MAXIMUM AND MINIMUM POWER ADAPTATION ANALYSIS FOR TRANSMISSION OF DIFFERENT IMAGE FORMATS USING UNILEVEL HAAR WAVELET

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Abstract

This paper addresses power allocation methods for multimedia signals over wireless channels. The aim of this paper is to minimize total power allocated for image compression and transmission, while the power for each bit is kept at a predetermined value. Maximum and minimum power control algorithms are proposed. In this work, an approach for minimizing the total power allocated to a multimedia like image due to source compression and transmission subject to a fixed bit source distortion using different parameters are analysed. Simulations are performed using haar wavelet over AWGN channel. Structural Content (SC), Average Difference, Normalized Absolute Error (NAE), etc are analysed. Maximum Power Adaptation Algorithm shows better performance than Conventional Power Adaptation Algorithm.

Keywords— *PSNR, MSE, SC, NAE, Correlation, Image formats*

1. INTRODUCTION

One of the most important and challenging goal of current and future communication is transmission of high quality 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 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 images, video and audio to medicaland financial data. Techniques are continuously being developed to maximise data throughput and efficiency in these wireless communication systems while endeavouring 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].

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2. PROBLEM FORMULATION

Efficient use of the multimedia power is one of the major challenges in information devices. Some of the key technologies that affect the power in this respect are source signal compression, channel error control coding, and radio transmission. Depending on the Allocation, power control algorithms can be categorized as either centralized or distributed. An optimum centralized power control algorithm which can achieve the minimum outage probability was studied in [3]. It is assumed that all the active link gains are available and remain constant during execution of the algorithm. This assumption, of course, is not realistic because of the high computational complexity required for the algorithm [4] [5]. In the previous algorithms of power allocation methods only local information is used to adjust transmitting power. In this paper, a power adaptation algorithm which does not need the normalization procedure is proposed [6, [7], [8].

3. OPTIMIZATION USING POWER ALLOCATION METHODS

When there are N number of images and M number of bits in a multimedia system, then the powers transmitted by the bits be$P = [P_1, P_2, \dots \dots \dots \dots \dots .. P_M]$ and the respective RMSEs at the bits be $RMSE = [RMSE_1, RMSE_2, \dots \dots \dots .. RMSE_M]$. Let $RMSE_T$ be the target RMSE.

A Communication system requires 2^M different samples to be transmitted for M bits per sample.

The mean square error (MSE) is given by

$$MSE = \sum_{j=0}^{2^M-1} (x_j - \grave{x_j})^2 P(x_j) \qquad (1)$$

Where xj is the estimate of the j^{th} sample reconstructed after detection of the M bits and P (x_j) is the a priori probability that the jth sample is transmitted. In general,2^M-1 combinations of M bits will be received. [17]. The probability that ith sample with a decimal value of (i) is reconstructed is given by

$$P_i = \prod_{k=0}^{M-1} [p_k \vartheta(k) + (1 - p_k)\widetilde{\vartheta(k)}] \qquad (2)$$

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

$$MSE = \frac{1}{\sqrt{2^M - 1}} \sum_{k=0}^{M-1} P_i \qquad (3)$$

The Root Mean Square Error (RMSE) is obtained by taking the square root of (3)[15-18] .Note that the probability of the kth bit to be in error for the AWGN case is given by

$$PE_k = Q(\sqrt{2\frac{E_b}{N_o}(k)}\,) \qquad (4)$$

1. Minimum Power Adaptation Algorithm

This algorithm is developed to minimize the interference experienced by a channel such that heterogeneous BER requirements of multimedia traffic are satisfied. Further, from analysis of the maximum capacity of a bit stream, it is concluded that both transmission rate and BER are necessary to reach a maximum capacity. A new scheme is proposed to serve in order to maximize the capacity of such an interference-sensitive system, the power levels allocated to code channels need to be minimized.[9-12]

ALGORITHM:

