CONTRIBUTION AND LIMITS OF A LOSSLESS DATA COMPRESSTION METHOD FOR PERFORMANCE OF OPTICAL WIRELESS CHANNELS IN DIGITAL MULTIMEDEA APPLICATIONS

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Abstract: For the digital multimedia communication systems, the modification of the transmission rate, transmission capacity and the bandwidth, parameters are an important for the performance of the Optical Wireless Channel (OWLC). Multilevel-Digital pulse Interval Modulation (M-DPIM) is the most method which contributes in the improving of these parameters. The large size of multimedia sources has been performed the main problem for the data transmission. Thus, in this paper a lossless images compression method by Minimizing Pixels Number of Objects (MPNO) is applied. The properties of the Digital Images Transmission (DIT) with and without compression by using MPNO method are discussed. The compression ratio of the MPNO method compared with other compression methods is evaluated. Transmission Parameters Values (TPV) of the M-DPIM system with and without compressed input by using MPNO method are computed. Finally, for special types of the DIT, the MPNO method has been satisfied good results.

1 INTRODUCTION

Multimedia era has been rapidly moved toward digitization, processing, storage, and transmission of images. With the increasing popularity of Web browsers, image transmission has become one of the largest uses of Internet bandwidth for multimedia communications. Thus, the digital images transmitted are compressed as much as possible before the bits are transmitted via the communications and storage channels. Recently, the increasing in numbers of digital images devices, such as scanners, plotters and digital camera has seen an explosion in the availability of Digital Images Transmission (DIT) (Kamimura et al., 1993), (Tanenbum, 2003), (Wu et al., 2003).

The OWLC (transmission and detection) offers immunity from fading and security at the physical level where the optical signal is typically contained within the indoor communication environment for the DIT. The transmission rate, transmission capacity and the bandwidth are important parameters for the performance of the OWLC (Smyth et al., 1993), (Hranilovic and Kschischang, 2003). Thus, the M-DPIM (Ghassemlooy and Aldibbiat, 2006) is the most method which contributes in the improving of these parameters compared with pulse position modulation (PPM) (Audeh et al., 1996), digital pulse interval modulation (DPIM) (Ghassemlooy et al., 1998) and dual header pulse interval modulation (DH-PIM) (Aldibbiat et al., 2002) But, still and all the large size of the DIT has been performed the main problem for the TPV. For a data compression field, a lossless images compression method by Minimizing Pixels Number of Objects (MPNO) is proposed and generalized in our previous works (Fahd et al., 2006), (Fahd et al., 2007).

In this paper we propose the contribution and limits of the MPNO method for a Digital Images Transmission (DIT) in the OWLC. We will apply MPNO method in OWLC which used the M-DPIM system. The transmission parameters values (TPV) of the M-DPIM system with and without compression by using MPNO method will be computed. The compression ratio of MPNO compared with Portable Network Graphics (PNG) and Graphics Interchange Format (GIF)

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compression methods is introduced in this work (ISO/IEC 15948, 2003), (Version 89a (c), 1987).

The rest of the paper is organized as follows. In Section 2, introduce overview of (PNG, GIF and M-DPIM system). The MPNO method is introduced In Section 3. The properties of the DIT are introduced in Section 4. The results and discussion of the compression ratio of the MPNO method compared with other methods, and (the bit rate, the transmission bandwidth requirement, transmission capacity and the reset delay time of demodulator) values of the DIT for the M-DPIM with and without compression by using MPNO method for M-DPIM system are computed in section 5. Contribution and limits of the MPNO for the performance of the OWLC are presented in conclusions of Section 6. Finally, the last section presents the references.

2 PREVIOUS WORKS

2.1 PNG Compression Method

Portable Network Graphics (PNG) is one of the modern image formats for lossless image compression. The PNG file format supports grayscale, indexed color, and true colours as well as other features, such as transparency, interlacing and gamma correction (ISO/IEC 15948, 2003).

2.2 GIF Compression Method

Graphics Interchange Format GIF offers a protocol intended for on-line transmission and interchange of raster graphic data. Cartoon-style images and clip-arts are often entropy-coded using the GIF format that supports 256 colors. However, the GIF format may not be the most efficient way to compress cartoon images. For example, cartoon images often contain large areas of a uniform color. This spatial relationship among colors has not been exploited explicitly in the GIF compression (Version 89a (c), 1987).

