ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 7, September 2012

PERFORMANCE ANALYSIS OF BALANCED AND DISTANCE POWER ADAPTATION ALGORITHMS FOR WIRELESS IMAGE TRANSMISSION

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Abstract-**Power is adapted for reducing the error in the data while transmission is carried. The Distance-based power adaptation algorithm (DPAA) uses the distance between reference bit and each bit to allocate transmitted power to each of its other bits. Thus, more transmitted power should be allocated to bits which are far from their corresponding bits. In order to avoid having very small transmitted powers for bits close to the reference bit, bits whose distance is less than a certain threshold value, the same transmitted power is allowed. The Balanced Power Adaptation Algorithm (BPAA) calculates the optimal transmission power assignment for each bit within the vector, taking into account all the neighboring bits.The algorithm sets upper and lower bounds for the power level to balance the power.In this paper,the performance of both the DBPAA and BPAA was analyzed based on the Mean Square Error(MSE),RootMeanSquareError (RMSE) and Peak Signal to Noise Ratio(PSNR).The Balanced Power Adaptation Algorithm (BPAA) shows better performance compared to Distance and Conventional Power AdaptationAlgorithm(DPAA) in terms of Mean Square Error and Image Quality.**

Keywords: Balanced, Distance, RMSE, PSNR

I. INTRODUCTION

One of the most important and challenging goal of current and future communication is transmission of high quality multimedia like images from source to destination quickly with least error where limitation of bandwidth is a prime problem.It is very difficult to afford adequate 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. 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 medical and financial data.
Techniques are continuously being developed to maximize data throughput and efficiency in this wireless Communication systems while endeavoring to keep data loss and error to a minimum. Power Adaptation has been an effective approach to extenuate 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.mitigation
The adaptation of power becomes even more critical with devices integrating complex multimedia processing techniques with communications. The need for dynamic adaptation of transmitted power in communication systems was first encountered in the area of satellite communications. To fulfill this, balancing (also called power balancing) algorithms were proposed by Aein [2] and Meyerhof [3] in the early 1970's.The power balancing algorithms equalize, where possible Although Systems are stochastic; the power adaptation problem leads to a purely deterministic eigen value problem or a linear equation. The Distance Power Adaptation Algorithm calculates the optimal transmission power assignment for each bit within the vector, taking into account all the neighboring bits.

This paper shows that the Distance Power Adaptation Algorithm is well suited for multimedia like image and video signals, where different bits carry different amount of information. The powers for these bits are balanced using this algorithm since it takes the advantage of the both Maximum and Minimum Power. So, the power neither goes to infinity nor goes to zero. The algorithm sets upper and lower bounds for the power level to balance the power. Both the schemes specifically are optimized for minimizing the mean square error (MSE) of the image or video signal and Peak Signal toNoise Ratio (PSNR) is analyzed for quality of images.

The rest of the paper is organized as follows. The noise used in this paper is AWGN .Section II presents the signal model. The Distance Power Adaptation Algorithm and Balanced Power Adaptation Algorithm is presented in section III. Section IV presents the simulation results. Finally, conclusions are drawn in section V.

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

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bits for transmission. The transmitted BPSK signal is represented as

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

The channel used in this paper is the additive white Gaussian noise (AWGN) channel. 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

$$Y = x + n \quad (2)$$

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

The bit error probability is $P_b = \int_A^{\infty} \frac{1}{\sqrt{2\pi\frac{\sigma^2}{2}}} e^{-\frac{x^2}{\frac{\sigma^2}{2}}}$ (3)

And the Q-function is given by

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

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

Equation (5) 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

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

With erf(0)= 0 and erf(∞)=1

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

$$P_s = 1 - [1 - Q(\sqrt{(2\gamma\_b)})]^2 \quad (8)$$

$$\gamma_s = 2\gamma_b = \frac{A^2}{N_o} \quad (9)$$

$$P_s \le 2Q(\sqrt{\gamma_s}) + Q(\sqrt{2\gamma_s}) \le 3Q(\sqrt{\gamma_s})$$

Where the Q function is defined as:

$$Q(x) \le \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-\frac{x^2}{2}} dx \quad (10)$$

III. Distance Power Adaptation Algorithm (DPAA)

When there are N number of images and M number of bits in a multimedia system, then the powers transmitted by the bits be $P = [P_1, P_2, \ldots\ldots\ldots\ldots\ldots.. P_M]$ 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 i_{th} sample with a decimal value of (i) is reconstructed is given by

$$P_i = \prod_{k=0}^{M-1} [p_k \vartheta(k) + (1-p_k)\widetilde{\vartheta(k)}] \quad (11)$$

