Efficient Image Transmission Over OFDM Channel with Energy Conservation and LS Channel Estimation with Various Modulation Schemes

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Abstract. To send data like text, images, music, and videos, packetization procedures are commonly used in communication apps. Just a portion of carriers in OFDM systems may be suitable for transmitting images due to channel fading. To reduce high channel errors at the receiver, the transmitter can proactively map descriptions onto good subcarriers and delete remaining descriptions if it has access to channel status information. In this study, discrete wavelet processing as an energy-saving approach for transmitting compressed image frames via OFDM channels. By utilizing one-bit channel status information at the transmitter, the descriptions are sorted and allocated to high-quality channels in a descending order of importance. To conserve energy, faulty sub-channel descriptions are removed at the transmitter. In this project, image transmission across OFDM channels is packetized to enable efficient data transfer while minimizing energy consumption. We also use the LS Channel estimation method to get a more accurate channel estimate with different modulation schemes and SNR. We obtained energy savings of up to 38% and improved channel estimation with various modulation schemes by utilizing MATLAB simulations to test on a variety of modulation schemes and channel SNR ratios.

keywords: OFDM, SNR, Transmission, DWT, LS Channel estimation

1. Introduction

Wavelet transformations are being utilized more and more in digital communication. Picture pixels are converted into wavelets using the discrete wavelet transform (DWT), which can then be compressed. The most important information is contained in the signal's high amplitude components, whereas its low amplitude portions contain less important information. By cutting out the low amplitude parts, data compression may be accomplished effectively. The JPEG2000 [1] compression standard is a method of picture compression based on wavelets. By making this step better, the total picture compression process may be

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made more effective and efficient. Orthogonal frequency division multiplexing (OFDM) technology helps increase the data rate across wireless networks. It transmits one data stream at a time over several slower subcarriers. Although there is a lot of overlap between the sub-channels, inter-carrier interference is kept to a minimum since the carriers are orthogonal to one another. In this work, four coefficients are generated using DWT and then entered OFDM sub-channels. The picture is sent over LS Channel estimation method to achieve a more accurate channel estimate utilizing different modulation schemes and SNR. Our findings show that by utilizing various modulation techniques, we may conserve energy by up to 38% while preserving a little fading margin in the quality PSNR of the received picture and enhanced channel estimation.

In sections 2.1 and 2.2, we will utilise the system model to demonstrate the operation of the DWT-OFDM system. Section 2.3 will cover least square channel estimation, while Section 2.4 will go through PAPR and BER reduction in OFDM. In section 2.5, we will go through flexible image compression using a lifting-based technique. Section 3 will go into formulation and analysis, followed by Section 4 which will explain the outcomes and analysis. Finally, in Section 5, we shall describe our findings.

2. System Model

2.1 DWT System

This section explains the traditional DWT method [2], which involves using the discrete wavelet transform to convert a discrete temporal signal into a discrete wavelet representation (DWT). Fig.1 shows how the wavelet transform separates an image into four component sections : HH, HL, LH, and LL. Low-frequency coefficients are represented by LL, high-frequency coefficients by LH and HL horizontally and vertically, respectively, while high-frequency coefficients are represented by HH diagonally. The DWT approach divides a picture into coefficients, or smaller sub-bands, before comparing them to a threshold. The coefficients below the threshold are set to zero, while those above it are compressed.

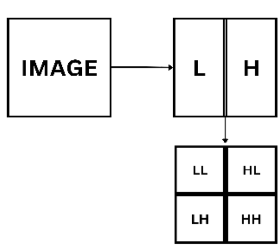

Fig. 1. DWT Process.

2.2 OFDM System Architecture System

Using multiple carriers, each operating at a distinct frequency and orthogonal to the others, OFDM is a method for transmitting digital information [3-4]. This parallel transmission technique minimizes the effects of multipath distortion and does away with the requirement for intricate equalizers. The carriers' frequency separation is selected to ensure that the modulated carriers are orthogonal and do not interfere with one another. In this study, digital information is sent via OFDM. Spectral images are captured using M-PSK, QAM, etc. to generate OFDM data, which is then transformed into the time domain using the inverse discrete Fourier(IDFT) transform. It is frequently utilized because using the Inverse Fast Fourier Transform (IFFT) is more economical. To make the most of the available frequency bandwidth, all carriers transmit simultaneously after the OFDM data has been transformed into the time domain. In the suggested system, we use BPSK and QPSK modulation on 15db SNR, as well as MSE, PSNR, and energy savings calculations.

