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An Improved PAPR Reduction Technique for OFDM Communication System Using Fragmentary Transmit Sequence

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Abstract

OFDM technique has been widely adopted in many wireless communication system due to its high data rate transmissibility and robustness to the multipath fading channel. A modified Fragmentation Transmit Sequence (FTS) which reduces the Peak Average To Power ratio (PAPR) to appreciable extend is presented in this paper. High PAPR was a major drawback in OFDM system as it causes large number of sub-carriers which results in band distortion due to which its usage in practical application is restricted. Here the combination of SPIHT (Set Partioning in Hierarchical Tree) and LDPC (Low Density Parity Check) in used in the modified OFDM system. In our paper OFDM system is modified to a new technique named Fragmentation transmit Sequence which generate multiple candidate signal that minimizes the PAPR and is then adopted as a final transmission signal. And all the results are verified using MATLAB software.

Keywords: OFDM, PAPR, SPIHT, LDPC, Unequal Error Protection (UEP), Fragmentation Transmit Sequence (FTS)

1. Introduction

Transmission of images over wireless communication systems requires robust and efficient source and channel coding algorithms. The current image coding standard JPEG2000 or SPIHT algorithm provides progressive image compression where the original image can be reconstructed incrementally. The main drawback of progressive organization of the bitstream is that it is highly prone to transmission noise. Channel codes are required to protect the source encoded bitstream. Traditionally, the problems of source coding and channel coding have been addressed independently. However, when the constraints of the communication channel are considered, a joint source/channel coding scheme (JSCC) is found to be the most promising scheme for communication of images over noisy channels. In this method, the channel code rate is carefully chosen to match the properties of source coder as well as the conditions of the channel. Forward Error Correction (FEC) scheme is employed to increase the transmitted data rate and protect the data prior to transmission. One of the FEC schemes is Low-Density Parity-Check (LDPC) codes, developed by Gallager . As an attractive technology for wireless communications Orthogonal Frequency Division Multiplexing (OFDM), which is one of multi-carrier modulation (MCM) techniques, offers a considerable high spectral efficiency, multipath delay spread tolerance, immunity to the frequency selective fading channels and power efficiency . However, some challenging issues remain unresolved in the design of the OFDM systems. One of the major problems is high Peak-to- Average Power Ratio (PAPR) of transmitted OFDM signals. Therefore, the OFDM receiver's detection efficiency is very sensitive to the nonlinear devices used in its signal processing loop, such as Digital-to-Analog Converter (DAC) and High Power Amplifier (HPA), which may severely impair system performance due to induced spectral regrowth and detection efficiency degradation. The target of this paper is to improve the quality of the reconstructed images over the OFDM system and reduce the PAPR of the OFDM signal. It presents a modified OFDM system with a JSCC scheme, which combines simple modification of the SPIHT image coding technique followed by an UEP process using LDPC. Moreover, OFDM system is modified to a new technique named Fragmentation transmit Sequence which generate multiple candidate signal that minimizes the PAPR and is then adopted as a final transmission signal.

2. SPIHT and UEP

The SPIHT coder is consider as one of the best image coding techniques in sense of decoded image quality, progressive rate control and transmission the simplicity of the coding process. In the SPIHT coding algorithm, after the wavelet transmission using 9/7 tap wavelets from Antonini et al. is applied to an image, the main algorithm works by partitioning the wavelet decomposed image into significant partitions based upon the following function.

$$S_n(\Gamma) = \begin{Bmatrix} 0, \text{ otherwise} \\ 1, \text{ if } \max_{(i,j)\in\Gamma}\{|Y(i,j) \geq 2^n|\} \end{Bmatrix} \quad (1)$$

where $S_n(\Gamma)$ the significance of the set is coordinates Γ , and Y(i,j) is the coefficient value at coordinate (i, j). There are two passes of the algorithm, the sorting pass and the refinement pass. The sorting pass is performed on the list of insignificant sets (LIS), list of insignificant pixels (LIP) and the list of significant pixels (LSP) . The LIP and LSP consist of nodes that contain single pixels while the LIS contains nodes that have descendants. The maximum number of bits required to represent the largest coefficients in the spatial orientation tree is obtained and designed as n_{max} and is given by

