal dither.

A near-orthogonal dithers d_i = {d0, d1,….. d_{M-1}} are generated using Hadamard function [32] and a random number that is created using a secret key (k). The Hadamard matrix is of smallest possible order is defined as:

$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$

The Hadamard matrix can be created from H_2 based on Kronecker product which is given by:

$H_L = H_2 \otimes H_{L/2}$

$H_L = \begin{bmatrix} HL/2 & HL/2 \\ HL/2 & -HL/2 \end{bmatrix}$

The Hadamard matrix is orthogonal means all rows and column also are orthogonal. The dither can be generated as follows:

$d_i = H(.) \times R \times \Delta/3$

here H(.) is the Hadamard function used to generate orthogonal codes, Δ is the step size and R is a random number. In QIM embedding , the message 'm' may be embedded into the characteristic vector X, given by:

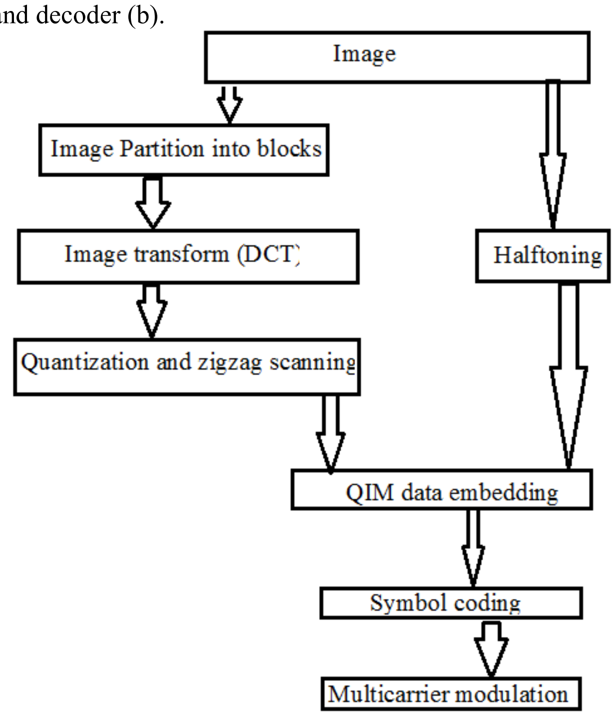
$\widetilde{X_i} = Q_\Delta(X_i + d_i(m)) - d_i(m)$; m∊ {0,1,…..M-1}

At the decoder, the signal $\widetilde{X_i}$ is requantized by the use quantizer 'd' to find out the embedded message bit i.e.

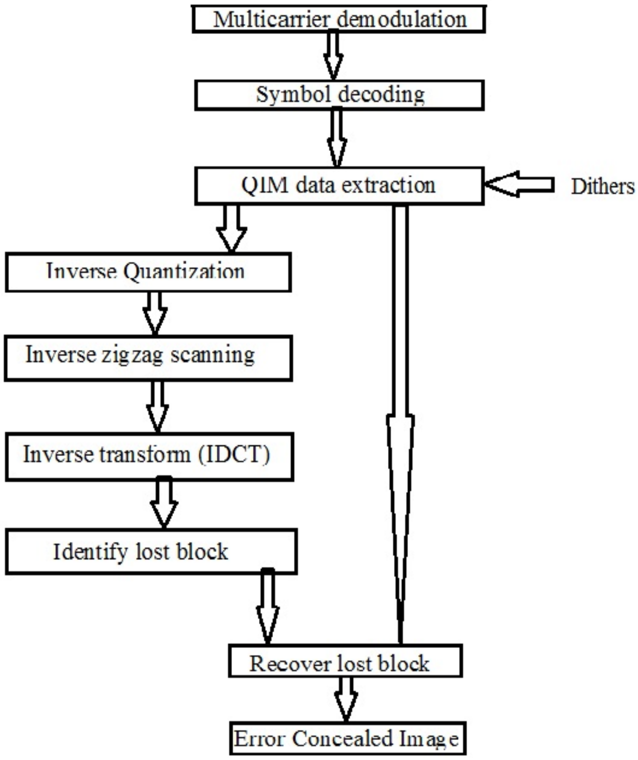
m ^= arg $\min_{m\epsilon\ \{0,1\}} \sum_{i=1}^{L} \left| \tilde{}X_i - Q_\Delta(X_i + d_i(m)) - d_i(m) \right|$; m∊ {0,1,….M-1}.

