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EMBEDDED ZEROTREE WAVELET CODED MAXIMUM POWER ADAPTATION FOR IMAGE TRANSMISSION OVER WIRELESS CHANNELS USING LABVIEW

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Abstract - This paper focuses on Embedded Zero Tree Wavelet coding for Image transmission over wireless channels with maximum power adaptation. The objective is to minimize total power allocated for image compression and transmission, while the power for each bit is kept at a predetermined value. In this Paper, an approach for minimizing the total power adapted in a multimedia like image due to source compression and transmission subject to a fixed bit source distortion is considered. Simulations are performed using Embedded Zero Tree Wavelet (EZW) over AWGN channel using QPSK modulation. The numerical analysis shows that optimized power methods can reduce the total Power Adapted by a significant factor and the Bit error rate is reduced considerably compared to the Conventional Power Adaptation method.

Keywords— Embedded Zero Tree Wavelet (EZW), Maximum Power, QPSK, AWGN, Modulation

I: INTRODUCTION

By the advent of multimedia communications and the information superhighway 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. 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.

Power Adaptation has been an effective approach to mitigating the effect of fading channels 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. For instance, if the channel is good then less power is used while if the channel is bad then more power is used. Few modifications to this strategy have been proposed such as to send higher data rates rather than reducing the power if the channel is good or not to send at all if the channel is bad. These systems are considered as opportunistic systems since they take advantage of the information about the channel to optimize the communications process. The main issues for these systems are the need for a feedback link fast enough to track the time variation of the channel and not utilizing the message structure of the image or video signal to be transmitted in power Adaptation.

II: MAXIMUM POWER ADAPTATION METHOD (MAPAA)

When there are N number of images and M number of bits in a multimedia system, then the powers transmitted by the bits be $p=[p_1, p_2, ...p_M]$ and the respective RMSEs at the bits be $RMSE=[RMSE_1, RMSE_2, ...RMSE_M]$.

Let $RMSE^T$ be the target RMSE.

1. Initialize power values for all the bits.

2. For 1 to No. of iterations and No. of bits, calculate the RMSE and update the power of all the bits using

$$P_i^{n+1} = R_i^n \times P_i^n \tag{1}$$

Where

$$R_i^n = \frac{Max(RMSE_i^n, RMSE^T)}{RMSE_i^n} \quad (2)$$

$RMSE_i^n$ =Root mean square error of ith bit in nth iteration

$RMSE^T$ =Target Root Mean Square error

3. Calculate the minimum power of each bit.

Here the new power level is calculated by the product of the previous power level and the ratio of RMSEs

III: BER OF QPSK MODULATION

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

$$Y = x + n \quad (4)$$

Where $x \varepsilon \{-A, A\}$ and $\sigma^2 = N_0$

The bit error probability is

$$P_b = \int_A^{\infty} \frac{1}{\sqrt{2\pi\sigma^2/2}} e^{-\frac{x^2}{2\frac{\sigma^2}{2}}} \quad (5)$$

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-\frac{x^2}{2}} dx \quad (6)$$

$$Q(x) \approx \left[\frac{1}{(1-a)x + a(x^2+b)^{0.5}}\right] \frac{1}{(2\pi)^{0.5}} e^{-\frac{x^2}{2}} \quad (7)$$

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

$$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-y^2} dy \quad (8)$$

With erf (0) = 0 and $erf(\infty)$ =1

$$P_b = Q\left(\sqrt{2\gamma_b}\right) \quad (9)$$

$$P_s = 1 - \left[1 - Q\left(\sqrt{2\gamma_b}\right)\right]^2 \quad (10)$$

$$\gamma_s = 2\gamma_b = \frac{A^2}{N_o} \quad (11)$$

Where the Q function is defined as:

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-\frac{x^2}{2}} dx \quad (12)$$

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

$$P_b = Q\left(\sqrt{2\gamma_b}\right) \quad (13)$$

The Probability of symbol error rate is given by

$$P_s = 1 - \left[1 - Q\left(\sqrt{2\gamma_b}\right)\right]^2 \quad (14)$$

Therefore, the Q-function can be expressed as

$$Q(z) \leq \frac{1}{z\sqrt{2\pi}} e^{-\frac{z^2}{2}} \quad (15)$$

and $P_s \leq \frac{3}{\sqrt{2\pi\gamma_s}} e^{-0.5\gamma_s}$ (16)