$$n_{max} = \lfloor \log_2(\max_{(i,j)}\{|Y(i,j|\}) \rfloor \quad (2)$$

During the sorting pass, the coordinates of the pixels which remain in the LIP are tested for significance by using equation (1). Those that are significant will be transferred to the LSP as well as have their sign bit output. Sets in the LIS will also have theirsignificance tested and if found to be significant wil be added to the LSP, or else they will be added to the LIP. During the refinement pass, the nth most significant bit of the coefficients in the LSP is output. The value of n is decreased by 1 and the sorting and refinement passes occur again. This continues until either the desired rate is reached or until n = 0 and all nodes in the LSP have all their bits output. In this work, modification of the output bit-stream of the SPIHT coder is done. One bit in the coded image is then corrupted, starting from the first bit to the last bit. Each time a bit is corrupted, and coded image is decoded and the resultant MES is obtained. The corrupted bit is corrected before proceeding on to the next bit. On analysis, there are four major types of bit sensitivities within the SPIHT coded bits. Their description is summarized as follows:

- The significance bit in the bit stream. It decides whether nodes in the LIP are significant.
- The sign bit of a significant node that is transmitted after the significance bit.
- The set bit that decided the set is significant or not.
- The refinement bits that are transmitted during the refinement passes.

In Figure 1, the order of significance from the most significant types of bits to the least significant for gray (512×512) LENA image (at 0.129 bpp) is as follows: the significance bits > sign bits > set bits > refinement bits.

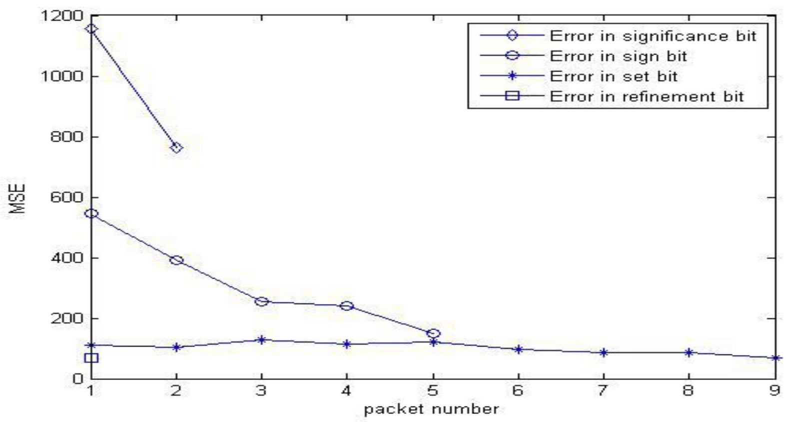

Fig. 1: Error bit sensitivities within the SPIHT bit stream.

3. The Modified OFDM System With The Proposed FTS

The block diagram of the proposed modified OFDM System is illustrated in Figure 2. The SPIHT coder is chosen as the source coding technique due to its flexibility of code rate and simplicity of designingoptimal system. The modified SPIHT divides the image bit stream into several groups according to its sensitivities. Afterwards the information bits are unequally encoded with the LDPC encoder.