3. Proposed Model

The modeling setup includes MATLAB R2010a and communications block set running on windows 7. The model shown in Fig. 1 consists of two main components encoder (a) and decoder (b).



(a) Block Diagram of Encoding Process



(b) Block Diagram of Decoding Process

Figure 1: System Model

4. Encoding Process

The image encoding process of the following steps.

Step 1: **Halftoning :** Halftoning is a method to transform the continuous tone digital image into a binary image consisting only of 1's and 0's. The value 1represent a black dot in the present position and 0 represent to stay the corresponding position empty. As the human eyes have the low pass spatial frequency belongings, human eyes recognize areas of black and white marks as some sort of average grey when viewed from sufficiently far distance. Human eyes cannot differentiate the small dots patterns and our eyes put together the black dots and the non-printed areas as varying shades of gray. It is created using the following steps:

a) The test image (H) of size (r × r) is resized into 1/4th of its actual size. It is resized because the amount of information is sufficient for error recovery,

b) Floyd-Steinberg diffusion kernel D_{FS} is used to generate a halftone image given by

$$D_{FS} = 1/16 \begin{matrix} 0 & 0 & 0 \\ 0 & P & 7 \\ 3 & 5 & 1 \end{matrix}$$

where P is the present pixel position and D_{FS} is usually applied on each (3x3) block of the image. The resulting halftone image is represented by W which is of size (r/4 × r/4).

c) An image digest ($\sim$W) is generated by the halftone image (W) using a secret key (K). The image digest ($\sim$W) should cause the error pixel of the cover to be separated as possible as from the embedded bit of the digest (~W). By using this the error concealment can be more valuable.

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Fig: 2

Step 2: **Image Partition n to Blocks:** Test image is partitioned into non-overlapping variable blocks of pixels size. This variable block sizes are chosen in order to make the system compliant with the JPEG codec.

Step 3: **Image Transform**: By subtracting 2m-1, the pixel values of each block are level shifted, where 'm' is the number of bits to represent the gray level of images.

Step 4: **Quantization and Zigzag Scanning:**

The DCT coefficients are normalized and quantized using baseline JPEG. The resulted quantized DCT coefficients are then reordered with the zigzag pattern.

Step 5: **Watermark Embedding using M-ary Modulation:**

The symbol (m) represent the number of bits of image digests (~W). This image digests embedded as a watermark into the test image by modulating quantized coefficients using the steps:

1) The non-zero AC coefficients of DCT are divided into two non-overlapping sets. The two bits of image digest (~W) are then represented by m.
2) A message (m) is embedded into quantized coefficients by modulation one set of DCT coefficients. That results embedding of 4 bits from image digest (~W) in a block.

The q^{th} DCT coefficient S^q is achieved as follows:

$$S^q = Q_\Delta \{X^q + d(m)\} - d(m);$$

where X^q is the q^{th} DCT coefficient, Q is a uniform quantizer with step 'Δ' and $m \in \{0,1,\ldots,M-1\}$.

Step 6: **Symbol Coding:**

The coefficients are Huffman coded, after watermark embedding, for efficient representation of bit sequence.

5. Decoding Process

The decoding process is just opposite to that of the encoding process. The steps for decoding process are described below.

Step 1: **Symbol Decoding:**

The received bits are Huffman decoded to get the quantized DCT coefficient.

Step 2: **Extraction of watermark:**

The embed message (mˆ) is extracted from the received quantized coefficients using the rule.

$$\hat{m} = \arg\min_{m \in \{0,1\ldots M-1\}} \sum_{i=1}^{L} [X\sim - Q_\Delta \{Xq + d(m)\} - d(m)];$$

where $m \in \{0,1,\ldots,M-1\}$.

The image digest (~W) is generated depending on the extracted message (ˆm), and is reversed to get the decoded watermark (W). After decoding a non-linear inverse scaling is performed on the quantized DCT coefficients.

Step 3: **Inverse Transformation:**

Inverse zigzag scan, dequantization and inverse DCT is performed on the resulted quantized DCT coefficients found in step -1 to reconstruct the image.

