Statistical Performance Analysis of Unilevel Wavelet Based Power Allocation for Wireless Image Transmission using Lab View

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ABSTRACT

Power control has been an effective approach for mitigating the effect of fading in the quality of signal transmission over wireless channels. The system typically involves a mechanism of measuring the quality of the channel seen by the receiver and providing such information to the transmitter to adjust the amount of transmitted power. Statistical analysis play an important role in analyzing image transmission. Measures of tendency like mean, mode, median, kurtosis, standard deviation gives a detailed analysis of image transmitted. The proposed algorithm performs power allocation for individual bits to minimize the Root Mean Square Error (RMSE) of a 2D-signal transmitted over AWGN channel. A gain in E_b/N_o is observed for the proposed power allocation method over conventional power allocation method. This gain is achieved without any increase in bandwidth.

Keywords-AWGNChannel, Power Mean, Mode, Median,

Allocation, Kurtosis, Wavelets

I. INTRODUCTION

By the advent of multimedia communications and the information super highway has given rise to an enormous demand on high-performance communication systems. Multimedia transmission of signals over wireless links is considered as one of the prime applications of future mobile radio communication systems. However, such applications require the use of relatively high data rates (in the Mbps range) compared to voice applications. With such requirement, it is very challenging to provide acceptable quality of services as measured by the bit error rate (BER) due to the limitations imposed by the wireless communication channels such as fading and multipath propagation. Furthermore, the user mobility makes such a task more difficult because of the time varying nature of the channel. The main resources available to communications systems designers are power and bandwidth as well as system complexity. Thus, it is imperative to use techniques that are both power and bandwidth efficient for proper utilization of the communication resources [1-2].

Recently, a new algorithm for power allocation to information bits according to their importance was proposed. The proposed scheme was based on adjusting the amount of power transmitted for each bit [6] according to its importance in the image quality as measured by the mean-square error. However, the system suffered from an increase in the peak-to-average power ratio.

II.SYSTEM CONFIGURATION

A typical binary phase shift keying (BPSK) digital communication system is considered for image transmission. Initially, the image is sampled, quantized, and then coded into binary bits for transmission by the BPSK system. Each sample is coded into M bits. The transmitted signal is represented as

$$S(t) = \sum_{k=0}^{\infty} \sum_{i=0}^{M-1} \sqrt{w_i} b_{ki} g(t-(kM+i)T_b) \tag{1}$$

where w_i is the transmitted power and b_{ki} is the information data (±1) of the ith bit in the kthi block of the M bits representing one of the samples, g(t) is a rectangular pulse shape of transmitted signal, and Tb is the bit duration. Index i represents the location of a bit within the M bits belonging to the same sample with M-1 the representing the most significant bit (MSB) and index 0 representing the least significant bits (LSB).The wireless channel is modeled as a flat Rayleigh fading channel with received signal given by

$$r(t) = \alpha s(t-\tau) + n(t) \tag{2}$$

Where α represents the complex channel coefficient with amplitude following the Rayleigh distribution and uniform phase over [0,2π] and r is the propagation delay. The additive white Gaussian noise (AWGN) is represented by n(t) with zero-mean and two sided power spectral density of No /2.

The received signal is processed using a matched filter to minimize the BER. Perfect knowledge of the channel coefficient is assumed to allow for coherent detection. Once the decision about the information bits is made; digital to analog conversion is used to reconstruct the 2D signal[3-5].

III. POWER CONTROL ALGORITHM

A better performance measure in such cases is the root-mean square error (RMSE) rather than the BER because bits transmitted by the system do not carry the same amount of information about the message. Thus, it is important to establish a relationship between the RMSE and BER for those applications.

