ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 7, July 2015

Progressive Image Transmission Using OFDM System

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Abstract: This paper describes a new method for progressive image transmission using Orthogonal Frequency Division Multiplexing (OFDM). Low Density Parity Check Coding (LDPC) is used to improve the BER of the system. Trigonometric transforms are used for reducing the Peak-to-Average Power Ratio (PAPR) of OFDM signal. The Set Partitioning In Hierarchical Trees (SPIHT) algorithm is used for source coding of the images. In this method, the transmit data sequence of the OFDM signal is grouped into in-phase and in-quadrature components after Inverse Fast Fourier Transform (IFFT), then each component is transformed using Discrete Cosine Transform (DCT) or Discrete Sine Transform (DST).

Keywords: OFDM, PAPR, SPIHT, LDPC.

I. INTRODUCTION

OFDM modulation system is used in various wireless multimedia transmission standards, such as Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB. It gives high degree of immunity to multipath fading and impulsive noise. Another advantage of OFDM is high spectral efficiency and efficient modulation and demodulation by IFFT/FFT. OFDM divides frequency-selective channel into various parallel non frequency selective narrow-band channels and modulates signal into different frequencies. It can also improve the channel transmission performance. It has broad application area in wireless image and video communication systems.

OFDM system still has some challenging issues which remain unresolved in the design of OFDM systems. One of the major problems is high Peak-To-Average Power Ratio (PAPR) of transmitted OFDM signals.

This paper concentrates on two targets, one is to reduce the PAPR of the OFDM signal and another one is to improve the quality of the reconstructed images. It uses the trigonometric transforms for reducing the PAPR. The data of OFDM signal is modulated by IFFT. Then DCT/DST is used to reduce the PAPR. OFDM system which is modified by DCT/DST will maintain the system orthogonal properties. So it will not result in additional noise and need not transmit side information.

II. LITERATURE SURVEY

There are several developed techniques to reduce the PAPR in OFDM systems [7, 12] such as Clipping [7], Companding [4, 6, 15] , Partial Transmit Sequence (PTS) [3,5,12], Selected Mapping (SLM) [7,12] and Coding [10]. The clipping technique is the simplest one that can be used in OFDM systems, but it causes additional clipping noise, which degrades the system performance. An alternative technique to mitigate the PAPR problem is based on signal transformations. This technique involves a signal transformation prior to amplification, then an inverse transformation at the receiver prior to demodulation.

Trigonometric transforms were suggested as alternatives for the FFT to reduce the PAPR. The authors concluded that OFDM systems with trigonometric transforms provide higher PAPR reduction than the standard FFT based system. However, they modified the OFDM symbols before transmission using the PTS. Their results reveal that without PTS, the distribution of PAPR is the same for that conventional one such that the reduction depends on PTS, which makes redundancy in the system.

The SPIHT is used for image transmission over the OFDM system in several research works [11] because the SPIHT has a good rate-distortion performance for still images with comparatively low complexity and it is scalable or completely embeddable.

Yan Sun [16] proposed A Joint Channel Estimation and Unequal Error Protection Scheme for Image Transmission in Wireless OFDM Systems. This orthogonal frequency division multiplexing (OFDM) modulation, adopted by the digital video broadcasting (DVB-T) standard, has been recognized for its good performance for high data rate wireless communications. Therefore, the study of the robust transmission of multimedia data over OFDM systems has attracted extensive research interests. In the past, channel estimation, which is an important aspect in OFDM systems, has not been exploited for multimedia transmission. When using the block training based channel estimation, OFDM data blocks experience unequal decoding error rate due to the imprecision of channel estimation. We use this property to provide unequal error protection (UEP) for transmission of SPIHT coded images. Compared with the systems using pilot training channel estimation schemes, which are recommended in the DVB-T standard, the proposed scheme improves the PSNR of reconstructed images by up to 2 dB.

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Gusmao, Rui [17] proposed an On Frequency Domain Equalization and Diversity Combining for Broadband Wireless Communications. This is concerned with the use of frequency-domain equalization (FDE) and space diversity within block transmission schemes for broadband wireless communications. The expected performance with both multicarrier (MC) and single-carrier (SC) modulations is emphasized, when a cyclic prefix, long enough to cope with the maximum relative channel delay, is appended to each transmitted block. A set of numerical results is presented and discussed, with the help of appropriate, analytical performance bounds which are conditional on a given channel realization. These bounds are used to explain the performance advantage of the SC/FDE option, the benefits of space diversity, and the impact of the criterion for computing the FDE parameters.