Step 4: **Recovery of Lost Blocks (Error Concealment)**

Lost blocks are recovered based on the following steps.

a) The received error image is resized into 1/4th of its size and the received resized error image halftoned by Floyd halftoning. The lost pixels of resulted halftone image are recovered with the help of W.

b) Inverse Floyd halftoning is done on output of step 4(a) and resized error image as an input. The output of inverse Floyd halftoning is then resized to the size of the original image. Let H^{ht} is then the resultant output.

c) Then error concealment is done using following rule.

$$H^R(r,r) = \begin{cases} H'(r,r) \text{ if correct pixel} \\ Hht(r,r) \text{ if lost pixel} \end{cases}$$

Here H^R is the error concealed image, H′(r, r) is the pixel of the received error image and Hht (r, r) is the pixel of the inverse halftone image in step 4(b).

6. Simulation Results

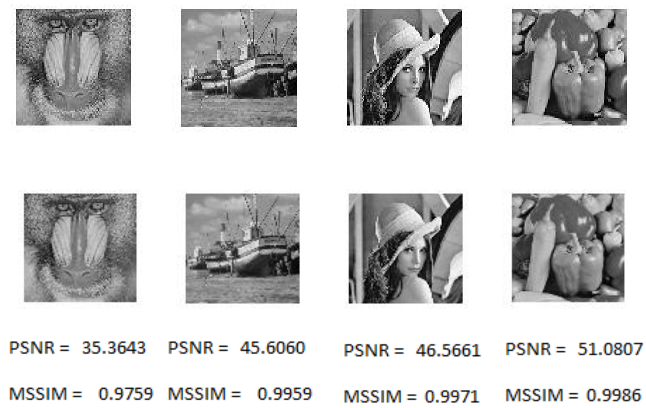

Figure 3: Compressed images with watermarking. Performance in term of PSNR (dB) and MSSIM is represented

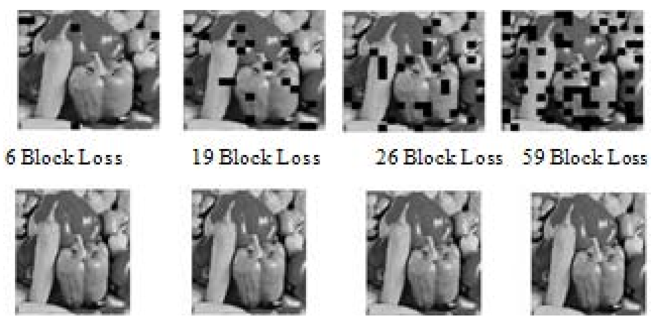

Figure 4: Error images (16 x 16) and error concealed images respectively .

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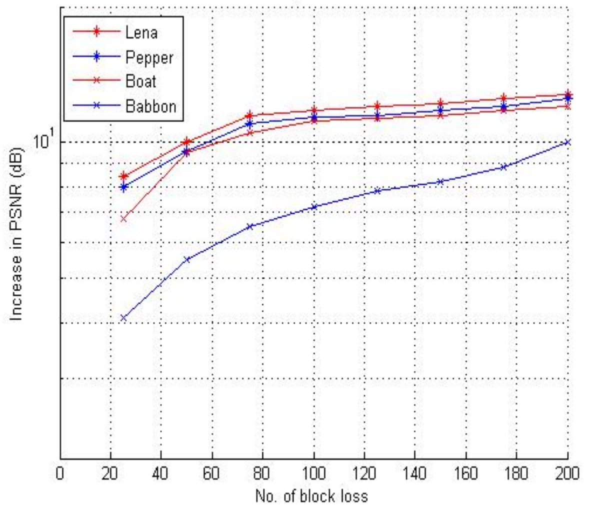

Figure 5: Improvement in quality after error concealment in term of PSNR (dB) for lost blocks having size (8 x 8).