1. Initialize the power distribution vector to all ones

2. For 1 to No. of iterations and No. of bits, calculate the MSE using (5) and (6) and keep changing the energy of the two bits until you find the minimum value of MSE and update the power of all the bits using

$$P_i^{n+1} = RMSE_i^n x P_i^n \tag{5}$$

Where
$$RMSE_i^n = \frac{MIN\ (RMSE_i^n, RMSE_T)}{RMSE_i^n} \tag{6}$$

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

3. Define two bits, R is recipient power and C is contributing power and assumes the power step size to ΔP.

4. Calculate the minimum power of each bit.Repeat the same procedure (2) and (3) above but with the contributor bit C is incremented by one until all least significant bits are used.

5. Calculate the Minimum MSE.

2. Maximum Power Adaptation Algorithm

In these systems, the MSE level is satisfied at each bit. Once the bit allocation is carried out, the power control takes a role of controlling the error caused by bits. On one hand, this algorithm must be reduced to minimize the interference at other bits, and, on the other hand, it must be sufficient for data communication[23-24].

ALGORITHM:

1. Initialize the power distribution vector to all ones

2. For 1 to No. of iterations and No. of bits, calculate the MSE using (5) and (7) and keep changing the energy of the two bits until you find the minimum value of MSE and update the power of all the bits using

$$P_i^{n+1} = RMSE_i^n x P_i^n$$

Where
$$RMSE_i^n = \frac{MAX\ (RMSE_i^n, RMSE_T)}{RMSE_i^n} \tag{7}$$

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

3. Define two bits, R is recipient power and C is contributing power and assumes the power step size to ΔP.

4. Calculate the maximum power of each bit. Repeat the same procedure (2) and (3) above but with the contributor bit C is incremented by one until all least significant bits are used.
5. Calculate the Maximum MSE.

4. WAVELETS AND IMAGE FORMATS

Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale [17]. 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. An image can be decomposed into subbands.These sub bands are decomposed into LL,LH,HL and HH bands. 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.

There are different image formats available for different applications. In this paper, four types of formats., PNG, BMP, TIF and GIF are considered.Each format undergoes one different application in real-time.

5. NUMERICAL RESULTS AND CONCLUSIONS

Objective and Subjective quality parameter values are obtained for Equal Power Adaptation Algorithm, Minimum Power Adaptation Algorithm and Maximum Power Adaptation Algorithms. The improvement in performance is obtained by the Minimum Power allocation Algorithm which affects the Maximum Power Adaptation Algorithm performance in comparison as shown in Table I, Table II, Table III.

Fig.1, Fig.2 and Fig.3 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 as shown in Fig.4, Fig.5, Fig.6.

In all the three methods, Maximum Power Adaptation algorithm (MAPCAA) shows better performance with less error with all remaining formats. Each and every image format has its own characteristic in quality performance.

Power Allocation Method	**MPAA**			
Image Format	**Barbara.png**	**Lena.bmp**	**Cameraman.tif**	**Lena1.gif**
MSE	2.76E+03	3.66E+03	3.78E+03	1.66E+03
PSNR	1.37E+01	1.25E+01	1.24E+01	1.59E+01
MNCorr.	0.9117	1.03E+00	0.8526	0.952
AD	-10.19	-3.17E+01	-8.8678	-6.8534
SC	1.0097	7.30E-01	1.0921	0.9941
MD	123	1.09E+02	123	86
NAE	0.373	5.23E-01	0.4124	0.277
Elapsed time (sec)	7.621745	7.672785	7.673764	9.840020
STD	10.5236	1.06E+01	13.6214	8.8657
SFM	0.3935	3.77E-01	0.25	0.3045
En	5.06917	4.84E+00	4.5857	4.386662
Correlation	0.1969	1.98E-01	0.2165	0.2097

Table. I Table showing different parameters using Minimum Power Adaptation Algorithm for different image formats

