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Enhancing Image Quality in Wireless Transmission through Compression and De-noising Filters

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ABSTRACT

Image compression is now essential for applications such as transmission and storage in data bases. Image processing for wireless transmission is a challenging task, because of the amount of image data that need to be processed in real time, the restriction of transmission bandwidth, and other limited resources of the wireless network. In this paper we compression techniques and wireless transmission, some type of noise is also induced in compressed image. So we need improving image quality measured by such parameter. These are done by using de-noising filter such as Wiener filter and Median filter at receiving end. The accuracy of compression methods is measured by CR and PSNR, with QPSK and 8-PSK modulation on AWGN Channel. Performance of these systems is measured by BER plot with respect to SNR. The experimental result shows that the proposed scheme maintains the accuracy of compression, transmission and decompression of image.

KEYWORDS: *Median filter, Image compression, PSK, AWGN. Haar-wavelet, Wiener filter*

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I. INTRODUCTION

In the field of digital communication and image processing, the constant evolution of approaches for efficient data transfer while maintaining quality is critical. The combination of picture compression techniques and advanced modulation algorithms brings up new possibilities for improving bandwidth utilization and transmission efficiency, especially in noisy conditions. This study investigates the combination of Harr Wavelet Transformer-based image compression with a Quadrature Phase Shift Keying (QPSK) modulation scheme, all over an Additive White Gaussian Noise (AWGN) channel. By investigating this combination, the researchers hope to shed light on the advantages and disadvantages of using wavelet-based compression before modulation and transmission over a noisy channel, as well as provide insights into its practical uses and theoretical consequences.

Discrete Wavelet Transform (DWT) is broadly considered as an efficient approach to replace FFT in the conventional OFDM systems due to its better time-frequency localization, bit error rate improvement, interference minimization, improvement in bandwidth efficiency and many more advantages. Moreover, Convolution codes are used in DWT based OFDM system which improves the bit error rate performance of the system. In communication systems, when the signal is transmitted over the channel, noise and unwanted interferences are introduced which leads to the distortion of transmitted signal. Hence, error control coding techniques are used to mitigate the effect of such channel distortions. Sine wave extend from minus to plus infinity in place of limited duration. And where sine waves are smooth and predictable, wavelets transform to be irregular and symmetric. The figure 1 shows the Image bands LL, LH, HL and HH of the first scale.

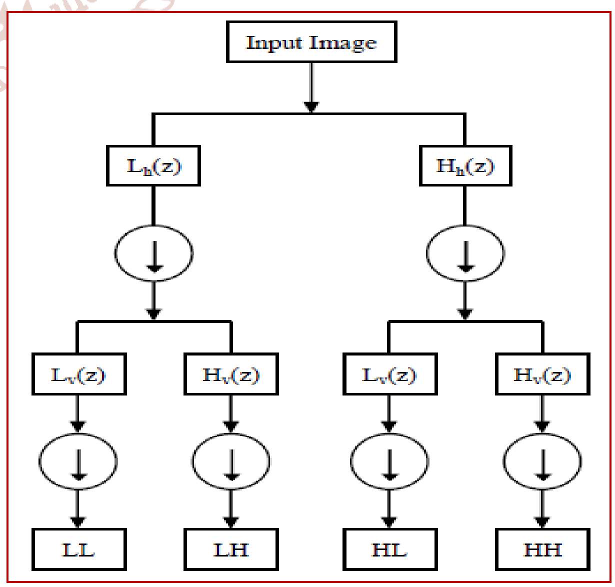

Fig. 1: Image bands LL, LH, HL and HH of the first scale

II. LITERATURE REVIEW

[1] Hemalatha Sa. et al. “Wavelet transform based steganography technique to hide audio signals in image” Published by Elsevier, Procedia Computer Science 47, 2015.