Chih-Yuan Yang [18] proposed a LDPC Coded OFDM Modulation for High Spectral Efficiency Transmission This paper investigates efficient low-density parity-check (LDPC) coded orthogonal frequency division multiplexing (OFDM) modulation schemes for fixed wireless application. We use partially LDPC coded with double gray code labeling technique and Reed-Solomon code with LDPC Coded Modulation (RS-LCM) to achieve better performance than the conventional LDPC bit-interleaved coded modulation (BICM) scheme. RS-LCM scheme outperforms BICM scheme by 0.4 dB at a BER of 10^{-5}.

Sashuang Wang [19] proposed a Progressive Image Transmission over Wavelet Packet Based OFDM. A new scheme for progressive image transmission over wavelet packet based orthogonal frequency division multiplexing (WP-OFDM) system is proposed. First, the BER performances of WP-OFDM systems with different Daubechies wavelet as orthogonal basis functions in multipath fading channel are investigated. The results show that there are error floors in the BER curves, so an equalization method is applied to eliminate the error floor. Then in the WP-OFDM system with the equalization method, a joint source channel coding (JSCC) method is introduced to give image encoder output bit streams with different perception importance unequal error protection. Simulation results confirm the effectiveness of our proposed image transmission scheme.

Rushdi [20] proposed a PAPR reduction in Trigonometric Based OFDM System. A key building block in any OFDM transceiver is the Fast Fourier Transform (FFT) and its inverse. A number of researchers have recently proposed the use of the discrete cosine transform (DCT) and the discrete sine transform (DST), and their inverses as alternative modulating/demodulating bases to improve the BER performance of OFDM schemes while maintaining a low implementation cost. In this paper, we consider the open problem of reducing the peak-to-average power ratio (PAPR) in OFDM systems that deploy these trigonometric transforms. In specific, we show that similar to the FFT case, the complex envelope of a band limited DCT/DST-OFDM signal has a chi-square distribution with one degree of freedom and hence converges weakly to a Gaussian random process as the number of sub-carriers becomes large. Using this result, we then derive closed form expressions for the complementary cumulative distribution functions (CCDF) of each system and show that OFDM systems with trigonometric transforms provide higher PAPR reduction than the standard FFT-based system. Simulation results that compare the CCDFs of the different transforms using the partial transmit sequences (PTS) technique confirm our theoretical findings.

Tao Jiang [7] proposed An Overview of Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals. One of the challenging issues for Orthogonal Frequency Division Multiplexing (OFDM) system is its high Peak-to-Average Power Ratio (PAPR). In review and analysis different OFDM PAPR reduction techniques, based on computational complexity, bandwidth expansion, spectral spillage and performance and also some methods of PAPR reduction for multiuser OFDM broadband communication systems.

III. SPIHT ALGORITHM

The SPIHT algorithm is based on wavelet transform, and restricts the necessity of random access to the whole image to small sub images. The principle of the SPIHT is partial ordering by magnitude with a set partitioning sorting algorithm, ordered bit plane transmission, and exploitation of self similarity across different scales of an image wavelet transform. The success of this algorithm in compression efficiency and simplicity makes it well known as a benchmark for embedded wavelet image coding. The SPIHT is used for image transmission over the OFDM system in several research works because the SPIHT has a good rate-distortion performance for still images with comparatively low complexity and it is scalable or completely embeddable.

The SPIHT algorithm defines and partitions sets in the wavelet decomposed image using a special data structure called a spatial orientation tree. A spatial orientation tree is a group of wavelet coefficients organized into a tree rooted in the lowest frequency (coarsest scale) subband with offspring in several generations along the same spatial orientation in the higher frequency subbands. Fig.l, shows a spatial orientation tree and parentchildren dependency defmed by the SPIHT algorithm across subbands in the wavelet image. The tree is defined in such a way that each node has either no offspring (the leaves) or four offspring at the same spatial location in the next fmer subband level. The pixels in the lowest frequency subband-tree roots are grouped into blocks of 2x2 adjacent pixels, and in each block one of them; marked by star as shown in Fig. 1; has no descendants.
SPIHT describes this collocation with one to four parent-children relationships,

$$\text{parent} = (i,j)$$
$$\text{children} = [(2i,2j),(2i + 1,2j),(2i,2j + 1),(2i + 1,2j + 1)]$$

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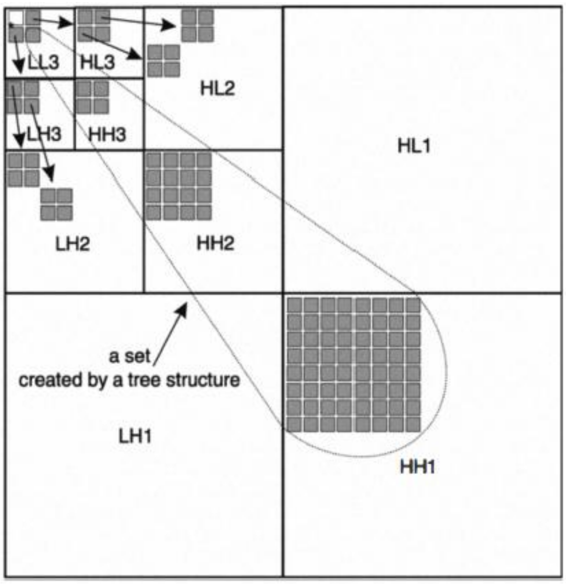