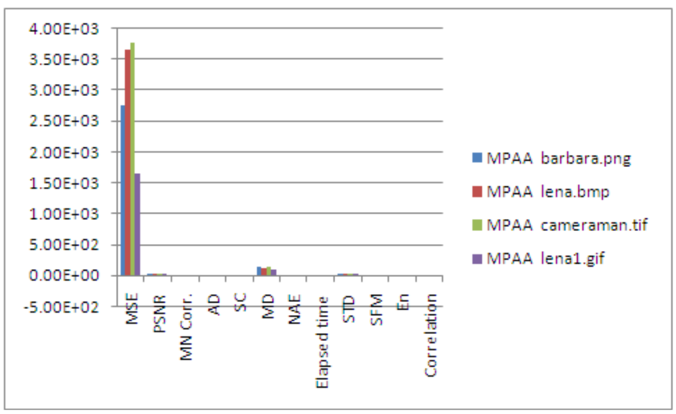

Fig.1 Plot showing different parameters using Minimum Power Adaptation Algorithm for different image formats

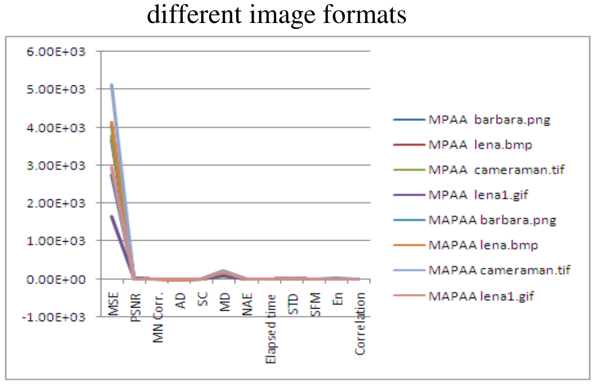

Fig.2 Plot showing different parameters using Minimum and Maximum Power Adaptation Algorithm for different image formats

Power Allocation Method	MAPAA			
Image Format	**Barbara.png**	**Lena.bmp**	**Cameraman.tif**	**Lena1.gif**
MSE	4.06E+03	4.14E+03	5.13E+03	2.95E+03
PSNR	1.20E+01	1.20E+01	1.10E+01	1.34E+01
MNCorr.	0.7895	0.8979	0.7394	0.8283
AD	6.6688	-14.9932	7.8111	9.8273
SC	1.2134	0.8754	1.3087	1.1931
MD	224	214	227	202
NAE	0.4368	0.55	0.4824	0.35
Elapsed time (sec)	7.798703 seconds	7.663775 seconds	7.606087 seconds	7.639787 seconds
STD	37.1228	36.9908	37.9231	36.4632
SFM	0.3916	0.3767	0.2499	0.3038
En	6.052191	5.912548	5.735599	5.604073
Correlation	0.034	0.0552	0.0538	0.0534

Table. II Table showing different parameters using Maximum Power Adaptation Algorithm for different image formats

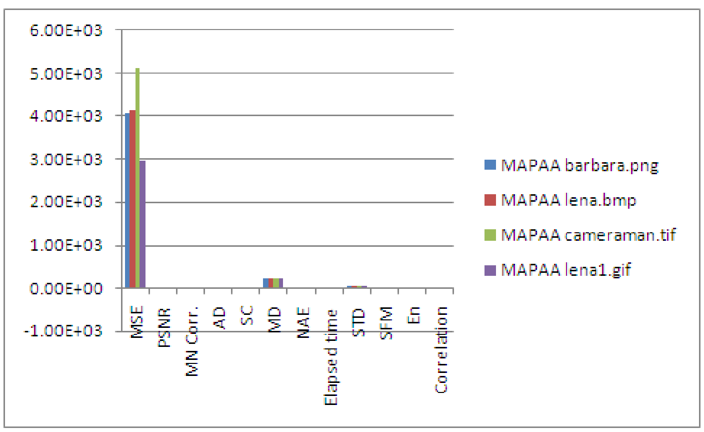

Fig.3 Plot showing different parameters using Maximum Power Adaptation Algorithm for different image formats