In this paper work, the results show good quality stego signal and the stego signal is analyzed for different attacks. It is found that the technique is robust and it can withstand the attacks. The quality of the stage image is measured by Peak Signal to Noise Ratio (PSNR), Structural Similarity Index Metric (SSIM), Universal Image Quality Index (UIQI). The quality of extracted secret audio signal is measured by Signal to Noise Ratio (SNR), Squared Pearson Correlation Coefficient (SPCC). The results show good values for these metrics. In this paper a secure, robust and high capacity image steganography technique is proposed. It gives good values for all the metrics and hence this is an efficient way to send audio files without revealing its existence. The performance against some of the attacks is also good. The technique needs to be tested against other attacks like histogram equalization, cropping, occlusion, translation etc. the experimental results show that the secret audio can be extracted without much distortion in most of the cases [6].

[2] Rajesh M. et al. "Transmission of DWT Image over OFDM Fading Channel with Channel State Feedback" IJCEM International Journal of Computational Engineering & Management, Vol. 16 Issue 6, November 2013. This paper describes the saving of energy approach for transmission of first level discrete wavelet transformed (DWT) based compressed image over fading channel. With the availability of channel state information at the transmitter and the description based on the descending order priority. This will reduce the consumption of power in the system, by dropping the data onto the bad subcarriers with mapped description at the transmitter. The parameter that were analyzed for system power consumption without effecting the data are in terms of peak signal-noise ratio(PSNR), distortion, Bit error rate(BER) are simulated using MATLAB. It gives 60% of energy saving. The coefficients with the lower important power level will be discarded at the transmitter with this power can be saved. All the analytical parameter and observations of the performance is done using MATLAB simulation software. As the work ahead, it can be extended to CSI adaptive channel rate and a power control which is a trade-off between transmissions [7].

[3] Padmaja M. et al. "Maximum and Minimum Power Adaptation Analysis for Transmission of Different Image formats using Unilevel Haar Wavelet" SIPIJ Vol.3, No.4, August 2012. In this paper addresses power allocation methods for multimedia signals over wireless channels. The main aim of this paper is to reduce total power allocated for image compression and transmission, while the power for each bit is kept at a pre specified value. Maximum and minimum power control algorithms are proposed. Simulations are performed using haar wavelet over AWGN channel. Maximum Power Adaptation Algorithm shows better performance than Conventional Power Adaptation Algorithm. The wavelet transform has the ability to de-correlate an image both in space and frequency there by distributing energy compactly into a few low frequency and a high frequency coefficients. The four bands are transmitted over wireless channel and the coefficients are reconstructed using inverse transform. These paper shows the plots of different parameters such as Mean Square Error, Peak Signal To Noise Ratio (PSNR), Average Difference (AD), Normalized Average Error (NAE), etc for Maximum, minimum and Conventional Equal power Adaptation methods. Both Minimum Adaptation Algorithm and Maximum Power Adaptation Algorithms show better performance in image transmission using unilevel of haar wavelet compared with Conventional Power Adaptation [8].

[4] Ahmed A. et al. "Effects of Fading Channels on OFDM" 2012 In this paper, Effects of fading channels on OFDM are investigated. MATLAB is used to simulate wireless fading channels environments that are either based on Doppler spread or Delay Spread. OFDM technique is studied over wireless communication environment to examine the effects of fading. MATLAB to simulate the process of transmitting image signals over fading channels with various SNRs. OFDM model discussed in the first part of this paper was followed and Fading channels were implemented according to Clarke's model. It assumes that there is no line of sight between transmitter and receiver ends. For flat and frequency selective fading, the speed of the receiver was either slow 3-miles/ hour or fast 100-miles/hour. 3 Miles/hour was assigned as the speed of the receiver for the purpose of simulating Small Doppler Spread and 100 Miles/hour was used to simulate large Doppler Spread [9].

[5] Nilima D. M. et al. "Comparison of image compression using wavelet for curvelet transform & transmission over wireless channel" International Journal of Scientific and Research Publications, Volume 2, Issue 5, May 2012. This paper presents an efficient scheme to transmit JPEG coded images over wireless channels. The compressed image is protected against various channel effects of wireless channel using Reed soloman block code and transmitted over wireless channel. This shows that the Curvelet Transforms are more suitable for the image data to represent the singularities over geometric structures in the image, than the Wavelet counterpart. Curvelet is designed to age data to represent handle the singularities on curves. Wavelets are effective for point singularities. Transmission over wireless channel remains a major issue. Many techniques have been proposed for the transmission of images over wireless networks [10].