For a system with M bits per sample, there are 2M different samples to be transmitted. The binary representation of sample xj is given by the jth row of the following $2^M \times M$ Matrix,

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \qquad (3)$$

With elements hjk. The mean square error (MSE) is given by

$$MSE = \sum_{j=0}^{2^M-1}\left(x_j - \hat{x}_j\right)^2 P(x_j) \qquad (4)$$

Where x_i is the estimate of the j^{th} sample reconstructed after detection of the M bits and P($\gamma_{io}(k)$) is the a priori probability that the j^{th} sample is transmitted. The probability that ith sample with a decimal value of (i) is reconstructed is given by

$$PS_i = \prod_{k=0}^{M-1}[P_k\gamma_{i0}(k) + (1-p_k)\overline{\gamma_{i0}(k)}] \qquad (5)$$

Where P_k is the probability that the k^{th} bit is in error and $\overline{\gamma_{io}(k)}$ is

$$\gamma_{i0}(k) = 0 \;\; if \;\; h_{0k} = h_{ik}$$
$$= 1 \;\; if \;\; h_{0k} \neq h_{ik} \qquad (6)$$

The notation $\overline{\gamma_{io}(k)}$ represents the binary inversion of $\gamma_{io}(k)$.The MSE for the above case is calculated as

$$MSE_0 = \frac{1}{2^M - 1}\sum_{J=1}^{2^M-1} i^2 \prod_{k=0}^{M-1}\left[P_k\gamma_{i0}(k) + \left(1-P_k\right)\bar{\gamma}_{i0}(k)\right]$$

(7)

The MSE for other samples can be obtained following a similar procedure and the average MSE can be calculated by averaging over all possible samples. Hence equation (7) will be average MSE. The probability of the kth bit to be in error for the AWGN case, without coding is given by

$$Pk = Q(\sqrt{2E_b(k)/N_o}) \qquad (8)$$

The iterative power allocation algorithm is as follows:

1. The power distribution vector is initialized to all ones (the energy is assumed to be the same for all bits with wi = 1for i = 0, 1, …, M - 1). MSE is calculated using (7) and (8) for a given Eb/No . Two bits are defined, B is borrowing power and D is donating power. Maximum limit of the PAPR is set to PAPRmax and energy step size to ΔEb

2. Most significant bit (MSB) is set to B = M −1, as borrower; and D = 0, least significant bit (LSB) as donor. The energy for the D bit is reduced by ΔEb and the energy of B bit increased by the same amount such that during the nth iteration we have

$$E_b D(n) = E_b D(n-1) - \Delta E_b$$
$$E_b B(n) = E_b B(n-1) + \Delta E_b$$

Within a block of M bits, the minimum energy per bit is zero and the maximum energy per bit is MEb, where Eb is the average energy per bit. MSE is calculated using (7) and (8) for a given Eb/No . We keep changing the energy of the two bits until we find the minimum value of MSE while the PAPR is kept less than PAPRmax. The same procedure above is repeated but with the donor bit D is incremented by one until all least significant bits are used. Next the borrower bit is reduced by one to optimize the second most significant bit (B=M − 2) and repeat steps.

The above steps are repeated until all bits are optimized; i.e. B = 0.Every time the minimum MSE is searched for and PAPR is ensured to be within the limit of PAPRmax.After all bits have been updated, the optimum power allocation vector w is calculated form the final energy distribution of each bit. Finally, the 2D-signal is transmitted with this optimized power. The optimum vector of power allocation is independent of the actual 2D-signal to be transmitted and can be used for transmission of different 2D-signals[7]. It is also important to note that the optimum power allocation can be pre-computed in advance for each value of Eb/No [8-10].

