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Optimized MSE Analysis of Maximum Power Adaptation with Code Rates over Wireless Cropped Image Transmission using Labview

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***Abstract* – Coding plays significant role in wireless transmission as the most important scheme for communication of cropped images over wireless channels, due to its ability to deal with various channel qualities and to approach the hypothetical limits of transmission rates. In this paper, Maximum Power Adaptation Algorithm is implemented along with convolution codes for different rates. This Proposed method shows better performance compared to Conventional Power Adaptation Algorithm combined with convolution codes for different rates. The proposed scheme works iteratively to find the optimal combination of coding and power transmitted for individual bits to minimize the mean square error for better cropped image excellence. It is shown that bits of major importance i.e most significant bits should always be coded and allocated most of the power transmitted. However, other bits of less significance may be transmitted with less power. This is done while maintaining the average power per bit at the same level. Code rate ½ showed better performance compared with other codes.**

***Keywords* – Convolution Codes, Code Rate, maximum.**

I. INTRODUCTION

One of the most important and challenging goal **of** current and future communication is transmission of high quality cropped images from source to destination quickly with least error where limitation of bandwidth is a prime problem. By the advent of multimedia communications, the multimedia transmission of multimedia over wireless links is considered as one of the major applications of future communication systems. However, such systems require the use of relatively high power adaptation compared to other applications.

With such requirement, it is very challenging to provide acceptable quality of services as measured by the Root Mean Square Error (RMSE) due to the limitations imposed by the wireless communication channels such as fading and multipath propagation. With the increasing complexity of these communication systems comes increasing complexity in the type of content being transmitted and received. The early content of plain speech/audio and basic black and white cropped images used in early radio and television has developed into high definition audio and video streams; and with the introduction of computers into the mix even more complex content needs to be considered from cropped images, video and audio to medical and financial data. Techniques are continuously being developed to maximize data throughput and efficiency in these wireless communication systems while endeavoring to keep data loss and error to a minimum. Power control has been an effective approach to mitigating the effect of fading channels in the quality of signal transmission over wireless channels [1-2].

The use of power in multimedia communications is becoming more and more important and intricate, predominantly when multimedia signal processing is incorporated. Since high power wireless systems are distorted, it is essential to adjust power of the transmitted bits to guarantee signal reliability. Wireless cropped image transmission is important for a variety of applications, from security and surveillance to in-home monitoring. Most existing studies on Power optimization of wireless communications consider error-free bit transmission, where the entire bit stream has to be retransmitted if there is even a single bit error. However, for cropped image transmission applications, there is often a certain tolerance to errors in the received data, as errors in the decoded data become distortion in the cropped image content.

Appadwedula et al. [2] formulated an energy optimization problem subject to statistical distortion and rate constraints for transmitting cropped images over wireless channels. Considering transmission, source, and channel coding components in the formulation of the problem, the authors deployed a gradient based method to solve the problem. Without considering transmission power, Zhang et al. [5] proposed a generic power optimization problem subject to distortion and rate constraints for transmitting video across wireless backbone.

II. SYSTEM MODEL

The system is a typical binary phase shift keying (BPSK) digital communication system for multimedia transmission. The signal is sampled, quantized and then coded into binary bits for transmission. The transmitted BPSK signal is represented as

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

Modulation is the process by which signal waveforms are transformed and enabled to better withstand the channel impairments.

In a BPSK system the received signal is given by

$$\mathrm{Y = x + n} \tag{2}$$

Where $x \in \{-A, A\}$ and $\sigma^2 = N_o$

The bit error probability is

$$P_{b=\int_A^\infty \frac{1}{\sqrt{2\pi\frac{\sigma^2}{2}}} e^{-\frac{x^2}{\frac{\sigma^2}{2}}}} \tag{3}$$

And the Q-function is given by

$$Q(x)=\frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{x^2}{2}}\, dx \tag{4}$$

$$Q(x) = \left[\frac{1}{(1-a)x + a(x^2+b)^{0.5}}\right] \frac{1}{(2\pi)^{0.5}} e^{-\frac{x^2}{2}} \tag{5}$$

