PERFORMANCE EVALUATION OF LOSSY IMAGE COMPRESSION TECHNIQUES OVER AN AWGN CHANNEL

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Abstract

Recent advancement in image compression research resulted in reducing the time and cost in image storage and transmission without significant reduction of the image quality. In this paper software algorithms for image compression based on psycho visual and inter pixel redundancy elimination have been developed and implemented.

This paper examines the suitability of these two compression techniques over a practical AWGN communication channel and concludes with an experimental comparison on the basis of BER v/s E_b/N_o ratio.

Key Words: *Psycho visual redundancy, inter pixel redundancy, lossless and lossy compression, AWGN channel, BER, Eb/No ratio.*

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1. INTRODUCTION

Image compression is the technique of reducing the amount of data required to represent a digital image using elimination of redundant data present in it. Image compression techniques fall in to two broad categories: Information preserving and Lossy. Information preserving compression technique allows an image to be compressed and decompressed without losing information. Satellite imagery, digital radiography, archival of medical or business documents are the fields essentially demanding information preserving compression techniques. Lossy image compression provides higher levels of data reduction but results in a less accurate reproduction of the original image. Lossy compression is most commonly used to compress multimedia data (audio, video and still image), especially in applications such as streaming media and internet telephony.

Transmission of compressed digital image with increased compression ratio over a practical AWGN channels a interesting subject of research since last long.

In this paper section 2 elaborates both the theoretic and practical aspects of the PV and IP redundancy elimination methods. The two methods are compared on the basis of signal to quantization noise ratio v/s no of quantization levels.

Section 3 examines the performance of the tow compression methods individually while transmitting over an AWGN channel. This section concludes with the comparison of the two methods on the basis of BER v/s E_b/N_o ratio

2. TYPES OF DATA REDUNDANCIES IN DIGITAL IMAGE

In digital image compression, three basic data redundancies can be identified and exploited:

[1]. Psycho-visual redundancy
[2]. Inter pixel redundancy
[3]. coding redundancy

2.1 Psycho Visual Redundancy

As human eyes are more responsive to slow and gradual changes of illumination than perceiving finer details and rapid changes of intensities, Certain information simply has less relative importance than other information in normal visual processing. This information is said to be Psycho visual redundant. This type of redundancy can be eliminated without significantly impairing the quality of image perception. The elimination of Psycho visually redundant data results in a loss of quantitative information. This commonly refers to as quantization. Image quantization refers to the process by which a continuous image function (gray-values) is mapped to a set of discrete gray-values. An image quantized with n bits can be represented by 2^n different gray-values.

2.1.1 Reduction Of Psycho Visual Redundancy

With the help of MATLAB simulation results we noted that as number of quantization bits is increased from the value of 1 to 2, 3, 4 quality of image is improved greatly. This is due to fact that as no of bits increases the loss of qualitative information decreases. The results are as shown in figure 1

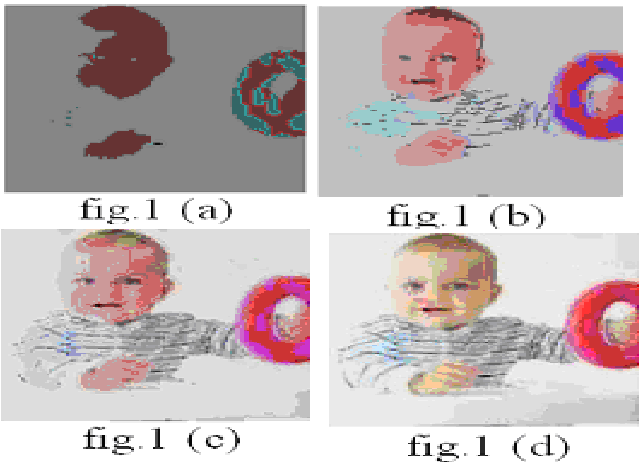

Fig. 1. Image quantization using 1, 2, 3 and 4 quantization bits respectively

Now again the number of quantization bits is increased from 6 to 8, 9, 10 and the result shows clearly that due to human eyes limitation we are not able to resolve any quality improvement after a threshold level. In this experimentation this threshold level is found at 8 bits per sample. Results are as shown in figure 2.

This shows that the no of bits in quantization can be restricted to 8 to achieve a good quality of image reproduction and hence less data is required to represent the given image using psycho visual redundancy.