IV. WAVELETS

Wavelets are mathematical functions that cut up data into different frequency components, and then study each

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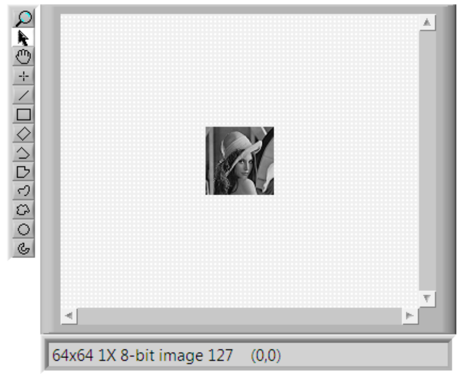
component with a resolution matched to its scale. The wavelet transform has the ability to decorrelate an image both in space and frequency there by distributing energy compactly into a few low frequency and a high frequency coefficients.The efficiency of a wavelet based image compression scheme depends both on the wavelet filters chosen as well as on the coefficient quantization scheme.
In the discrete wavelet transform, an image signal can be analyzed by passing it through an analysis filter bank followed by decimation operation. The analysis filter bank consists of a low pass and high pass filter at each decomposition stage./when the signal passes through these filters it splits into two bands. The low pass filter corresponds to an averaging operation, extracts the coarse information of the signal, The high pass filter corresponds to a differencing operation that extracts the detail information of the signal. The output of the filtering operation is then decimated by two.A two dimensional transform is accomplished by performing two separate one dimensional transforms. First the image is filtered along the row and decimated by two. It is then followed by filtering the sub image along the column and decimated by two. This operation splits the image into four bands, namely LL, LH, HL and HH respectively
The LL band is transmitted along the channel by allocating power allocation and one level of decomposition was taken into consideration. The four bands are transmitted over wireless channel and the coefficients are reconstructed using inverse transform. The approximation coefficients are reconstructed using inverse discrete transform process and various parameters are studied in the proposed and conventional methods for one level of sub band decomposition.

V.IMPLEMENTAION OF LAB VIEW

Laboratory Virtual Instrumentation Engineering Workbench (Lab VIEW) is a platform and development environment for a visual programming language from National Instruments. The purpose of such programming is automating the usage of processing and measuring equipment in any laboratory setup. Lab VIEW is commonly used for data acquisition, instrument control, and industrial automation.

Fig:1 64X64 Input Image



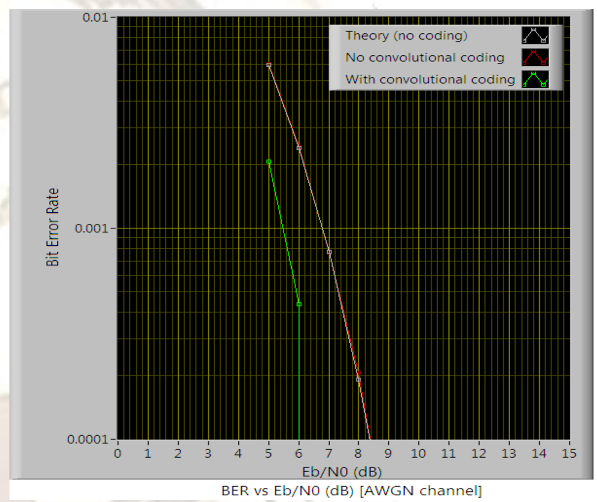
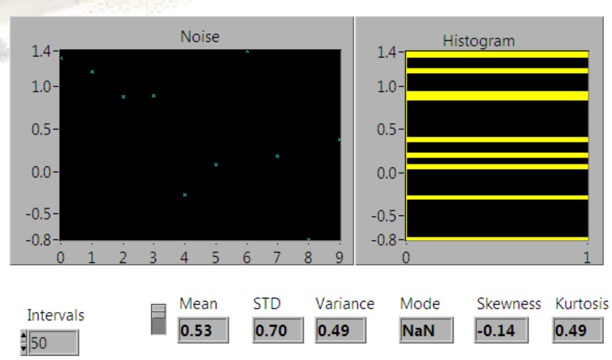