[6] Lakshmi G.M. et al. "Image Compression Using Self-Organizing Feature Map And Wavelet Transformation" ICTACT Journal On Image And Video Processing, August 2012, Volume: 03, Issue: 01. In this paper Performance of the proposed work is tested with varying codebook size and various training images. Experimental results show that the reconstructed images obtained by the proposed method are of good quality with better compression ratio and higher Peak Signal–to–Noise Ratio. The method for compressing the gray scale images using Self Organizing Feature Map and Wavelet Transformation is discussed. A novel method for designing vector quantizer for image compression that produces the reconstructed image with better quality is proposed. The method uses the SOFM based neural network techniques for initial codebook generation. In order to reduce the blocking effects in the reconstructed image, Haar wavelet based vector quantization scheme is used. From Table.3 it is evident that the proposed work achieves higher PSNR value of 35.72 and CR of 10% when compared to other proposed yields a better quality reconstructed image [11].

III. PROPOSED WORK AND CONTRIBUTION

This work analyzes the effectiveness of using the Harr Wavelet Transformer for image compression before transmitting the compressed image via Quadrature Phase Shift Keying (QPSK) modulation over an Additive White Gaussian Noise (AWGN) channel. The primary goal of the research is to assess the integrated system's performance in terms of image quality after reception and bandwidth efficiency. The research approach consists of a series of tests in which images are compressed using the Harr Wavelet Transformer, modulated with QPSK, sent via an AWGN channel, and then reconstructed at the receiver end. Performance parameters such as Signal-to-Noise Ratio (SNR), Bit Error Rate (BER), and image quality indices are carefully examined. The findings reveal that the suggested method improves transmission efficiency while retaining acceptable image quality, demonstrating the potential of wavelet-based compression combined with QPSK modulation for successful digital image transmission in noisy situations. Block diagram of proposed methodology as shown in the Figure 2. The simulation model shows the procedure of whole process. This model can be divided into three sections:

A. Compression of image by Haar and Db2 Wavelet transform separated, De-noising, that Compressed image by Wiener and Median filter separately.
B. Transmission of data on wireless AWGN and Flat fading channel separately on QPSK & 8-PSK modulation separately.
C. On receiving end, after de–modulation, the whole procedure of step (a) is repeated.