Fig. 1. Parent-children dependency and spatial orientation trees across wavelet subbands in SPIHT

SPIHT algorithm consists of three stages: initialization, sorting and refinement. It sorts the wavelet coefficients into three ordered lists: the list of insignificant sets (LIS), the List of Insignificant Pixels (LIP), and the List of Significant Pixels (LSP). At the initialization stage the SPIHT algorithm first defines a start threshold based on the maximum value in the wavelet pyramid, then sets the LSP as an empty list and puts the coordinates of all coefficients in the coarsest level of the wavelet pyramid (Le. the lowest frequency band; LL band) into the LIP and those which have descendants also into the LIS.

In the sorting pass, the algorithm first sorts the elements of the LIP and then the sets with roots in the LIS. For each pixel in the LIP it performs a significance test against the current threshold and outputs the test result to the output bit stream. All test results are encoded as either 0 or 1, depending on the test outcome, so that the SPIHT algorithm directly produces a binary bitstream. If a coefficient is significant, its sign is coded and its coordinate is moved to the LSP. During the sorting pass of LIS, the SPIHT encoder carries out the significance test for each set in the LIS and outputs the significance information. If a set is significant, it is partitioned into its offspring and leaves. Sorting and partitioning are carried out until all significant coefficients have been found and stored in the LSP.

After the sorting pass for all elements in the LIP and LIS, SPIHT does a refinement pass with the current threshold for all entries in the LSP, except those which have been moved to the LSP during the last sorting pass.
Then the current threshold is divided by two and the sorting and refinement stages are continued until a predefined bit-budget is exhausted.

IV. LDPC CODING

Various error correcting codes have been applied to OFDM system to improve the BER performance of the system. LDPC codes have received much more attention particularly in the field of coding theory. LDPC codes are nothing but a class of linear block codes. It provides reliable transmission for coding with relatively low decoding complexity. LDPC coding has been adopted as the DVB-S2 standard.

The combination of the OFDM modulation technique and LDPC coding will give a efficient method for high speed broadband wireless applications. The BER performance of the Low Density Parity Check Coding- Coded Orthogonal Frequency Division Multiplexing system (LDPC-COFDM) is characterized by the subchannels which have deep fad due to frequency selective fading. According to this combination, several algorithms were introduced into LDPC-COFDM system to improve the BER by adaptive bit loading and power allocation of each subcarrier.

V. SYSTEM DEVELOPMENT

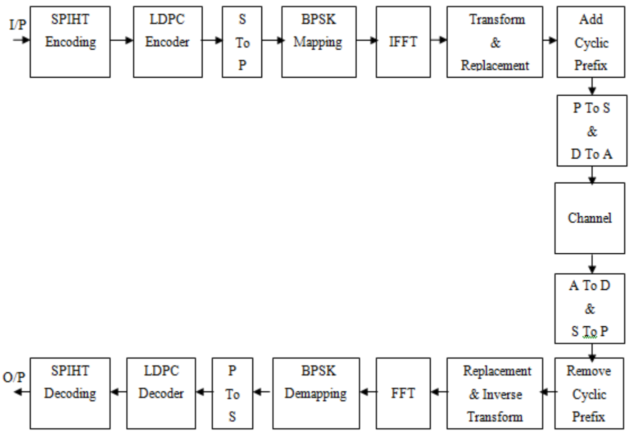

Fig. 2. OFDM system model

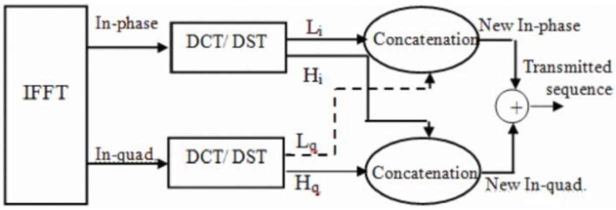

Fig. 3. Trigonometric transform and replacement process

The fig. 2 shows the block diagram of proposed OFDM system. The SPIHT coder is used as the source coding technique because it has flexibility of code rate and it simplifies the designing of optimal system. The SPIHT algorithm divides the image stream into various layers according to the importance of progressive image stream. Then the image stream is converted to a binary format. After converting the image stream into binary format, the LDPC encoder encode the information bits. The OFDM in this method uses N frequency tones. Tone represents

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DOI 10.17148/IJARCCE.2015.4728

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
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number of subcarriers. The baseband data is first converted into parallel data form of N subchannels so that each bit of a codeword is on different subcarrier. The N numbers of subcarriers are chosen to be orthogonal. Then, the transmitted data of each parallel subchannel is modulated by Binary phase Shift Keying (BPSK) modulation. BPSK in combination with OFDM provides high throughput and best performance. In the last step, the modulated data is fed into an IFFT circuit, such that the OFDM signal is generated.