2.3 The M-DPIM for OWLC System

Multilevel-Digital pulse Interval Modulation (M-DPIM) is the most method which contributes in the improving of the TPV of the DIT within OWLC (Ghassemlooy and Aldibbiat, 2006). The transmission parameters of M-DPIM modulator are:

- Bandwidth requirement normalized to NRZ-OOK is:

$$B_{req} = \frac{(R_b)\cdot(L_{av})}{M} \qquad (1)$$

Where: R_b, L_{av}, M are the bit rate of DIT, average symbol length of the modulated codeword and the number of slots of the input data respectively.

$$L_{av} = \frac{(2^{M-1}+3)}{2} \qquad (2)$$

- Transmission capacity (TC) is:

$$TC = \frac{4M^2 B_{req}(2^{M-1}+1)}{(2^{M-1}+3)^2} \qquad (3)$$

- In the M-DPIM modulator, the latch will fetch the next input word after a delay period, which is the duration of transmitting the present symbol. This delay period is:

$$\text{Delay period} = (d+2)T_s \qquad (4)$$

Where: Ts: is the pulse duration within the modulator.

$$T_s = \frac{2^M}{(2^{M-1}+3)R_b} \qquad (5)$$

- For the demodulator stage of M-DPIM system, the reset delay time of counter (RDT) is:

$$RDT = 2T_s \qquad (6)$$

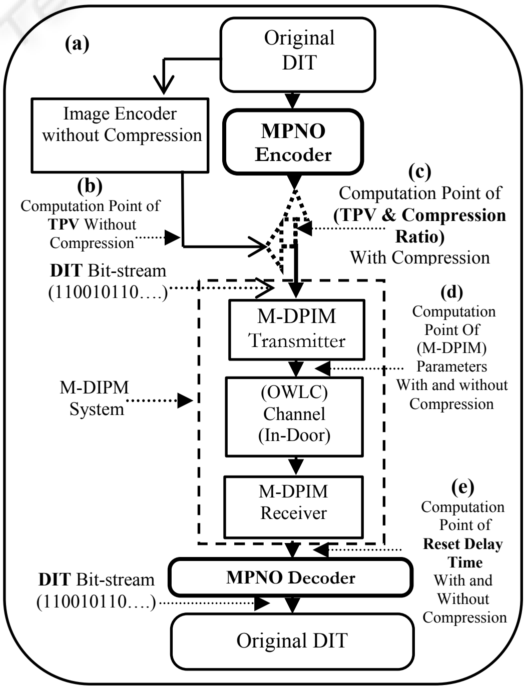


Figure 1: Paper structure, (a) block diagram of MPNO and M-DIPM system, (b, c, d, e) computation points.

3 MPNO METHOD

The basic structure of this paper is illustrated in figure1. The encoder of the MPNO method has the following main stages: image preparation, object extraction, object preparation, vectoring, differential encoding, Huffman encoding, and frame building.

In image preparation: The image is converting into 2D matrix, which consists of the pixels values of this image.

In object extraction stage: the matrix of the image is scanned from top to bottom and from left to right in order to detect the starting pixel of the object, after that the pixels of the object (PO's) are detected and the pattern for PO's is generated, the output of this process as shown in figure 2, where: (0,0) and (Xpmax , Ypmax) are the start and end points of the pattern of the extracted object, respectively.

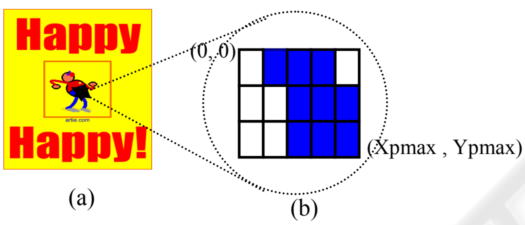


Figure 2: Object Extraction, (a) the image, (b) pattern of PO's of blue object.

In object preparation stage: The repetitions of the PO's in the horizontal, vertical and diagonal coordinates and the intersection are removed. The out of object preparation is encoded in encoding stage. -The compression ratio for any type of image compression is computed by the following formula:

$$\text{Compression Ratio of Image} = \frac{\text{OSI} - \text{CSI}}{\text{OSI}} * 100 \qquad (7)$$

Where: **OSI** and **CSI** are: Original Image Size (KB) and Compressed Image Size (KB) respectively.

In frame building stage: the encoder has general structure which defines the format of the total fields in output bit-stream. The decoder part of this method builds an exact copy for the transmitted image from its bit-stream frame as follows. Firstly, the decoder decompresses the objects embedded in the bit-stream frame and secondly, it fills the pixels values which removed by the encoder stage.

4 PROPERTIES OF DIT

We consider that Intra- frame of video film (I-frame) can be represented by a one digital image. Then one image must be transmitted on line in time approximately equal to (0.033) sec, then the duration time of the pulse which represent one bit (0 or 1) of the transmitted bit stream (T_b) is:

$$T_b = \frac{0.033}{\text{TBI}} \qquad (8)$$

Where: TBI is transmission bandwidth of image:

$$TBI\ (Mb) = \frac{(IS \times 8)}{(10^3)} \qquad (9)$$

Image Size (IS) is:

$$IS(KB) = \frac{(HPN) \times (VPN) \times (NbP)}{(8 \times 10^3)} \qquad (10)$$

Where: (HPN, VPN, NbP, IS and TBI) are: is horizontal pixels number, vertical pixels number, and number of bits per pixel, image size (KB) respectively.