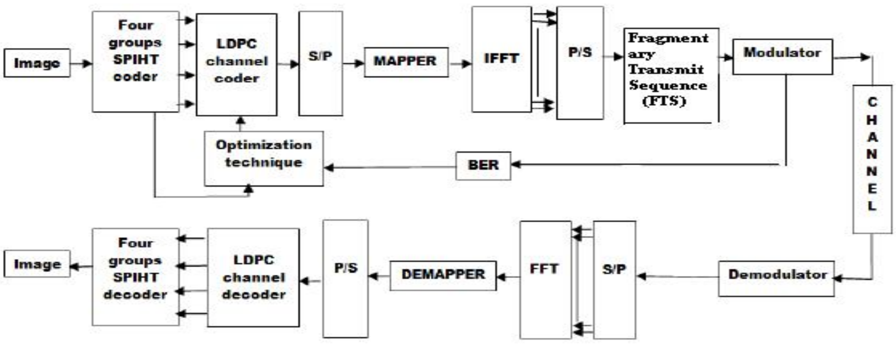

Fig. 2: The modified OFDM system diagram

The OFDM considered in this work utilizes N frequency tones (number of subcarriers) hence the baseband data is first converted into parallel data of N sub-channels so that each bit of a codeword is on different subcarrier. Then, the transmitted data of each parallel sub-channel is modulated by QBSK or QAM16. Finally, the modulated data are fed into an IFFT circuit, such that the OFDM signal is generated. At the receiver, the OFDM sub-channel demodulation is implemented by using a FFT then the Parallel-to-Serial (P/S) conversion is implemented. This received OFDM symbols are de-modulated at the de-mapper. The demodulated bits are decoded with the LDPC decoder and data bits are restored. These data are converted into image format, such that SPIHT decoder can be obtained. As shown in figure 2 the modified OFDM system includes Fragmentary Transmit sequence, in this scheme the input symbols are partitioned into several disjoint subblocks. Inverse fast Fourier transform (IFFT) is applied to each disjoint subblock, and each corresponding time-domain signal is multiplied by a rotation phase. The objective of the FTS scheme is to select the rotation phases such that the PAPR of the combined time-domain signal is minimized.Hence the modified FTS scheme is proposed to lower the computational complexity which maintains the similar PAPR reduction performance compared with the conventional FTS scheme. In this paper, modified PTS is combined with forward error-correcting codes (FECs) such as Low-Density Parity Check (LDPC) codes and SPIHT used for the PAPR reduction of the transmitted signal in multiple transmit antenna systems. In the previous work, an adaptive clipping is used for the amplitude of the input signal, where each of signals related to the different four groups of the modified SPIHT coder is clipped with a different clipping level according to the group sensitivity.PAPR reduction is jointly optimized in both the real and imaginary parts separately multiplied with phase factors when dividing the different subcarriers into 4 subgroups . In this work, the new approach to tackle the PAPR problem to reduce the complexity based on FTS which can be utilized for finding the optimum phase.

4. Simulation Results

4.1 BER performance for the modified OFDM system

The proposed scheme is experimentally evaluated for the transmission of the (512 × 512) 8-bit monochrome test image "LENA" over the modified OFDM system.

Scalable bit stream was generated using the modified SPIHT source coder. Then we use LDPC for encoding the output of the SPIHT coder with EEP and UEP schemes, the equal protection code rate REEP = 3/4 and total transmission rate RT = 0.172 bpp. The simulation parameters of OFDM system is N = 256 subcarriers and CP=0.25. Table 1 shows the simulation results. These results have been obtained with transmitting the image over an AWGN channel in two cases: in the first case SNR = 5dB and the mapping format is QBSK, in the second case SNR = 12dB and QAM16 mapping is used. As shown from the simulation results: our proposed modified OFDM system outperforms the original OFDM system.

TABLE I: THE DECODED "LENA" FOR EEP AND UEP AT RT =0.172BPP.

Scheme / Measure	Original OFDM	Modified OFDM (EEP)	Modified OFDM (UEP)
Mapping=QPSK SNR=5dB Code Rate=3/4			
MSE	4.1937e+003	3.3561e+003	175.1295
PSNR (dB)	11.5670	12.9628	25.7271
Mapping=QAM16 SNR=12dB Code Rate=3/4			
MSE	3.6295e+003	2.9059e+003	153.1731
PSNR (dB)	12.7586	13.9452	26.5336

Fig. 3: The decoded "LENA" from left to right, (a) original, (b) Original OFDM [PSNR= 24.5140 dB], (c) Modified OFDM (UEP) [PSNR= 30.4160 dB]

The superior performance of the modified OFDM system is due to employing the JSCC, which based on the modified SPIHT and LDPC. The modified OFDM system achieves an improvement in the PSNR of the reconstructed image over the original system, i.e. approximately 6 dB improvement over AWGN with SNR = 15 dB, QAM16 mapping and RT = 0.172 bpp.