Equation (6) is widely used in Bit error rate calculation. The Q-function can be described as a function of error function defined over $[0,\infty)$ and is given by

$$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-y^2} dy \tag{6}$$

With erf(0)= 0 and erf(∞)=1

$$P_b = Q(\sqrt{2\gamma_b}) \tag{7}$$

$$P_s = 1 - [1 - Q(\sqrt{(2\gamma b\,)})]^2 \tag{8}$$

$$\gamma_s = 2\gamma_b = \frac{A^2}{N_o} \tag{8a}$$

Where the Q function is defined as:

$$Q(x) \le \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{x^2}{2}}\, dx \tag{9}$$

The Bit Error rate of BPSK involves two BPSK modulations on in-phase and quadrature components of the signal. The bit error probability is given by

$$Q(z) \le \frac{1}{z\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx \tag{10}$$

$$P_{s \le \frac{3}{\sqrt{2\pi\gamma_s}}} e^{-0.5\gamma_s} \tag{11}$$

P_b Can be approximated from P_s by P_b as

$$P_b = \frac{P_s}{2} \tag{12}$$

The Bit Error Rate for BPSK signaling can be calculated by an approximation of symbol error rate using nearest neighbor approximation. The Symbol error probability can be approximated by

$$P_s = 2Q\left[\frac{2A\sin\frac{\pi}{M}}{\sqrt{2N_o}}\right] = 2Q\left[\sqrt{2\gamma_s}\,\mathrm{Sin}\,\frac{\pi}{M}\right] \tag{13}$$

When there are N number of images and M number of bits in a multimedia system, then the powers transmitted by the bits are $P = [P_1, P_2, \ldots\ldots\ldots\ldots\ldots..P_M]$ and the respective RMSEs at the bits be $RMSE = [RMSE_1, RMSE_2, \ldots\ldots\ldots..RMSE_M]$. Let $RMSE_T$ be the target RMSE. For a system with M bits per sample, there are 2^M different samples to be transmitted.

The probability that ith sample with a decimal value of (i) is reconstructed is given by

$$PD_i = \prod_{k=0}^{M-1} [p_k \vartheta(k) + (1 - p_k)\widetilde{\vartheta(k)}] \tag{14}$$

Where p_k is the probability that the kth bit is in error.$\vartheta(k)$ is equal to zero if the indices of i and k are same and the value will be equal to 1 if the indices are different. The notation $\widetilde{\vartheta(k)}$] represents the binary inversion of $\vartheta(k)$. The MSE for the above case is calculated as

$$MSE = \frac{1}{\sqrt{2^M - 1}} \sum_{k=0}^{M-1} PD_i \tag{15}$$

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. It is possible to show that, on average, all MSE values are approximately the same and hence equation (7) will be average MSE. The Root Mean Square Error (RMSE) is obtained by taking the square root of (7)[15-18] .The probability of the kth bit to be in error for the AWGN case is given by

$$P_k = Q(\sqrt{2\frac{E_b}{N_o}(k)}\,) \tag{16}$$

Algorithm:

1. Initialize number of iterations
2. Initialize number of bits
3. Initialize power step size to ΔP.
4. Initialize$\mathbf{PAPR_{max}}$..
    - For i = 1 to iterations
5. Initialize power vector to all ones
6. Define two bits, R is recipient power and C is contributing power,
    - For j = 1 to bits
7. Compute RMSE.
8. Update power of all the bits using

$$\mathbf{P_i^{n+1} = RMSE_i^n x P_i^n} \tag{17}$$

Where

$$\mathbf{RMSE_i^n = \frac{MAX(RMSE_i^n, RMSE_T)}{RMSE_i^n}} \tag{18}$$

$\mathbf{P_i^{n+1}}$ =Power allocated in the n+1 state
$\mathbf{P_i^n}$ = Power allocated in the n state
$\mathbf{RMSE_i^n}$=Root mean square error of i^{th} bit in n^{th} iteration
$\mathbf{RMSE_T}$ =Target Root Mean Square Error

Calculate the maximum power of each bit.