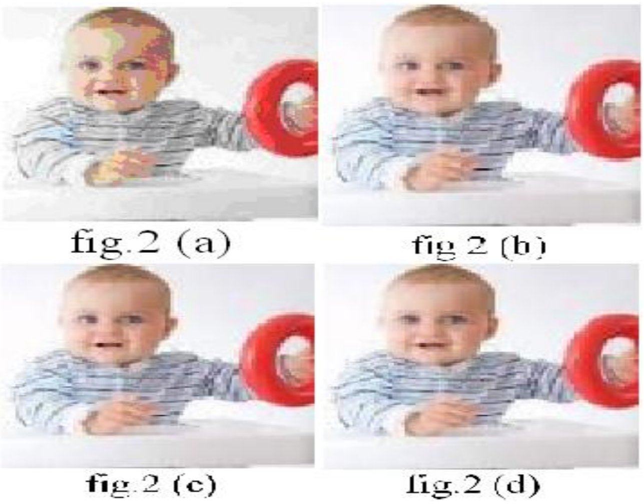

Fig. 2. Image quantization using 6, 8, 9 and 10 quantization bits respectively

2.2 Psycho Visual Redundancy

The structural or geometric relationships between the objects in the image results in the correlation between pixels and with the help of this correlation the value of any pixel can be approximated from the value of its neighbours. It shows that much of the visual contribution of a single pixel to an image is redundant, it could have been guessed on the basis of the values of its neighbours. This is known as inter-pixel redundancy. In order to reduce the inter-pixel redundancy in an image, the 2D pixel array normally used for human viewing and interpretation must be transformed into a more efficient format. Various techniques used for this transformation are run length coding, delta compression, constant area coding, predictive coding etc. Here the transformation is carried out on the basis of well known differential pulse code modulation (DPCM) technique. In DPCM the difference between adjacent pixels can be used to represent an image. At the transmitter end differential pixels are quantized, encoded, modulated and transmitted. At the receivers end accumulation of differential pixels followed by demodulation results in the regeneration of original pixels.

2.2.1 Reduction Of Inter-Pixel Redundancy

The MATLAB simulation of an image using DPCM for 2, 4, 8 and 16 quantization levels are shown in fig 3 a, b, c and d respectively. As the differential pixels are generally smaller than the original pixels, lesser bits are required to represent the differential pixel. This finally reduces the number of bits required to represent the image and hence eliminates the interpixel redundancy. This is experimentally verified that the same visual quality can be obtained with less no of bits per sample in case of differential pixel quantization as compared to earlier case of quantization discussed in section no 2.1.

2.2.2 Comparison Between Methods Used For PV And IP Redundancy Reduction

The two methods used for Psycho visual and Inter-pixel redundancy reduction can be directly compared on the basis of visual image quality, which shows that better visual results are obtained from the experimentation carried for IP as compared to the same for PV for same no of bits per sample (i.e. 4 bits/sample) [fig. 1(d) and fig. 3(d)]

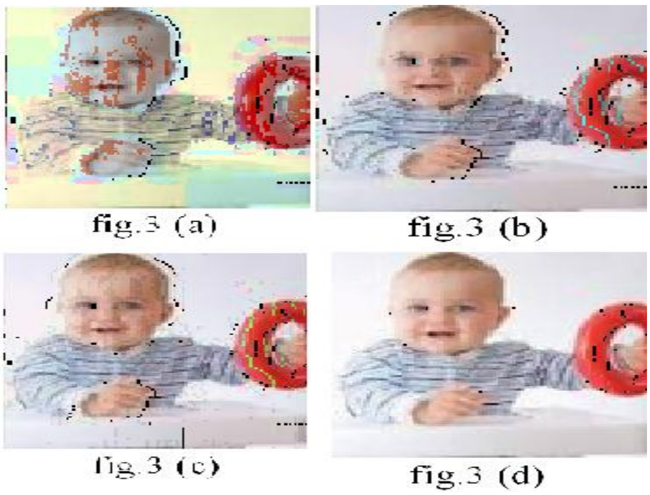

Fig. 3. DPCM simulation using 1, 2, 3 and 4 quantization bits respectively

A simulation is also carried out to show the same effect by plotting a graph between signal to quantization noise ratio and number of quantization levels for both the methodologies used for PV and IP redundancy reduction. This graph is shown in figure no 4.