P_b can be approximated from P_s by P_b as

$$P_b = \frac{P_s}{2} \quad (17)$$

The Bit Error Rate for QPSK signalling can be calculated by an approximation of symbol error rate using nearest neighbour approximation. The Symbol error probability can be approximated by

$$P_s = 2Q\left(\frac{2A\sin\frac{\pi}{M}}{\sqrt{2N_o}}\right) = 2Q\left(\sqrt{2\gamma_s}\sin\frac{\pi}{M}\right) \tag{18}$$

IV: EMBEDDED ZERO TREE WAVELET CODING

The Embedded Zero tree Wavelet algorithm (EZW) is a simple, yet remarkable effective, image compression algorithm, having the property that the bits in the bit stream are generated in order of importance, yielding a fully embedded code. Using an embedded coding algorithm, an encoder can terminate the encoding at any point thereby allowing a target rate or target distortion metric to be met exactly. Also, given a bit stream, the decoder can cease decoding at any point in the bit stream and still produce exactly the same image that would have been encoded at the bit rate corresponding to the truncated stream. In addition to producing a fully embedded bit stream, EZW consistently produces compression results that are competitive with virtually all known compression algorithms.

Fig.1 Coefficients are coded in a zero tree structure and scanned in a left-to-right order.

A wavelet coefficient x is said to be insignificant with respect to a given threshold T if |x|<T. The zero tree is based on the hypothesis that if a wavelet coefficient at a coarse scale is insignificant with respect to a threshold, then all wavelet coefficients of the same orientation in the same spatial location at the finer scale are likely to be insignificant with respect to the same threshold. More specifically, in a hierarchical sub band system, with the exception of the highest frequency sub bands, ever coefficient at a given scale can be related to a set of coefficients at the next finer scale of similar orientation. The coefficient at the coarse scale is called the parent, and all coefficients corresponding to the same spatial location at the next finer scale of similar orientation are called children. Similar, we can define the concepts descendants and ancestors. Given a threshold T to determine whether or not a coefficient is significant, a coefficient x is said to be an element of a zero tree for the threshold T if itself and all of its descendents are insignificant with respect to the threshold T. Therefore, given a threshold, any wavelet coefficient could be represented in one of the four data types: zero tree root (ZRT), isolated zero (IZ) (it is insignificant but its descendant is not), positive significant (POS) and negative significant (NEG).

Shapiro's algorithm creates rooted trees using a pixel of the LL sub band for the root of each tree and a specific order of similarly positioned pixels from the other sub bands for children. There are two types of passes performed: a dominant pass and a subordinate pass. The dominant pass finds pixel values above a certain threshold, and the subordinate pass quantizes all significant pixel values found in this and all previous dominant passes previous.

The decoder then decompresses the arithmetically encoded files into symbol files, creates all the proper size sub bands needed since it knows the sub band decomposition scale and the original image size, and proceeds to undo the Shapiro compression since it knows the initial threshold and the sub band scanning order.

V: IMPLEMENTATION IN 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.LabVIEW is commonly used for data acquisition, instrument control, and industrial automation.

In this first the image is given to IMAQ read file where the image is read from a file and then the image is converted into array using IMAQ image to array block then the rows and columns of image pixels are calculated and all are initialized with zeros and now by using the math script node the image is converted into binary bits. EZW coder is applied. Now the binary 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. This process is repeated for “with coding” by first passing the binary data to convolution coding block followed by above process followed by decoding EZW and BER block. The graph was plotted between theoretical, no coding and with coding of binary data that was obtained from the original image.

VI: NUMERICAL RESULTS AND CONCLUSIONS

This paper presents a computationally efficient method for power Adaptation with maximum power. Fig.1 shows the EZW coding process.Fig.2 and Fig.3 sows the Bit Error Rate plots and received images using Conventional Power adaptation Method with tabulated values. Fig.4, Fig.5 and Fig.6 sows the Bit

Error Rate plots and received images using Maximum Power adaptation Method with values in tabulated form.