10. Repeat the same procedure 8 and 9 above but with the Contributor bit C incremented by one until all least significant bits are used.
11. Calculate the maximum MSE.
12. Plot Energy per Bit versus RMSE, BER.

IV. CONVOLUTION CODING

Convolution coding is the most common and widely used channel coding technique used in global mobile communication systems, and it has many sub-categories which are standards of different wireless communication mechanisms. The convolution technique of channel coding involves the encoding of specified number of bits, which are the smallest units of data. These bits contain information about current or recently transmitted data values within streams of transmitted data. These data values inform the receiver about the size and features of the transmitted data. This information regarding data values not only help recipients check the received bits for any loss or path corruption, but also help to make sure the data received is as it was transmitted.

A convolution coder has memory and its output depends on the current block of input bits as well as past input bits. The coder accepts k bits at its input and produces n bits at its output, where the n bits are affected by v+k input bits. Memory is incorporated since v>0.The code rate is

RC=k/n. Typically k and n range from 1 to 8, the value of v ranges from 2 to 60, and the value of RC from 1/4 to 7/8.

V. NUMERICAL RESULTS AND CONCLUSIONS

This Paper is implemented in Lab View. Laboratory Virtual Instrumentation Engineering Workbench (Lab VIEW) is a platform and development environment for the 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. In this first the cropped image is given to IMAQ read file where the cropped image is read from a file and then the cropped image is converted into array using IMAQ cropped image to array block then the rows and columns of cropped image pixels are calculated and all are initialized with zeros and now the binary cropped image is applied to PSK modulator then AWGN noise is added and decimates the over samples and then the bits are passed through BER block for BER calculation. The optimized power vector is transmitted through the channel. This process is done by first passing the binary data to convolution coding block followed by above process followed by decoding and BER block. Fig.1 shows the Original cropped image. And cropped image Cropped image transmission over AWGN is considered with M = 8 bpp for Maximum power adaptation methods with and without coding. The performance obtained by the coding and No coding along with the Maximum Power Adaptation Algorithm are shown in Tabular forms I , II , III , IV and V.Better Performance is observed in Maximum Power Adaptation Algorithm (MAPAA) with coding compared with No Coding as shown in Fig.8,10.The Plots show that the performance with code rate ½ achieves better performance compared with other code rates1/3,1/4,2/3,3/4.

Fig.7 shows the received cropped image using Maximum Power Adaptation Algorithm. Ihe cropped image proves that better Performance is observed in Maximum Power Adaptation Algorithm using Coding with Code Rate 1/2 compared with other code rates1/3, 1/4, 2/3, 3/4. And No Coding as shown in fig.2, 3, 4 and 5.A better performance is observed with code rate 1/3 and ¾ after code rate ½.Higher values are observed with code rate 2/3.As E_b/N_o increases , MSE decreased using code rate ½ rather than no coding. This code rate-1/2 shows better performance compared with conventional power adaptation algorithm.Fig.11 shows plot of MSE values with Convolution Code Rate 1/2 and No Coding with Conventional power Adaptation Algorithm. Table VI shows MSE values with Conventional Power Adaptation Algorithm along with Convolution Code Rate ½.

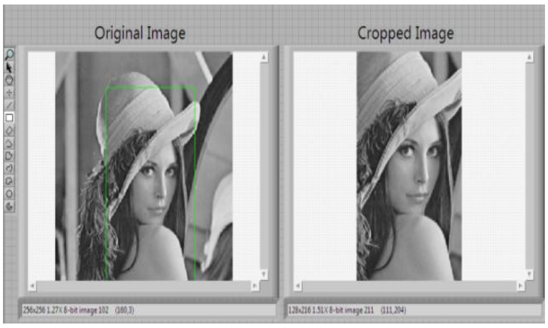

Fig.1. Original Cropped image and cropped image

Table I MSE values with Convolution Code Rate ½ and Maximum Power Adaptation

Eb/No	MSE(No Coding)	MSE(Coding)
1	2.67963	2.58995
2	2.63798	2.53929
3	2.61456	2.49067
4	2.59438	2.45956
5	2.56844	2.43093
6	2.55078	2.40506
7	2.53754	2.3803
8	2.52275	2.36609
9	2.51598	2.35006