The OFDM system uses the DWT data coefficient generated by DWT system[5]. A broad overview of the OFDM system, as shown in Fig.2 , will be provided in the sections that follow.

- First, a complex number is created by assembling the incoming serial data into x bits and switching it from serial to parallel. The upper portion of the system uses a signal mapper, such as 16 QAM, to digitally modulate these x bits.
- Following that, IFFT is used to modulate the complex numbers in baseband form. While the HPF filters conduct convolution with zero padding signals, the modulated signals are up sampled and filtered with LPF coefficients to get low frequency signals.
- A guard interval is added in the center of symbols to prevent ISI brought on by multipath distortion. DAC and Up convertor are used to transport the data through the channel.
- Based on channel information, the receiver employs a one tap equalizer to correct channel distortion. The channel information is used to compute the filter coefficients for the mesh.

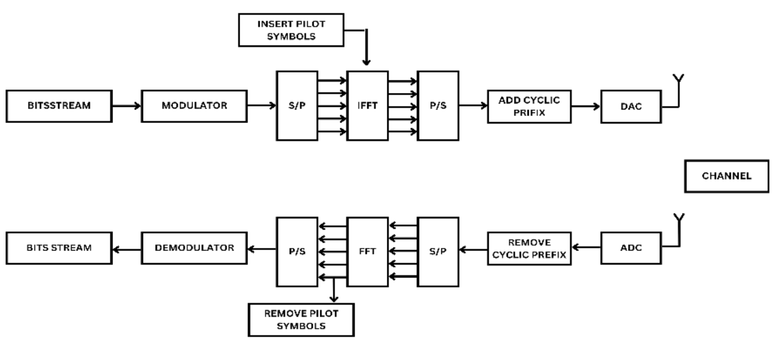

Fig. 2. OFDM System architecture

2.3 LS(Least Squares) Channel Estimation

Wireless communication systems evaluate the channel response using the LS (Least Squares) channel estimation technique [6]. The LS estimator seeks to minimise the mean square error between the actual received signal and the projected signal based on a known sent signal. This technique is simple and straightforward, and digital signal processors may easily implement it.

LS (Least Squares) channel estimation [7] using transmit and received constellations is a technique used in image transmission to estimate the channel response between both the transmitter and the receiver. This approach includes sending a known symbol constellation, such as BPSK, QPSK, 8PSK, 16QAM, 32QAM, 32QAM, and 64QAM, and then calculating the received constellation at the receiver. The difference between both the transmitted and received constellations is used to calculate the channel response, which is subsequently utilized to equalize and restore the transmitted image.

The use of transmit and received constellations in LS channel estimation has the benefit of providing a more accurate estimate of the channel response, particularly in channels impacted by fading and noise. By comparing the sent and received constellations, one can discriminate between the effects of fading and noise and more correctly estimate the channel responsiveness. The use of transmitted and received constellations in LS channel estimation has the benefit of providing a more accurate estimate of the channel response, particularly in channels impacted by fading and noise. By comparing the sent and received constellations, one can discriminate between the effects of fading and noise and more correctly estimate the channel responsiveness.

2.4 PAPR and BER Reduction in OFDM

To lower the Bit Error Rate (BER) and Peak-to-Average Power Ratio (PAPR) in the OFDM system[8], many wavelet types can be utilized, including Symlet, Coiflet, Daubechies, etc. Since guard intervals and pilot tones are not necessary with wavelet based OFDM, it has a higher spectral efficiency than regular OFDM. A decrease in BER and PAPR can be attained by dispersing the output mobility at the transmitter and employing full wavelet based OFDM. There must be a 3 dB improvement in all wavelet based OFDM systems. The wavelet has a higher order and many more coefficients than other mathematical structures.

2.5 Flexible Compression of The Image Using a Lifting-Based Technique

A lifting-based method enables adjustable picture compression [9]. With this method, the compression ratio may be changed without affecting the quality of the images. High compression ratios are attained using the lifting-based technique, a kind of wavelet transform, by using straightforward, effective computations. Additionally, this method is flexible and may be used to a variety of picture formats, including grayscale and color images. Given the circumstances, utilizing a lifting-based approach for picture compression gives users flexibility in getting the best compression ratios without sacrificing image quality.