The Maximum Power Adaptation method shows better performance in terms of BER. The optimum power adaptation will converge to the conventional scheme with equal power Adaptation per bit, for very high Eb/No.

In this paper power Adaptation 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 performance over the conventional equal-power adaptation algorithm.

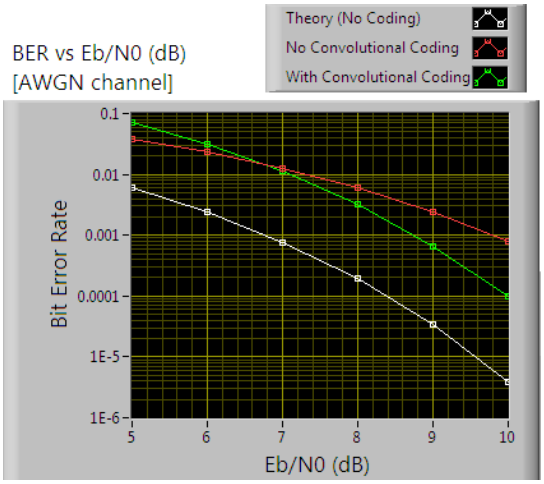

Fig1 AND .2 Plot showing Eb/No vs. BER using Maximum Power Adaptation

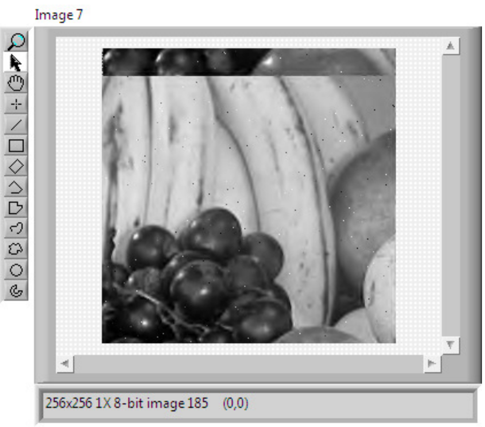

Fig.3 Received Image using EZW coding using Conventional Power Adaptation

Eb/No	No Convolution coding	Convolution coding	Theory
5	0.0362096	0.0712756	0.00634631
6	0.0234287	0.0313183	0.00241186
7	0.0102945	0.0124922	0.000792793
8	0.00634631	0.00307181	0.000204609
9	0.0025314	0.00065332	3.41675E-5
10	0.000832086	0.000109098	3.87468E-6

Fig.4 Table shows the BER values using Conventional Method

E_b/N_o	No Convolution coding	Convoluti on coding	Theory
5	0.0362096	0.0712756	0.00604662
6	0.0245899	0.0298394	0.00241186
7	0.0119023	0.0098083	0.000719686
8	0.00604662	0.0030718	0.00021475
9	0.0025314	0.0006533	3.41675E-5
10	0.000755355	0.0001039	3.6917E-6

Fig.5 Table shows the BER values using Maximum Power Adaptation Method

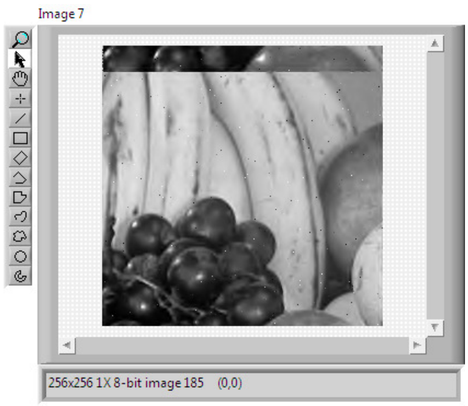

Fig.6 Received Image using EZW coding using Maximum Power Adaptation Method

EZW Encoder:

Resolution levels : 4

Target bit rate : 0.50 (bpp)

Target file size : 32768 (bits)

Quantizer coarseness

Pass 1 : 535.54

Pass 6 (final) : 16.74

EZW DECODING RESULTS:

Decoded bit rate : 0.50 (bpp)

Decoded #bits : 32768 (bits)

Mean Square Error : 23.6

Signal-to-Noise Ratio : 22.5 (dB)

PSNR : 34.4 (dB)

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