$\vartheta(k)$ 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

$$MSE = \frac{1}{\sqrt{2^M - 1}} \sum_{k=0}^{M-1} P_i \quad (12)$$

The probability of the kth bit to be in error for the AWGN case is given by

$$PE_k = Q(\sqrt{2\frac{E_b}{N_o}(k)}\,) \quad (13)$$

In these systems, the MSE level is satisfied at each bit. Once the bit adaptation is carried out, the power adaptation takes a role of adapting 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:

Distance Based Power Adaptation Algorithm (DBPAA)

- Initialize number of iterations

- Initialize number of bits
- Initialize power step size to ΔP.
- Initialize p_u, Upper bound power and p_l, Lower bound power
- Initialize dmin, R, k, n
- for i = 1 to iterations
- Initialize power vector to all ones
- Initialize PAPRmax
- For j = 1 to bits
- if $d_{bb} \leq$ dmin
- $p\ (j) = k\ (dmin/\ R)^n$
- else
- $p\ (j) = k(d_{bb}\ (j)/R)^n$
- end
- Initialize power step size to ΔP.
- For i = 1 to iterations
- Define two bits, R is recipient power and C is contributing power ,
- For j = 1 to bits
- Compute RMSE.
- Update power of all the bits using

$$P_i^{n+1} = RMSE_i^n x P_i^n \quad (14)$$

Where

$$RMSE_i^n = \frac{MAX\ (RMSE_i^n, RMSE_T)}{RMSE_i^n} \quad (15)$$

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

- Calculate the maximum power of each bit.

Balanced Power Adaptation Algorithm (BPAA)

- Define two bits, R is recipient power and C is contributing power ,
- for j = 1 to bits
- Compute RMSE.
- Update power of all the bits using

$$RMSE_i^n = \frac{MIN(RMSE_i^n, RMSE_T)}{RMSE_i^n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots p_n^i \geq p_u$$

$$= \frac{MAX\ (RMSE_i^n, RMSE_T)}{RMSE_i^n} \ldots\ldots\ldots\ldots\ldots\ldots\ p_n^i \geq p_l$$

$$= RMSE_i^n\text{-}1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . p_u \leq p \leq p_l \quad (16)$$

- Repeat the same procedure above using equations (14) and (15) but with the Contributor bit C incremented by one until all least significant bits are used.
- Calculate the maximum MSE.
- Plot Energy per Bit versus RMSE and PSNR.

IV. Numerical Results and Conclusions

Fig.1 shows the Original image. Image transmission over AWGN is considered with M = 8 bpp for Conventional and Distance power adaptation and Balanced Power Adaptation Algorithms. The improvement in performance obtained by the Conventional power adaptation Algorithm is compared with the Distance Power Adaptation Algorithm and the Balanced Power Adaptation Algorithm. The values of MSE, RMSE and PSNR are shown in Table 1 and Table 2.Better Performance of PSNR is observed in Balanced Power Adaptation Algorithm (BPAA) compared with Distance and Conventional Power Adaptation Algorithm (CPAA) as shown in Fig.3.

Fig.2and Fig.3 shows the Received image using Distance Power Adaptation Algorithm and Balanced Power Adaptation Algorithm. The image proves that better Performance is observed in Balanced Power Adaptation Algorithm compared with Distance and Conventional Power Adaptation Algorithm.

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Fig.5 and Fig.6 shows the plots of PSNR and RMSE performance of Distance Power Adaptation Algorithm, Balanced Power Adaptation Algorithm and Conventional Power Adaptation Algorithm. Ihe plots proves that better Performance is observed in Balanced Power Adaptation Algorithm compared with Distance and Conventional Power Adaptation Algorithm.