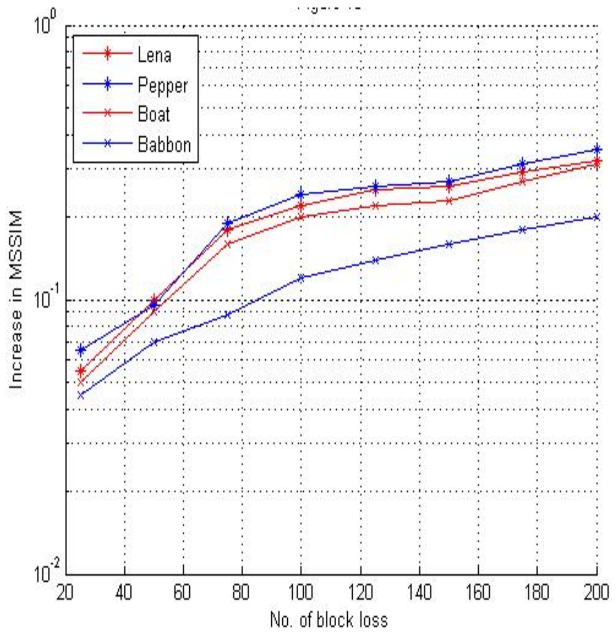

Figure 6: Improvement in quality after error concealment in term of MSSIM for lost blocks having size (8 x 8).

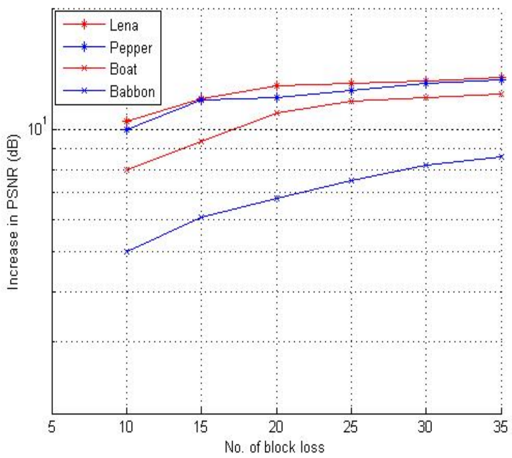

Figure 7: improvement in quality after error concealment in term of PSNR (db) for lost blocks having size (16 x 16).

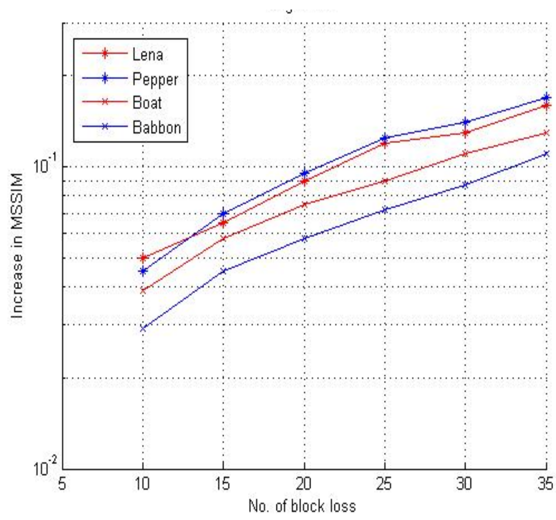

Figure 8: Improvement in quality after error concealment in term of MSSIM for lost blocks having size (16 x 16).

The results of the simulation are presented in this section. We have plotted the No. of Block loss vs.PSNR and No. of Block loss vs .MSSIM in figures 5, 6, 7 & 8.
In Fig: 3 we have compressed images with watermarking. Performance in term of PSNR (dB) and MSSIM is represented in this figure for different test images. In Fig. 4,we have shown the Error images (16 x16) and error concealed images respectively.

In figure 5 shows the improvement in quality after error concealment in term of PSNR (dB) for lost blocks having size (8 x 8) for four test images. Figure 6 shows the improvement in quality after error concealment in term of MSSIM for lost blocks having size (8 x 8).

In figure 7 shows the improvement in quality after error concealment in term of PSNR (dB) for lost blocks having size (16 x 16) for four test images. Figure 8 shows the improvement in quality after error concealment in term of MSSIM for lost blocks having size (16 x 16).

7. Conclusion

This paper present the error concealment scheme for protection of compressed image using M-ary QIM data hiding. The proposed Error concealment method of DCT compressed image using QIM data hiding doesn't affect the compatibility of standard JPEG coding. The use of halftoning technique along with Quantization index modulation allows large volume of important data embedding. It is observe that proposed scheme is effective for transmission over fading wireless channel and increases system performance over other error concealment. The scheme provides significant improvement on visual quality in term of PSNR (dB) and MSSIM values for block loss with different sizes.

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