Analysis of Objective Quality Metrics for Qpsk Image Transmission over Different Wireless Channels with Maximum Power Adaptation Method

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Abstract: This Paper gives an analysis of different distortions in Image transmission over wireless channel with Maximum Power Adaptation Method. Metrics to analyze the quality of image as perceived by human observers are becoming increasingly important, due to the large number of applications in multimedia. In this paper, Local var, Speckle distotion, poisson distortion types of distortions are considered.RMSE, PSNR, SSIM results show a better performance in Maximum Power Adaptation Algorithm (MAPAA) rather than conventional Power Adaptation Algorithm (CPAA).

Keywords: **Metric, Maximum Power, Distortion, RMSE, PSNR**

I.INTRODUCTION

Objective Quality Metrics play an important role in the analysis of image quality .Generally transmission of images is a complex process which involves a lot of high reliable speed transmission is required. Moreover, multipath fading also degrades transmission reliability. It is a challenge to realize multimedia data transmission in wireless communications.

Today’s Human beings are not only used to just looking at the natural environment anymore but rather at artificial productions of it in terms of digital images such as multimedia. As we are accustomed to real world environment quality, whatever the images observed by people also expect some quality. However, the quality is often reduced due to many factors which influence some features such as acquisition, source coding, or transmission of the image or multimedia

The parameters that are responsible for the degradation of visual eminence often warp the openness of the image. The dilapidation in image quality depends highly on the type and severeness of the parameter to make a judgement about the visual quality. Considering the easiness of degraded parameter detection by a human observer, it is therefore highly desirable to achieve high quality representations of the ubiquitous image and video applications.

In this paper, we present our analysis of objective image quality metrics for Image Transmission over Wirelesss Channels with different distortions. The rest of the paper is structured as follows: In the subsequent section, we discuss problems of image transmission over wireless communication channel, and we present our research approach. Section I11 provides some background about Maximum Power Adaptation Algorithm. Section IV presents experimental results.The performance analysis and evaluations are discussed in section V. Finally, there is a brief conclusion and some remarks.

II. BRIEF OVERVIEW OF OBJECTIVE METRICS AND DISTORTIONS

2.1 TYPES OF DISTORTIONS

Gaussian noise - Gaussian noise is statistical noise that has a probability density function of the normal distribution (also known as Gaussian distribution). In other words, the values that the noise can take on are Gaussian-distributed. It is most commonly used as additive white noise to yield additive white Gaussian noise (AWGN).

Poisson noise - Poisson noise has a probability density function of a Poisson distribution.

Salt & pepper noise - It represents itself as randomly occurring white and black pixels. An effective noise reduction method for this type of noise involves the usage of a median filter. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching, take place. The image after distortion from salt and pepper noise looks like the image attached.

Speckle noise - Speckle noise is a granular noise that inherently exists in and degrades the quality of images. Speckle noise is a multiplicative noise, i.e. it is in direct proportion to the local grey level in any area. The signal and the noise are statistically independent of each other.

2.2 OBJECTIVE QUALITY METRICS

Image quality metrics are dominant to offer quantitative data on the fidelity of rendered images. Typically the quality of an image combination method is evaluated using mathematical techniques which attempt to quantify fidelity using image to image comparisons

(1)RMSE

The Root Mean Square Error (RMSE) (also called the root mean square deviation, RMSD) is a commonly used quantity of the difference between values predicted by a model and the values actually observed from the situation that is being modeled. These character differences are also called residuals, and the RMSE serves to summative them into a particular measure of analytical power.

The RMSE of a model prediction with respect to the estimated capricious Xmodel is defined as the square root of the mean squared error:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_{obs,i} - X_{model,i})^2}{n}}$$

Where Xobs is observed values and Xdesign is designed values at time i.

The calculated RMSE values will have units

(2)PSNR

Peak Signal-to-Noise Ratio, often abridged PSNR, is an trade term for the ratio between the maximum probable power of a signal and the power of humiliating noise that affects the loyalty of its representation. Because many signals have a very wide energetic range, PSNR is typically expressed in terms of the logarithmic decibel scale.

PSNR is most commonly used to measure the eminence of renovation of lossy density codecs. The signal in this case is the novel data, and the noise is the fault introduced by compression. When comparing density codecs, PSNR is an estimate to human observation of renovation quality. Although a superior PSNR generally indicates that the modernization is of higher quality, in some cases it may not.

(3)SSIM

SSIM is an objective image eminence metric and is better to conventional quantitative measures such as MSE and PSNR.

A general form of SSIM is

$$SSIM(x,y) = [l(x,y)]^{˜}[c(x,y)]\ [s(x,y)]^{¥},$$

Where x, y are image patches and

$$l(x,y) = \frac{2«_x«_y + C_1}{«_x^2 + «_y^2 + C_1},\quad c(x,y) = \frac{2±_x±_y + C_2}{±_x^2 + ±_y^2 + C_2},\quad s(x,y) = \frac{±_{xy} + C_3}{±_x±_y + C_3}$$ and

l(x,y) is luminance comparison (eq. 6), c(x,y) is contrast comparison (eq. 9), and s(x,y) is structural comparison (eq. 10). C_1, C_2, C_3 are constants. μx, μy, σx, σy, σxy are defined in Eqs.14, 15, 16 in the reference paper. Gaussian $w(n_1,n_2) = \exp\left(-\frac{n_1^2+n_2^2}{2±^2}\right)$, $n_1, n_2 = 1, 2, \cdots, 11$

III . MAXIMUM POWER ADAPTATION ALGORITHM(MAPAA)

MAPAA is an improved version of the MPAA algorithm. The previous algorithm considers the minimum of the basic information, whereas this algorithm differs from it in its consideration of the maximum value of the same. Here the new power level is calculated by the product of the previous power level and the maximum value ratio of RMSEs. All the constraints of MPAA are also satisfied by MAPAA. The power adaptation is done according to the following steps:

Algorithm Steps:

1. *Initialize number of iterations, N*
2. *Initialize number of bits, M*
3. *Initialize power step size to ΔP.*
4. *Initialize* $PAPR_{max}$.