Fig. 1 Original Image

Fig.2 Received Image Using Distance Power Adaptation Algorithm

Fig.3 Received Image Using Balanced Power Adaptation Algorithm

Fig.4 Received Image Using Conventional Power Adaptation Algorithm

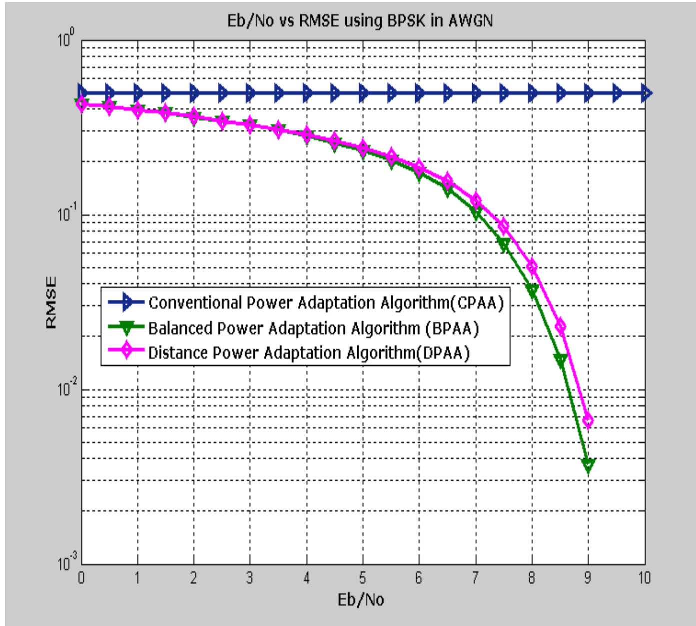

Fig.5 Plot showing RMSE over AWGN using Balanced, Distance Conventional power Adaptation Algorithm

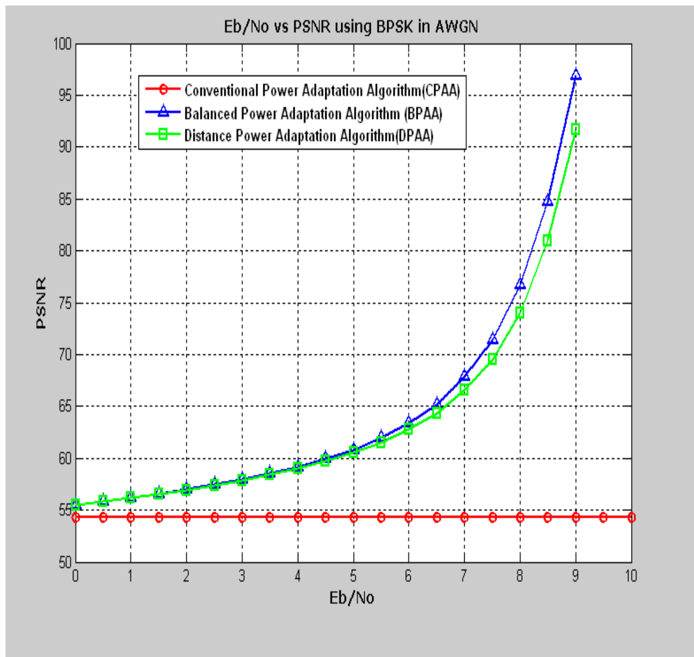

Fig.6 Plot showing PSNR over AWGN using Balanced, Distance Conventional power Adaptation Algorithm

Table I: RMSE, PSNR values of Image Transmission using Distance Power Adaptation Algorithm

E_b/N_o dB	RMSE	PSNR
0	0.4299	55.4973
0.5	0.4141	55.8221
1	0.398	56.1669
1.5	0.3815	56.5357
2	0.3635	56.9548
2.5	0.3455	57.3966
3	0.3264	57.8902
3.5	0.3072	58.4164
4	0.286	59.0382
4.5	0.2639	59.7366
5	0.2409	60.5278
5.5	0.2151	61.5123
6	0.1862	62.766
6.5	0.1547	64.3744
7	0.12	66.5787
7.5	0.0854	69.5353
8	0.0508	74.0539
8.5	0.0299	80.983
9	0.0066	91.7432
9.5	0	Inf

Table II: RMSE, PSNR values of Image Transmission Using Conventional Power Adaptation Algorithm

E_b/N_o dB	RMSE	PSNR
0	0.4953	54.2673
0.5	0.4951	54.2796
1	0.4947	54.2643
1.5	0.4945	54.2688
2	0.4942	54.2553
2.5	0.4951	54.271
3	0.4945	54.2839
3.5	0.4957	54.2757
4	0.4946	54.2941
4.5	0.495	54.2673
5	0.4958	54.2779
5.5	0.4948	54.2757
6	0.4948	54.2758
6.5	0.4944	54.2697
7	0.495	54.2699
7.5	0.4953	54.2772
8	0.4952	54.2641
8.5	0.4946	54.2897
9	0.4946	54.2758
9.5	0.4942	54.2687

Table III: RMSE, PSNR values of Image Transmission using Balanced Power Adaptation Algorithm

E_b/N_o dB	RMSE	PSNR
0	0.4303	55.4901
0.5	0.4148	55.8074
1	0.3981	56.1642
1.5	0.3812	56.5411
2	0.3626	56.9764
2.5	0.3437	57.4409
3	0.3242	57.9473
3.5	0.3041	58.5038
4	0.2821	59.1563
4.5	0.2583	59.9234
5	0.2339	60.7852
5.5	0.2038	61.9819
6	0.1739	63.3597
6.5	0.1417	65.1383
7	0.1041	67.814
7.5	0.0686	71.437
8	0.03	76.7332
8.5	0.0149	84.7159
9	0.0037	96.9095
9.5	0	Inf

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