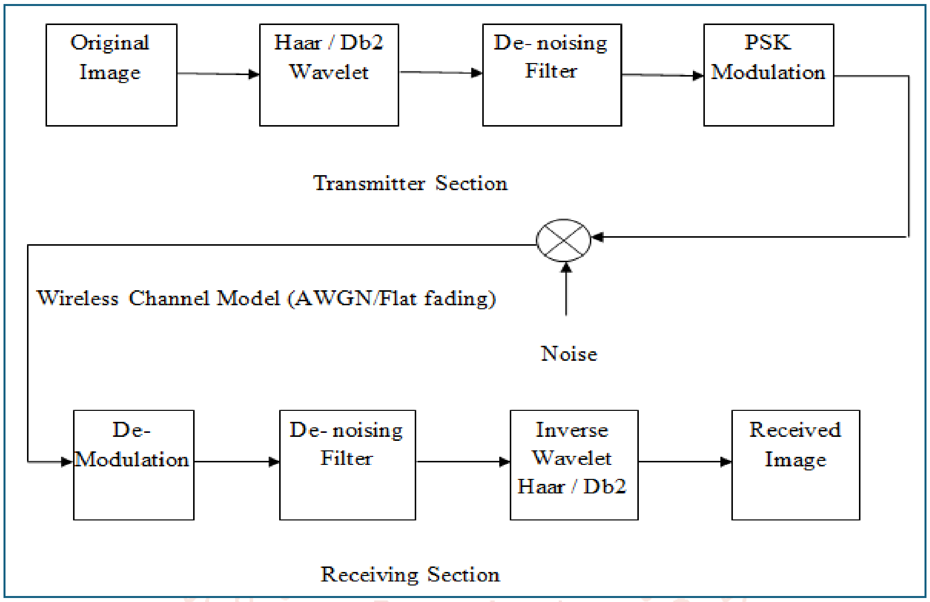

Fig. 2 Block diagram of proposed methodology

IV. WAVELET TRANSFORMATION

Wavelet transformation decomposes a signal or an image into a set of basic functions called wavelets. Unlike the traditional Fourier transform, which only offers frequency information, wavelets provide both frequency and location information, making them exceptionally suited for analyzing non-stationary signals (signals whose frequency components change over time) like images. Wavelets are generated from a single base function called the "mother wavelet" through dilation (scaling) and translation (shifting). This allows the analysis of the signal at various scales and positions, offering a hierarchical, multi-level decomposition. The transformation results in two sets of coefficients:

Approximation coefficients: represent the low-frequency (smooth) parts of the image.

Detail coefficients: capture the high-frequency (edge or detail) components.

A. Haar wavelet

The Haar wavelet, named after Alfréd Haar, is the most basic of all wavelet transforms, known for its simplicity and efficiency in processing. It is defined as a piecewise constant function, making it ideal for learning the fundamentals of wavelet analysis and for applications that require quick, simple computations.

The Haar wavelet transform averages pairs of pixel values for the approximation coefficients and computes the differences for the detail coefficients. This procedure is applied iteratively to the approximation coefficients to analyze the image at various scales. The original image may be properly rebuilt from its wavelet coefficients, indicating that the Haar transform is reversible, or orthogonal. Haar used these functions to give an example of a countable other normal system for the space of square integral functions on the real line. The study of wavelets, and even the term "wavelet", did not come until much later. As a special case of the Daubechies wavelet, it is also known as D2. The Haar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions, such as monitoring of tool failure in machines.

B. Applications and Advantages

Image Compression: Wavelet transforms, particularly the Haar wavelet, are commonly employed in image compression methods. They enable for the reduction of image file size with little loss of quality by retaining the significant coefficients while rejecting the others.

Feature Extraction: Wavelet transforms are used in computer vision to extract images' features for tasks such as recognition and classification. The multi-resolution analysis capabilities aids in recognizing characteristics at various scales and orientations.

Noise Reduction: Wavelet transformations can effectively extract noise from a signal or image by isolating high-frequency components. This allows you to minimize noise while still maintaining critical image information.

The Haar wavelet, with its simplicity, is a great introduction to the larger realm of wavelet transforms in image processing. Its efficiency and compact image representation make it an invaluable tool in a variety of applications requiring high image quality and processing speed.

V. COMPRESSION RATIO (CR)

The ratio of the size of original data set to the size of the compressed data set, compression ratio is find out, defined in equation 1. Compression ratio is defined as the ratio between the original image size and compressed image size.

$$\text{Comprassion ratio} - \frac{X}{Y} \times 100 (1)$$

Where X = Number of Bytes in the original data set, Y = Number of Bytes in the Compressed data set. It is clearer by this example. Example: An image, 1024 pixel×1024 pixel×24 bit, without compression, would require 3 MB of storage. If after compression storage requirement is reduced to 300 KB, so by using formula we find the compression ratio as 10:1.

VI. BIT-ERROR-RATE (BER)

When number of bits error occurs within one second in transmitted signal then we called Bit Error Rate (BER). In another sentence Bit Error rate is one type of parameter which used to access the system that can transmit digital signal from one end to other end. We can define BER as follows:

$$BER = \frac{\text{Error Nimber}}{\text{Total Number of bit sent}} \qquad (2)$$

If transmitter and receiver's medium are good in a particular time and Signal-to-Noise Ratio is high, then Bit Error rate is very low. In our thesis simulation we generated random signal when noise occurs after that we got the value of Bit error rate.