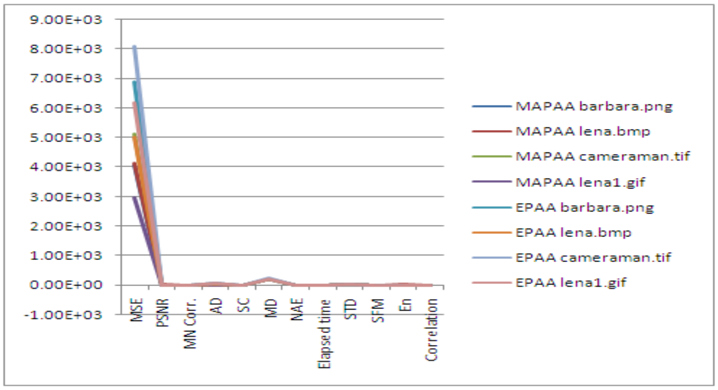

Fig.4 Plot showing different parameters using Maximum and Equal Power Adaptation Algorithm for different image formats

Table. III Table showing different parameters using Equal Power Adaptation Algorithm for different image formats

Power Allocation Method	EPAA			
Image Format	**Barbara.png**	**Lena.bmp**	**Cameraman.tif**	**Lena1.gif**
MSE	6890	5020	8.08E+03	6.18E+03
PSNR	9.75	11.12	9.06E+00	10.2194
MNCorr.	0.46	0.524	0.4313	0.4804
AD	53.5	31.64	54.532	56.4457
SC	2.99	2.139	3.209	2.9304
MD	223	219	237	209
NAE	0.58	0.592	0.6555	0.5408
Elapsed time (sec)	21.469618	22.067712	23.430954	22.361518
STD	38.3	38.29	38.5099	37.6496
SFM	0.39	0.37	0.2422	0.2978
En	7.08	7.085	7.098955	7.06968
Correlation	0.05	0.053	5.58E-02	0.0341

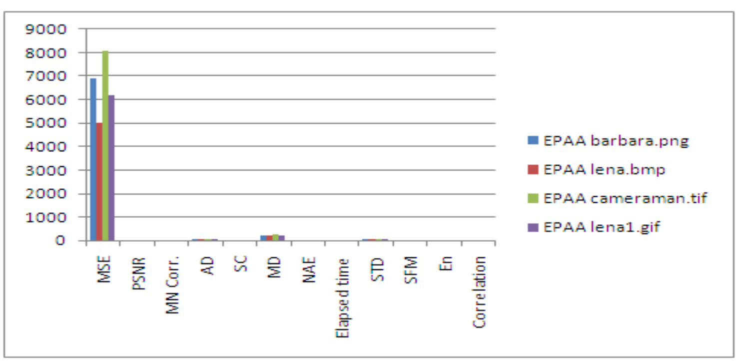

Fig.5 Plot showing different parameters using Equal Power Adaptation Algorithm for different image formats

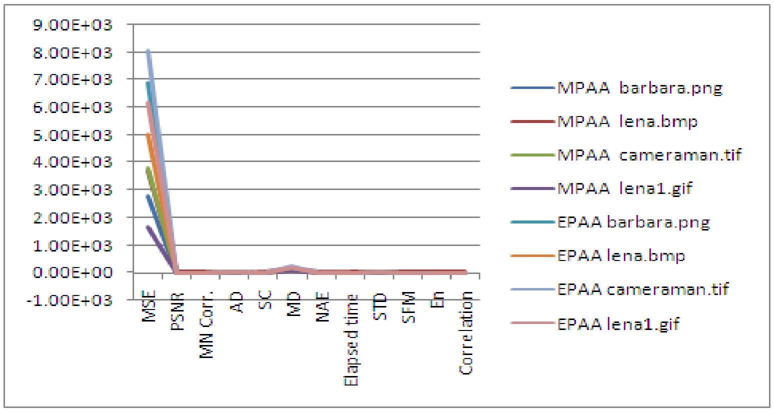

Fig.6 Plot showing different parameters using Minimum and Equal Power Adaptation Algorithm for different image formats

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