3. Parameters, Formulation and Analysis

3.1 Wavelets Formation

A signal is broken down into a collection of basic capabilities by wavelet rework . Wavelets are the name for these structural components. These wavelets are given as input to OFDM.

3.2 OFDM Parameters

The input picture, IFFT size, the quantity of carriers, the digital modulation technique, signal peak energy in clipping in dB, & ratio in dB are only some of the factors for OFDM. Any 8-bit grayscale bitmap data should be used as the input image. The IFFT size must have the lowest value of 8 and be an integer with a power of two. There should not be more carriers

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than ((IFFT size)/2-2). There are several choices for digital modulation techniques, such BPSK and QPSK. Both the signal-to-noise ratio and the signal peak energy in clipping are measured in dB.

3.3 Energy Saving

In the suggested technique, if the associated sub channel is fading, the less significant data vectors are elimінated at the transmitter to conserve power. Energy-saving expressions are as follows:

$$\%\ energy\ saved = \sum_{i=0}^{4} \frac{\mathrm{iPi}}{4} \quad (1)$$

4. Results and Analysis

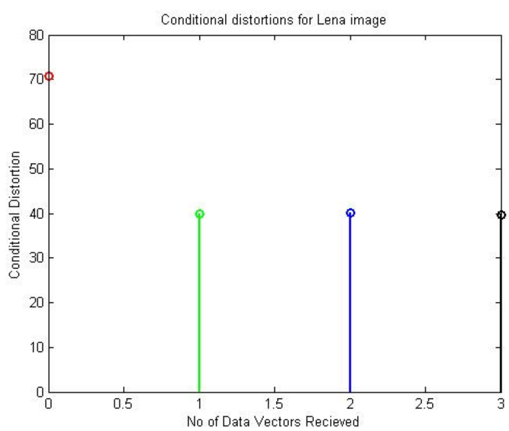

Fig. 3. Conditional Distortion for Lena Image

Fig. 4. Input Image

In Fig (3), the loss occurrences are displayed against the conditional distortion. We can see the distortion in relation to the data rate.

Fig. 5. Image obtained after DWT Process.

Fig. 6. Final Received image at SNR 15db**.**

Fig.6 shows the image with SNR 15db. It should be noted that SNR=15 dB equates to poor image quality. The image quality also will improve as the SNR levels rise. If PSNR is 40 dB, then image quality will increase.