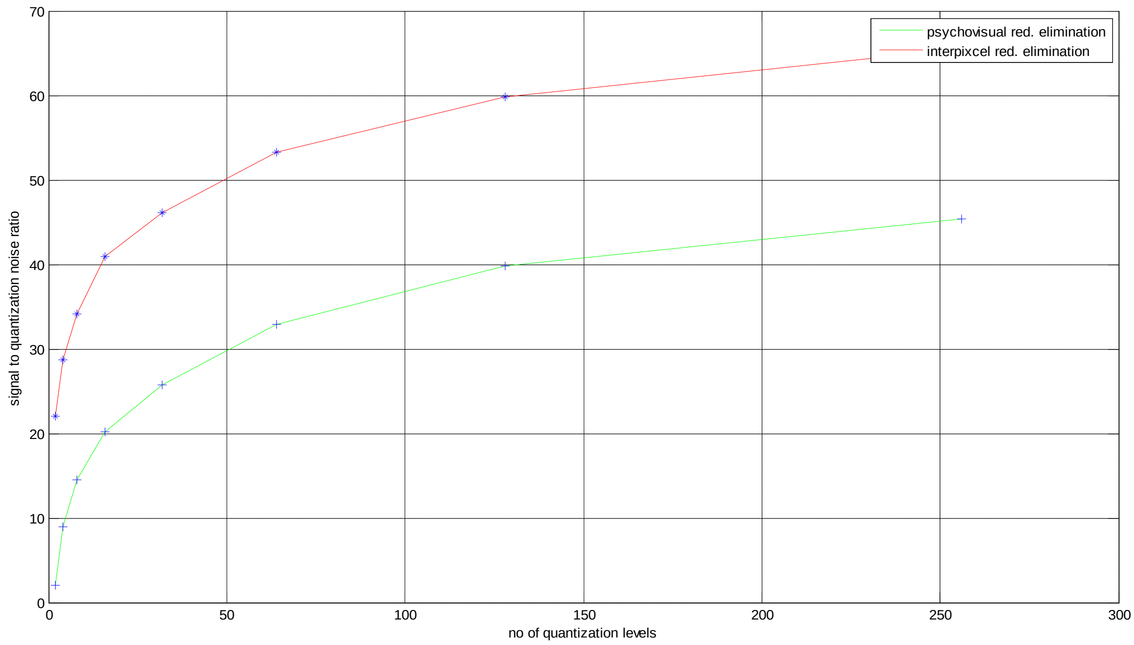

Fig. 4. Graph between signal to quantization noise ratio and number of quantization levels for both the methodologies used for PV and IP redundancy reduction

In figure no 4 the green line shows the variation of signal to quantization noise ratio v/s no of quantization ratio for PV redundancy reduction method and the red line shows the same for IP redundancy reduction method.

2.3 Coding Redundancy

Coding is a procedure for mapping a given set of symbols into a new set of encoded symbols in such a way that the transformation is one to one.

If the gray levels of an image are coded in a way that uses more symbols than absolutely necessary to represent each gray level, the resulting image is said to contain coding redundancy. It is almost always present when an images gray level is represented with a straight or natural binary code. The graph shown in figure no 5 is a result of variation in compression ratio v/s no of bits grouped to construct unique symbols from the digital image while coding.

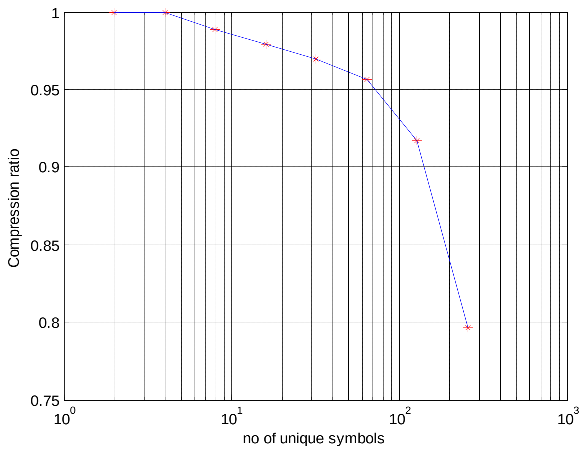

Fig. 5. Graph of variation in compression ratio v/s no of bits

3. PERFORMANCE EVALUATION OF (PC) PSYCHOVISUAL REDUNDANCY REDUCTION METHOD OVER A COMMUNICATION CHANNEL

The variation in quality of a psycho-visual redundancy eliminated signal in terms of signal to quantization noise ratio with variation in number of quantization levels used has already been discussed in section 2.2.2. In this section the signal quality is evaluated in terms of bit error rate with a variation in Eb/No ratio. With the above experimentation the conclusion is drawn that, if Eb/No ratio is increased for a particular image encoded with fixed number of quantization levels, bit error rate goes on reducing in the received image.