4.2 Performance of the adaptive clipping technique

Simulations are used to clarify the peak power reduction capability and the BER performance with the proposed technique. The modified OFDM system with the proposed FTS technique was experimentally evaluated for the transmission of the 8-bit monochrome test image "LENA" over AWGN channel. The simulation results and the values for the maximum PAPR (PAPR_max) and the average PAPR (PAPR_av) are shown in Table 2, where the simulation parameters are: code rate=3/4, RT=0.172 bpp, N = 256 subcarriers, CP=0.25, QPSK and QAM16.

TABLE II.: PERFORMANCE OF THE FTS FOR PAPR REDUCTION OVER AWGN CHANNEL AT RT = 0.172BPP

Measure / Scheme	PAPR_max	PAPR_av	PSNR (dB)
Mapping=QPSK SNR=9dB Code Rate=3/4			
Original OFDM	9.7902	7.8173	21.2803
Modified OFDM	11.2442	7.7623	29.5970
Proposed FTS Technique	7.000	2.990	30.4160
Mapping=QAM16 SNR=15dB Code Rate=3/4			
Original OFDM	10.8262	7.8394	23.0684
Modified OFDM	10.4304	7.7852	30.4160
Proposed FTS Technique	7.389	3.6170	29.9306

Figure 4 shows Complementary Cumulative Distribution Function (CCDF) comparison of PAPR for the modified OFDM system with FTS (W=2, W=4) and adaptive clipping over AWGN with SNR =9dB and with QBSK mapping. Form the CCDF curves we note that the modified OFDM system with the adaptive clipping outperforms the OFDM system without adaptive clipping. Also figure 5 shows the reconstructed “LENA” image over the OFDM system with and without adaptive clipping with the previous simulation parameters at RT= 0.172 bpp.

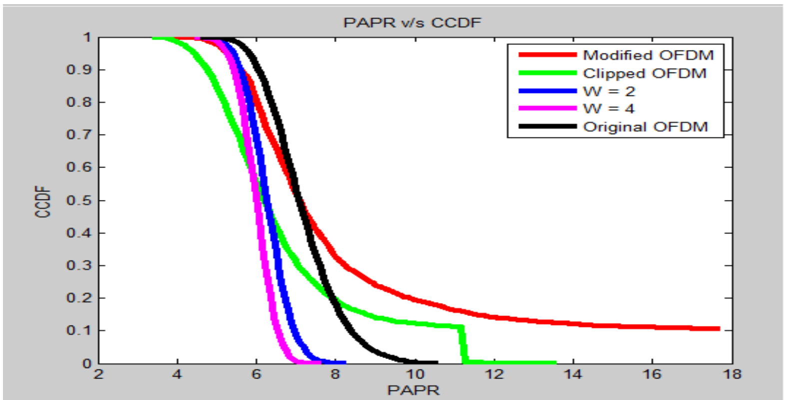

Fig. 4: CCDF comparison of PAPR for the modified OFDM system with FTS (W=2, W=4) and Adaptive Clipping.

Figure 5 shows the reconstructed “LENA” image for the modified OFDM system with FTS. The simulation carried over the AWGN channel using QAM16 mapping and with SNR = 15dB and RT = 0.172 bpp.

Fig. 5: The decoded “LENA” from left to right (a) original (b) modified OFDM [PSNR= 30.4160 dB] (c) Modified OFDM with adaptive clipping [PSNR= 29.9306 dB] over AWGN channel at SNR=15 dB with QAM16

As shown from the simulation results: The proposed FTS technique for PAPR reduction achieves good results and reduce the PAPR of the OFDM system with no noticeable effect on the PSNR of the reconstructed image. For example the proposed technique reduce the PAPR by approximately 3 dB over AWGN channel at SNR=9 dB using QBSK mapping and approximately by 2.5 dB over AWGN channel at SNR=12 dB using QAM16 mapping.