IFFT output is split into two components like in-phase and in-quadrature. Then DCT or DST is applied to each component separately. The first half of samples of the in-phase component after the transform (Li) is concatenated with the fIrst half of samples of the in-quadrature component after the transform (Lq) to form the new in-phase component. Similarly, the second half of samples of the in-phase component after the transform (Hi) is concatenated with the second half of samples of the in-quadrature component after the transform (Hq) to form the new in-quadrature component. Finally, the new components are added to produce the OFDM signal as shown in Fig. 3.

Each data block is padded with a cyclic prefix (CP). The continuous OFDM signal xg(t) is generated at the output of the digital to analog (D/A) converter. The PAPR of transmitted analog signal can be expressed as:

$$PAPR = \frac{Max\,|\,xg(t)\,|^2}{E\,[\,|\,xg(t)\,|^2\,]}$$

where E[.] is the average power.

Generally, the PAPR is considered for a single OFDM symbol having a time duration T. This duration comprises a number of samples equal to (Nf+Ng), where Ng is the guard interval length. The guard interval is removed and the time interval [O,T] is evaluated at the receiver. The replacement and inverse transform are then applied to the received samples. After that the OFDM subchannel demodulation is implemented by using a FFT. Parallel-to-Serial (P/S) conversion is performed & demodulator demodulates these received OFDM symbols. The demodulated bits are decoded with each LDPC encoded block and data bits are restored. These data bits are converted into image format with the help of SPIHT decoder.

VI. PERFORMANCE ANALYSIS

The simulation experiments are carried out to study the transmission of SPIHT coded images on LDPC COFDM modified by Trigonometric transforms over an AWGN channel.

The fidelity of the image was measured by the Peak Signal-to-Noise Ratio,

$$PSNR = 101og10\ (\ peak^2\ /\ MSE\ )$$

Fig. 4. Input image for SPIHT

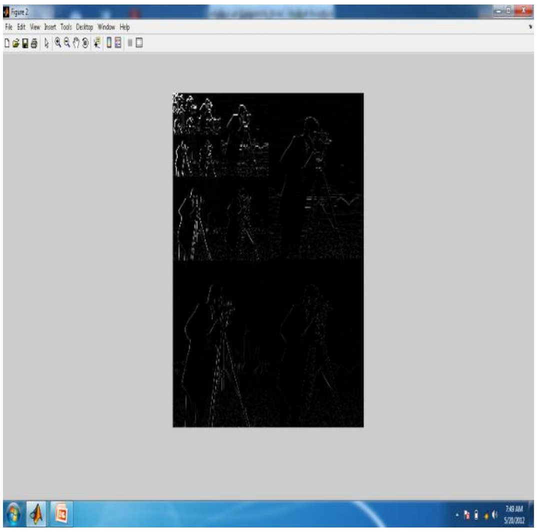

Fig. 5. Output image for SPIHT

Fig. 6. Transmitted image

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
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Fig. 7. Received image at compression rate r = 0.1

Fig. 8. Received image at compression rate r = 0.4

Fig. 9. Received image at compression rate r = 0.8

Fig. 10. Received image at compression rate r = 1

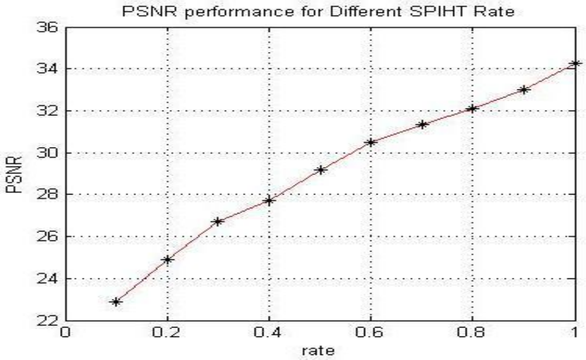

Fig. 11. PSNR vs. rate (r)

VII. CONCLUSION

The efficient LDPC coded OFDM system with trigonometric transforms supporting image transmission using SPIHT compression technique is presented and studied. The effectiveness of the proposed system is investigated through simulations over AWGN channel. It is found that the system must be designed carefully in order to achieve a reduction in the PAPR without degrading the PSNR performance.

ACKNOWLEDGMENT

I would like to thank the anonymous reviewers for their valuable comments and suggestions.

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