Fig:2 E_b/N_o vs BER with UnequalPowerAllocation

Fig:3 E_b/N_o vs BER with EqualPowerAllocation



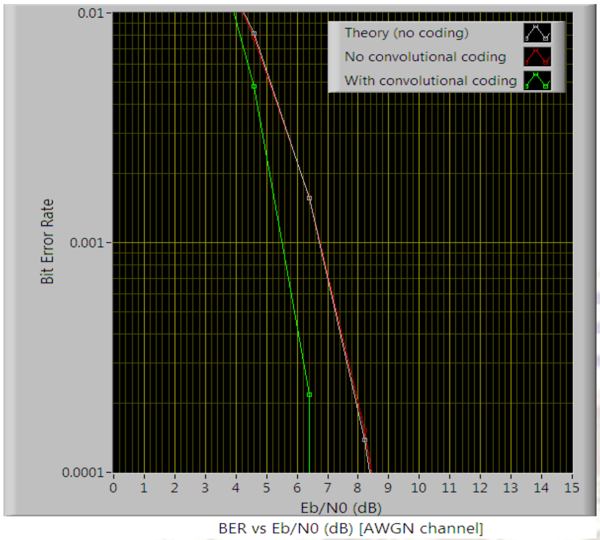


Fig: 4 Histogram for UnequalPowerAllocation

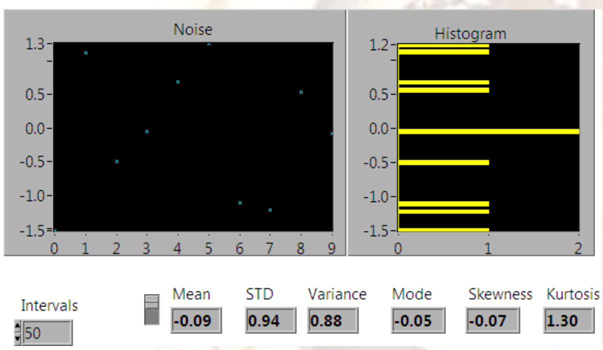


Fig: 5 Histogram for EqualPowerAllocation

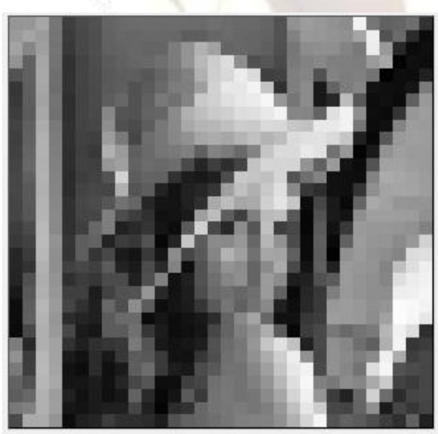


Fig:6 Received Image at unlevel of approximation With selected coefficients

VI. NUMERICAL RESULTS

Fig.1 shows a 64x64 input image. A gain in Eb/No of 9 dB at 8 bpp is observed for BER based power allocation algorithm over conventional equal power algorithm. Signal transmission over AWGN is considered.

Fig.2 and Fig.3 shows the plots of Eb/No versus BitErrorRate(BER) for Power Allocation Methods at first Level of decomposition.Fig.4 and fig.5 shows the histograms at equal and unequal power allocation methods. At lower values of Eb/No the proposed power allocation method performs better than the conventional method in terms of BER,Standarddeviation (STD) and Variance. Standard deviation and variance are more for the proposed method rather than conventional method. The Histogram represented in the fig.4 also gives a better equalized plots for proposed power method compared to conventional method.Fig.6 shows the received image at Unilevel of approximation with selected coefficients

VII. CONCLUSIONS

The optimum power allocation will converge to the conventional scheme with equal power allocation per bit, for very high Eb/No. In this paper power allocation using one level of decomposition of wavelets was optimized with the power vector and transmitted over a wireless channel The results obtained by this scheme show a significant gain of about 9 dB over both the conventional equal-power and proposed methods. The elapsed time compared with the two methods shows that proposed method consumes better time than the conventional method for both compressed images and uncompressed images. Standard deviation also known as the square root of the variance, which tells about the contrast.It describes the spread in the data,so,a high contrast image will have a high variance, and a low contrast image will have a low variance.This shows that proposed method performs better than Conventional method with respect to various parameters.

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