5. Conclusion

In this paper, a modified OFDM system was proposed. A JSCC was employed at the modified OFDM system, this JSCC consists of a modified SPIHT as source coder and an LDPC as channel coder. An UEP process was done for data protection based on the data sensitivity. Also an FTS technique for PAPR reduction was proposed in the modified OFDM system. The performance of the modified OFDM was evaluated with transmitting the modified SPIHT image streams over an AWGN channel. The simulation results indicate that the modified OFDM system scheme provides significantly better PSNR performance in comparison to the original OFDM system. Moreover, the simulation results for the FTS technique showed that the proposed technique achieved good results and reduced the PAPR value of the modified OFDM system without noticeable degradation in the PSNR the reconstructed image. Furthermore, the simulation results show that the FTS technique outperforms the adaptive clipping method for PAPR reduction.

References

[1] A. Said and W. A. Pearlman, "*A New Fast and Efficient Image Codec Based on Set Partitioning in Hierarchical Trees,*" IEEE Trans. Circuit Syst. Video Technol., vol. 6, pp. 243-250, June 1996.

[2] Junqing Liu, Dangui Xie, Shuifa Sun, "Progressive image transmission based on joint source channel distortion model ", *International Conference on Computer Application and System Modeling (ICCASM 2010)*

[3] S. Lin, and D. J. Costello, *Error Control Coding: Fundamental and Application*, Published by: Pearson Prentice Hall, 1983.

[4] R. G. Gallager, "*Low-Density Parity-Check Codes,*" MIT Press, Cambridge, 1963.

[5] Y.Wu and W. Y. Zou, "Orthogonal frequency division multiplexing: A multi-carrier modulation scheme," *IEEE Trans. Consumer Electronics,*vol. 41, no. 3, pp. 392–399, Aug. 1995.

[6] W. Y. Zou and Y. Wu, "*COFDM: An overview,*" IEEE Trans. Broadcasting, vol. 41, no. 1, pp. 1–8, Mar. 1995.

[7] T. Jiang, W. Xiang, H. H. Chen, and Q. Ni, "*Multicast broadcasting services support in OFDMA-based WiMAX systems,*" IEEE Communications Magazine, vol. 45, no. 8, pp. 78–86, Aug. 2007.

[8] T. Jiang and Y. Wu, "An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals", IEEE Transactions on Broadcasting, Vol. 54, No. 2, pp. 257-268, June 2008.
[9] F.S. AI-Kamali, M. I. Dessouky, B.M. Sallam, F. Shawki and F. E. Abd EI-Samie, "Transceiver Scheme For Single-Carrier Frequency Division Multiple Access Implementing the Wavelet Transform and PeakTo-Average-Power Ratio Reduction Methods" lET Communications, Vol. 4, No. 1, pp. 69-79, 2010.
[10] J. Kim and Y. Shin, "An Effective Clipped Companding Scheme for PAPR Reduction of OFDM Signals",Proceedings of the IEEE ICC'08, pp.668-672, 2008.
[11] T. Jiang, W. Yao, P. Guo, Y. Song and D. Qu, "Two Novel Nonlinear Companding Schemes With Iterative Receiver Reduce PAPR in Multi-Carrier Modulation Systems", IEEE Transactions on Broadcasting, Vol. 51, No. 2, pp. 268 - 273, June 2006.
[12] Usama S. Mohammed , Osama A. Omer, Ahmed S. A. Mubarak “Progressive image transmission over OFDM System using Adaptive Clipping”,IEEE Transaction on Broadcasting, 2013
[13] *Yi Sun, Ran-ming Li, Xiao-lei Cao*" Image Compression Method of Terrain Based on Antonini Wavelet Transform" IEEE Trans. Signal Processing, vol. 41,pp. 3445-3462,2005
[14] F. S. AI-Kamali, M. I. Dessouky, B. M. Sallam, F. Shawki and F. E. Abd EI-Samie, "Performance Enhancement of SC-FDMA Systems Using a Companding Technique", Ann. Telecommun. , Vol. 65, No. 5-6, pp. 293-300, 2010.