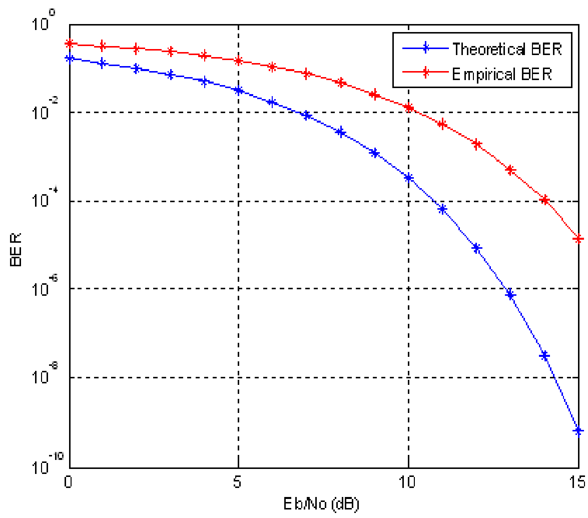

Fig. 6 BER v/s Eb/No for 8 bit/pixel for PV method

This graph shows variation in BER for a psycho-visual redundancy eliminated image quantized with 8bits per sample, with different values of Eb/No ratio between 0 to 15 dB for theoretical as well as empirical results. A direct comparison between received image and transmitted original tricolor image for Eb/No ratio 8 dB is also shown here in fig no.7 (a) and (b) respectively.

Fig. 7(a) Fig. 7(b)

Fig. 7. received image and transmitted original image for Eb/No ratio 8 dB

It is experimentally found that an image compressed with psycho-visual redundancy elimination with an optimum quantization level i.e. 8 bits per sample [section 2.1] if transmitted over a communication channel affected with additive white Gaussian noise then its clear reception and recognizable reproduction is possible with minimum signal to channel noise ratio.

4. PERFORMANCE EVALUATION OF (IP) INTER PIXCEL REDUNDANCY REDUCTION METHOD OVER A COMMUNICATION CHANNEL

In this section a MATLAB simulation is carried out for a tricolor image encoded using DPCM with 8bits/differential sample and sent over an AWGN channel with Eb/ No ratio 8dB. This simulation yields a conclusion that IP redundancy reduction not only requires less no of bits to compress a digital image as compared to PV redundancy reduction with same visual quality [section 2.1 and 2.2] but also provides the better image quality when transmitted over an AWGN channel. This statement is justified by figure no 8 in which a tricolor image encoded using DPCM with 8bits/differential sample and sent over an AWGN channel with Eb/ No ratio 8dB and the original tricolor image are shown respectively.

Fig. 8(a) Fig. 8(b)

Fig. 8. image encoded using DPCM and the original image

The quality evaluation of a inter-pixel redundancy eliminated image in terms of signal to quantization noise ratio with variation in number of bits per differential sample using delta modulation method has also been discussed in section 2.2.2. In this section the image quality is evaluated in terms of bit error rate with a variation in channel noise or signal to noise ratio of the channel. The comparative graph for this experimentation is shown in figure no 9.

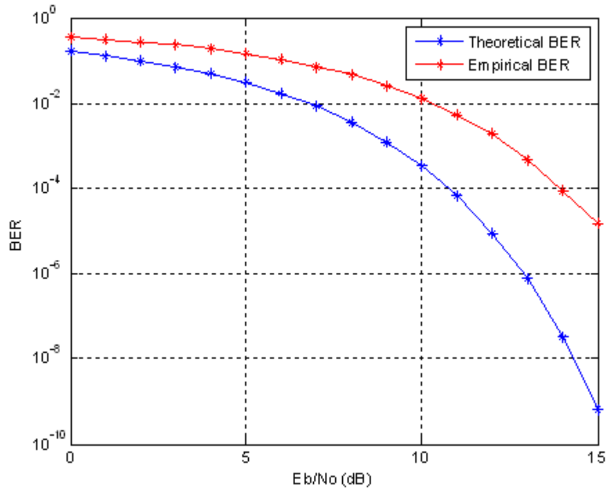

Fig. 9 BER v/s Eb/No for 8 bit/pixel for IP method

5. RESULT AND CONCLUSION

The experimentation carried out in this paper directly compares the Psycho visual and Inter pixel redundancy methods of image compression and it is found that better visual results are obtained from the experimentation carried for IP as compared to the same for PV for same no of bits per sample (i.e. 4 bits/sample).

A simulation of transmission over a communication channel affected with additive white Gaussian noise with Eb/No ratio 8 dB, is carried out for an original tricolour image compressed with psycho-visual redundancy method, which results in a conclusion that clear reception and recognizable reproduction is possible with an optimum quantization level (i.e. 8 bits per sample) below which the reproduction of image is not clear. On the other side when the same simulation is done for image compressed with inter-pixel redundancy method using DPCM coding, the visual quality of received image is found quiet better for same number of quantization levels (i.e. 8 bits per differential sample) as compared to the case of PV redundancy method [fig 8(a) and fig 7(a) respectively].

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BIOGRAPHY

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