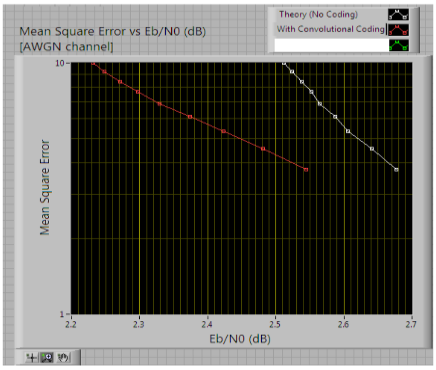

Fig.2. Plot showing MSE values with Convolution Code Rate ½ and No Coding

Table II MSE values with Convolution Code Rate 1/3 and Maximum Power Adaptation

Eb/No	MSE(No Coding)	MSE(Coding)
1	2.67807	2.91775
2	2.63481	2.81173
3	2.6099	2.72961
4	2.5859	2.65175
5	2.56713	2.5898
6	2.55542	2.53917
7	2.53969	2.49625
8	2.52658	2.46578
9	2.51602	2.4346

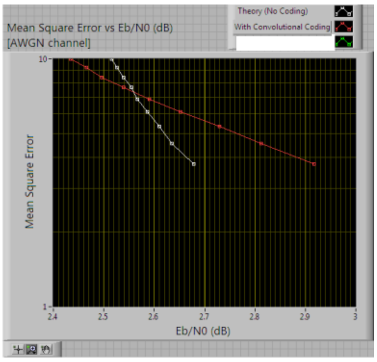

Fig.3. Plot showing MSE values with Convolution Code Rate 1/3 and No Coding

Table III MSE values with Convolution Code Rate 1/3 and Maximum Power Adaptation

E_b/N_o	MSE(No Coding)	MSE(Coding)
1	2.67719	2.54441
2	2.64087	2.4808
3	2.60617	2.42354
4	2.5872	2.37417
5	2.56462	2.32918
6	2.55243	2.29779
7	2.53801	2.27058
8	2.52435	2.24823
9	2.51184	2.23122

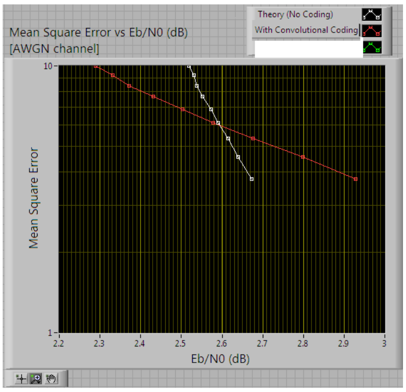

Fig.4. Plot showing MSE values with Convolution Code Rate 1/4 and No Coding

Table IV MSE values with Convolution Code Rate 2/3 and Maximum Power Adaptation

Eb/No	MSE(No Coding)	MSE(Coding)
1	2.6719	2.92775
2	2.64007	2.79822
3	2.61474	2.67656
4	2.58969	2.57805
5	2.57236	2.50294
6	2.55111	2.43085
7	2.53855	2.37221
8	2.5309	2.33154
9	2.5179	2.29004