VII. RESULT ANALYSIS

During our simulation we used Wavelet Transform (Haar and Daubechies) wavelet algorithms and different filters (Winar and Median) also used modulation in QPSK and 8-PSK techniques through MATLAB R2013a simulation toll used as shown in Figure 4, with the help of above modulation techniques we got the analysis parameters like the SNR versus BER, with different communication channel (AWGN and multipath fading channel). In the Figure 3(a) Original image, (b) Compressed image and (c) De-compressed image. The different methods were discussed to improve the compression ratio (CR), Bit error performance and result is obtained by their individual and combined performance such as CR and BER. The parameter involved in this thesis was PSNR, CR, MSE, BER and SNR. BER is applicable of radio data links as well as fiber optics data systems. It should be minimum for good communication system. Improved BER performance also improves quality of system in another word BER is reduced and SNR is increased. In the Figure 5 shown the performance of Harr Wavelet Transformer on 8-PSK Modulation with AWGN Channel

A. AWGN Channel on QPSK and 8-PSK Modulation with Harr Transform

The simulation result presented in the thesis focuses mainly on Compression ratio and PSNR which typically affects the picture quality. In this performance we consider AWGN channel on different modulation techniques with Harr wavelet transform. Most of the times as researchers go on increasing the compression ratio the quality of the resulting image use to go down for the proposed technique, test image "Cameraman.tif" size 256 $\times$ 256.