Then the bit rate (R_b) of DIT is:

$$R_b(b/s) = \frac{1}{T_b} \qquad (11)$$

5 DISCUSSION OF RESULTS

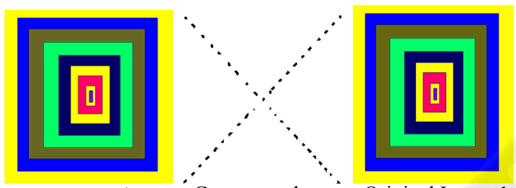
In this section, we evaluate and discuss the contribution of the MPNO method for TPV of the DIT within OWLC which used the M-DPIM stage.

The effect of image compression by using MPNO method is shown in figures 3 and 5. By using equation (7), the comparison between the proposed Method (MPNO) and both GIF and PNG methods is illustrated in Table 1. It is clear that the image compression by this method was more active especially for geometric-style images compared with GIF and PNG methods

The bit rate computation computed by using equations (8), (11). The bit rate computation of DIT with and without MPNO Compression is shown in Table (2). It is clear that, the MPNO method has been introduced lower values of (R_b). This minimization of the bit will be improved the values of both the hardware devices speed and the transmission bandwidth which requirements for OWLC system. Whereas, the increasing in speed of the hardware devices is performed the main problem for NRZ-transmission systems. By using equations

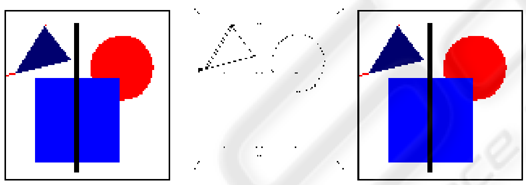
(1), (2), the B_{req} computation of DIT with and without MPNO Compression for M-DPIM Modulator is shown in Table 2. The compression of DIT by using MPNO method offers decreasing of B_{req} values. Related to the equations and the discussion of reference (Ghassemlooy and Aldibbiat, 2006), the performance of M-DPIM system has been improved by this minimization of B_{req}.

From equation (3) and Table (3), the TC value of M-DPIM Modulator at (M = 8) is decreasing with applied the DIT in (MPNO) encoder. By decreasing the TC, the performance of the M-DPIM system has been improved. Related to equation (6) and Table (3), the RDT value is increasing with applied the DIT in (MPNO) encoder, thus the demodulator hardware's speed is decreased. By the increasing of RDT value, it is also improves a slot synchronization in the demodulator stage for M-DPIM system.



Decompressed (199 KB) | Compressed (0.507 KB) | Original Image 1 443x458 (199 KB)

Figure 3: Effect of MPNO method on Image 1.



Decompressed (12.7 KB) | Compressed (0.499 KB) | Original Image 2 107x111 (12.7 KB)

Figure 4: Effect of MPNO method on Image 2.

Decompressed (118 KB) | Compressed (7.8 KB) | Original Image 3 300x400 (118 KB)

Figure 5: Effect of MPNO method on Image 3.

Table 1: The compression ratio comparison between MPNO method and both GIF and PNG methods.

DIT 8 - bits Images	Compressed Size (KB)			Compression Ratio (%)		
	MPNO	GIF	PNG	**MPNO**	GIF	PNG
Image **1** (443x458) 199 KB	**0. 507**	6.85	3.56	**99.74**	96.55	98.21
Image **2** (107x111) 12.7 KB	**0. 499**	1. 6	1. 37	**96. 07**	87.07	89.21
Image **3** (300x400) 118 KB	**7. 8**	7. 9	6. 2	**93 .38**	93.30	94.74

Table 2: The computations of DIT bit rate R_b and M-DPIM bandwidth requirement B_{req} with and without MPNO encoder.

DIT 8 – bits Images	(R_b) of DIT		$B_{req}(Mbs)$ at (M = 8)	
	Without MPNO (Mbs)	With MPNO (Mbs)	Without MPNO (Mbs)	With (MPNO) (Mbs)
Image (1) (443x458)	48. 242	**0. 123**	395.102	**1.007**
Image (2) (107x111)	3. 078	**0. 120**	25. 209	**0. 983**
Image (3) (300x400)	28. 606	**1. 890**	234. 28	**15 .479**

Table 3: The computations of transmission capacity (TC) of M-DPIM modulator and (RDT) of demodulator.

DIT 8 – bits Images	TC of M-DPIM at (M = 8)		(RDT) at (M = 8)	
	Without MPNO (Mbs)	With MPNO (Mbs)	Without MPNO $(\mu$ sec$)$	With (MPNO) $(\mu$ sec$)$
Image (1) (443x458)	760.176	**1.937**	0.081	**31.776**
Image (2) (107x111)	48.502	**1. 891**	1. 269	**32. 57**
Image (3) (300x400)	450.760	**29.781**	0. 136	**2. 067**

6 CONCLUSION

The paper results show that MPNO method offers good compression ratio compared with GIF and PNG methods lower Bit Rate lower bandwidth requirement, higher RDT and lower transmission capacity of DIT for M-DPIM system compared with no compression case. It also improves the speed of the hardware devices of the modulator and slot synchronization in the demodulator stage, especially for geometric-style images which has 256 colors at any size, but each colored object in image must be contented only one level from the 256 levels of colors. Finally, the MPNO method has been satisfied good contributions for digital multimedia applications.

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