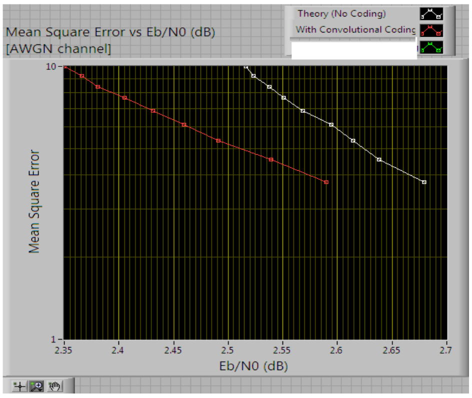

Fig.5. Plot showing MSE values with Convolution Code Rate 2/3 and No Coding

Table V MSE values with Convolution Code Rate 3/4 and Maximum Power Adaptation

Eb/No	MSE(No Coding)	MSE(Coding)
1	2.60162	2.53636
2	2.59179	2.514
3	2.57272	2.49616
4	2.55581	2.47704
5	2.55252	2.45509
6	2.54133	2.44546
7	2.53016	2.44003
8	2.52624	2.42618
9	2.52064	2.41738

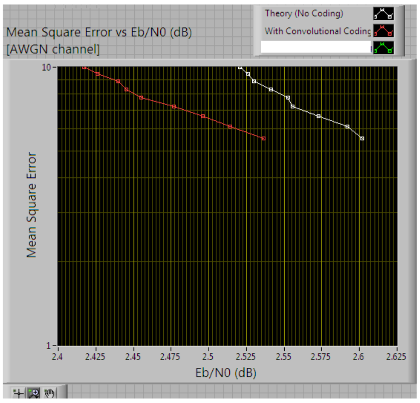

Fig.6. Plot showing MSE values with Convolution Code Rate ¾ and No Coding

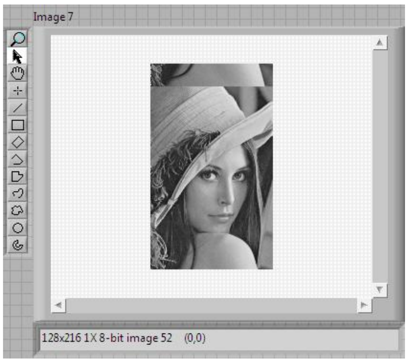

Fig.7. Received Image with Convolution Code Rate 1/2 And Maximum Power Adaptation Algorithm

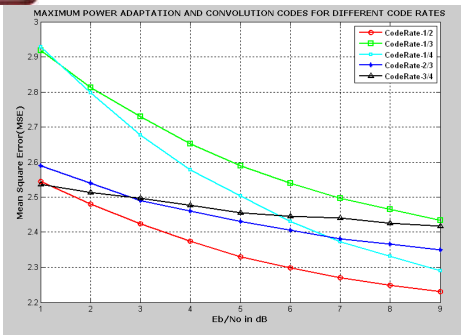

Fig.8. Plot showing Eb/No vs MSE values with different Code Rates

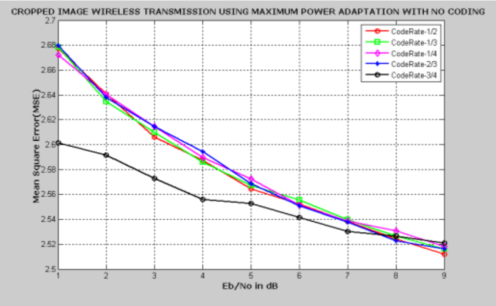

Fig.9. Plot showing Eb/No vs MSE values with No Coding at different rates

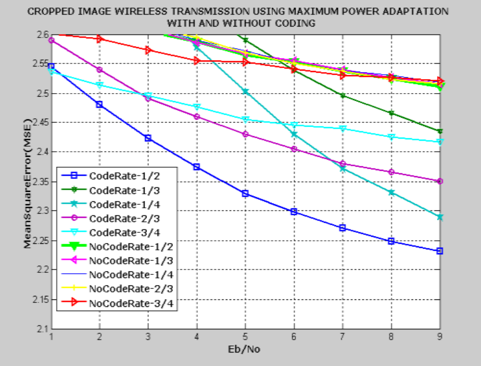

Fig.10. Plot showing Eb/No vs. MSE values with No Coding at different rates

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