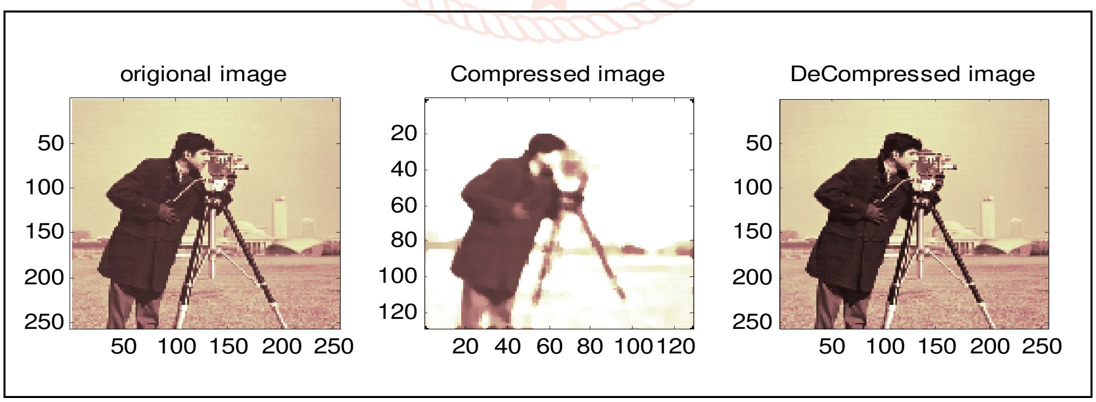

Fig. 3(a) Original image, (b) Compressed image and (c) De-compressed image

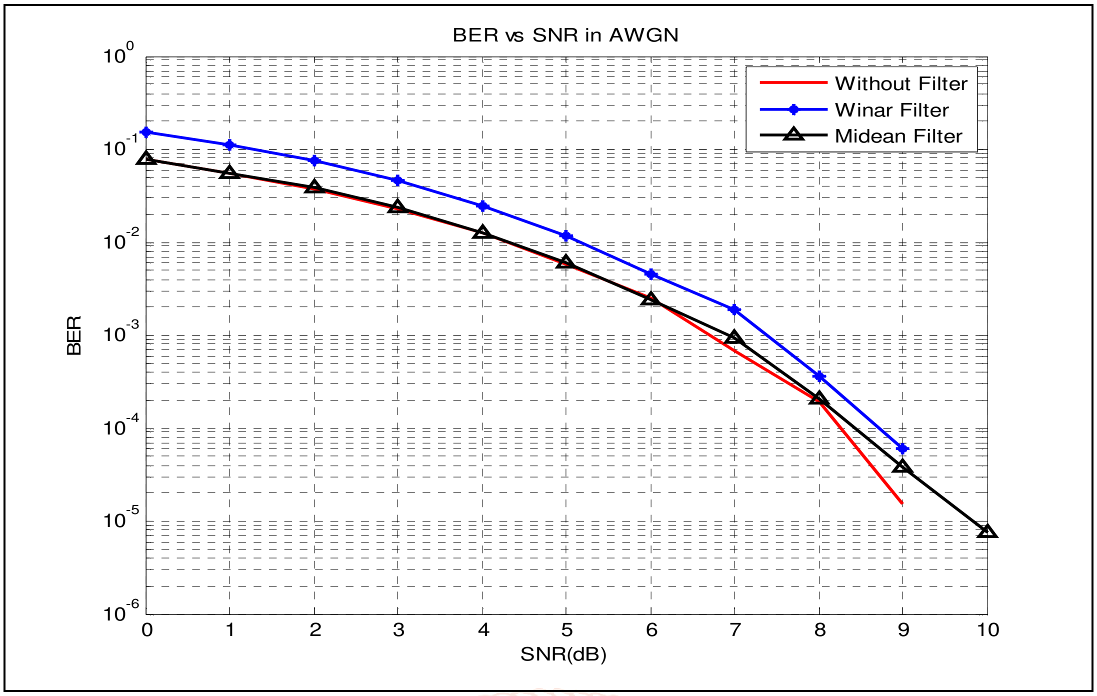

Fig 4: Performance of Harr Wavelet Transformer QPSK Modulation with AWGN Channel

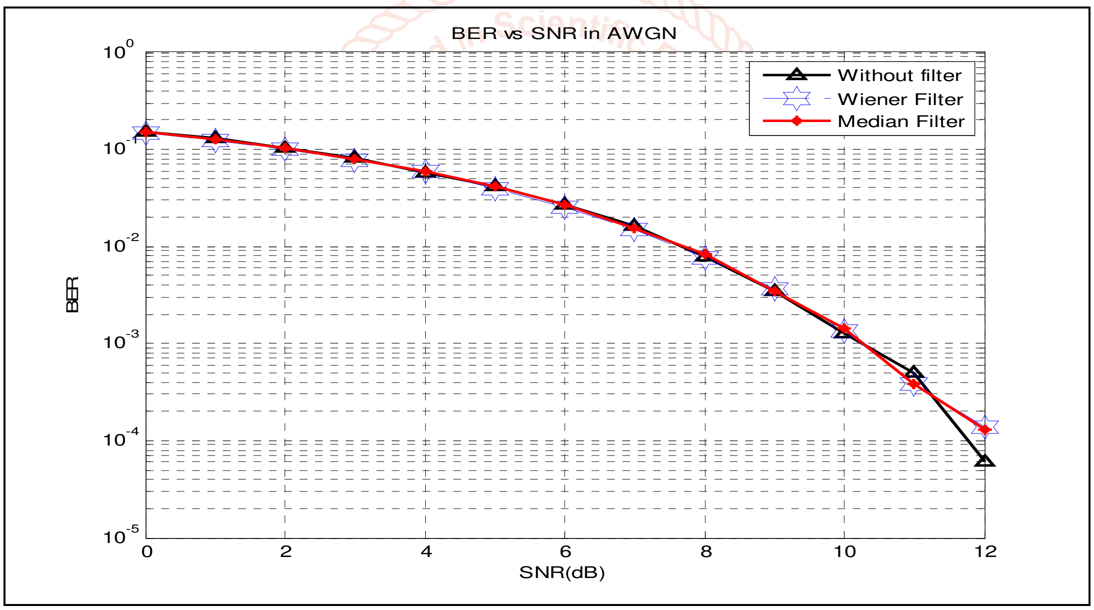

Fig 5: Performance of Harr Wavelet Transformer on 8-PSK Modulation with AWGN Channel

VIII. CONCLUSION

We get results of different wavelet image compression techniques Haar wavelet are presented and compared their effect. We also compare the result of de-noising filter (Wiener filter and Median filter). Our focus on increase Compression Ratio (CR) and Pick to signal ratio (PSNR) and decrease BER also get simulated result of wireless channels model (AWGN channel and Flat fading channel) with QPSK and 8-PSK modulation techniques and compared their effect, focus on decrease Bit Error Rate (BER).We find that that if we increase SNR value, BER performance is improved. We have notice that wiener filter with Haar wavelet compression ratio 8.1746 and with PSNR is 15.5734 by using AWGN Channel of 8-PSK.

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