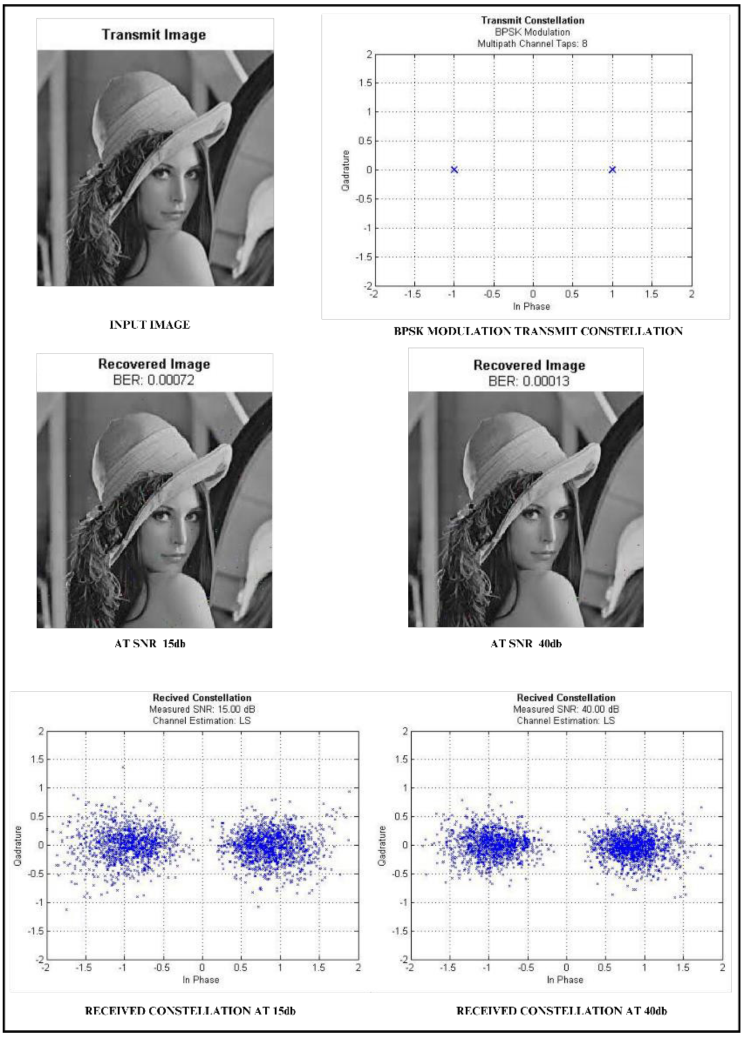

Fig. 7. BPSK Modulation for channel estimation

Fig.7 demonstrates that for an image communicated over an awgn channel using LS channel modulation and the transmit constellation symbol BPSK, the recovered picture at SNR 15db with a high bit rate error has lower quality than the recovered image at SNR 40db with a lower bit rate error.

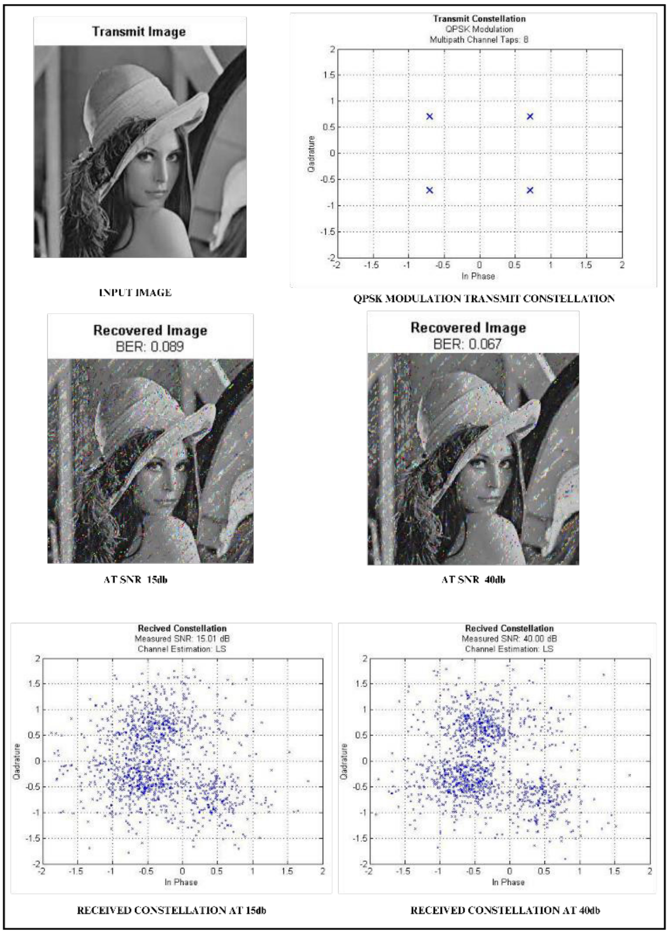

Fig. 8. QPSK Modulation for channel estimation

Fig.8 demonstrates that for an image communicated over an awgn channel using LS channel modulation and the transmit constellation symbol QPSK, the recovered picture at SNR 15db with a high bit rate error has lower quality than the recovered image at SNR 40db with a lower bit rate error.

5. Conclusion

To summarize our project, we investigated at the usage of DWT sub-band analyses packetization for sending images across OFDM channels when the transmitter has access to binary channel state information, but no retransmission is allowed. Our proposal involved arranging compressed coefficients in descending order of importance and mapping them onto good channels first to save energy. We discarded less important coefficients likely to be mapped onto bad channels to reduce power consumption without significant reception quality loss. Our project achieved a 38% energy savings when transmitting an image at an SNR ratio of 15db. We found that channel estimation using the least square method worked optimally with BPSK and QPSK modulation techniques, but not with higher modulation techniques like 16-QAM and 64-QAM on MATLAB Simulation results.

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