   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*

$$P_i^{n+1} = RMSE_i^n \, x \, P_i^n \qquad (1)$$

$$RMSE_i^n = \frac{MAX\,(RMSE_i^n, RMSE_T)}{RMSE_i^n} \qquad (2)$$

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

9. *Calculate the maximum power of each bit.*
10. *Repeat the same procedure (5) and (6) above but with the Contributor bit C incremented by one until all least significant bits are used.*
11. *Calculate the maximum RMSE.*

IV. NUMERICAL RESULTS AND CONCLUSIONS

(a) SALT AND PEPPER

E_bN_o(dB)	MSSIM	RMSE	PSNR
0	0.0720	106.7002	7.6015
1	0.0635	106.5161	7.6165
2	0.0608	106.3326	7.6315
3	0.0526	105.1957	7.7248
4	0.0354	103.6156	7.8563
5	0.0310	102.5241	7.9483
6	0.0298	101.3980	8.0442
7	0.0294	99.7710	8.1847
8	0.0304	99.5126	8.2072
9	0.0318	98.3590	8.3085

(b) LOCAL VAR

$E_{b-}N_o$(dB)	MSSIM	RMSE	PSNR
0	0.0763	106.8311	7.59
1	0.0621	106.4912	7.61
2	0.0513	106.0298	7.65
3	0.0396	105.2078	7.72
4	0.0333	104.1129	7.81
5	0.0313	102.9429	7.91
6	0.0301	101.6551	8.02
7	0.0302	100.3992	8.13

8	0.0309	99.3944	8.21
9	0.0315	98.4178	8.30

(c) SPECKLE

E_bN_o(dB)	MSSIM	RMSE	PSNR
0	0.1053	107.1940	7.5614
1	0.0940	106.8629	7.5883
2	0.0658	106.2785	7.6359
3	0.0408	105.3862	7.7091
4	0.0351	104.2236	7.8055
5	0.0306	102.8306	7.9224
6	0.0300	101.6852	8.0196
7	0.0298	100.6100	8.1120
8	0.0305	99.3784	8.2190
9	0.0316	98.4245	8.3027

(d) POISSON

E_bN_o(dB)	MSSIM	RMSE	PSNR
0	0.1084	107.2211	7.5592
1	0.1005	107.0102	7.5763
2	0.0900	106.5912	7.6104
3	0.0585	105.5947	7.6920
4	0.0382	104.2263	7.8053
5	0.0331	102.9988	7.9082
6	0.0299	101.7365	8.0153
7	0.0298	100.4428	8.1264
8	0.0306	99.6516	8.1951
9	0.0317	98.6563	8.2823

(e) MOTION BLUR

E_{b}-N_o(dB)	MSSIM	RMSE	PSNR
0	0.1208	107.19	7.5612
1	0.1058	106.93	7.5826
2	0.0964	106.55	7.6135
3	0.0783	105.39	7.7086
4	0.0441	103.74	7.8454
5	0.0347	102.52	7.9484
6	0.0336	101.28	8.0541
7	0.0325	100.03	8.1621
8	0.0334	99.602	8.1994
9	0.0343	98.485	8.2974

(f) EROSION

E_bN_o(dB)	MSSIM	RMSE	PSNR
0	0.0910	104.42	7.7889
1	0.0785	103.85	7.8359
2	0.0739	103.13	7.8970
3	0.0555	101.77	8.0121
4	0.0382	100.35	8.1338
5	0.0375	99.56	8.2029
6	0.0369	98.547	8.2919
7	0.0363	97.881	8.3508
8	0.0364	97.252	8.4067
9	0.0366	96.057	8.5141

(g) DILATION

$E_{b-}N_o$(dB)	MSSIM	RMSE	PSNR
0	0.0910	104.42	7.7889
1	0.0785	103.85	7.8359
2	0.0739	103.13	7.8970
3	0.0555	101.77	8.0121
4	0.0382	100.35	8.1338
5	0.0375	99.562	8.2029
6	0.0369	98.547	8.2919
7	0.0363	97.881	8.3508
8	0.0364	97.252	8.4067
9	0.0366	96.057	8.5141

(h) JPG COMPRESSION BLOCKING EFFECT

E_bN_o(dB)	MSSIM	RMSE	PSNR
0	0.1964	82.4416	9.8419
1	0.1964	82.4416	9.8419
2	0.1964	82.4416	9.8419
3	0.1964	82.4416	9.8419
4	0.1964	82.4416	9.8419
5	0.1964	82.4416	9.8419
6	0.1964	82.4416	9.8419
7	0.2182	73.7741	10.8067
8	0.2182	73.7741	10.8067
9	0.2182	73.7741	10.8067

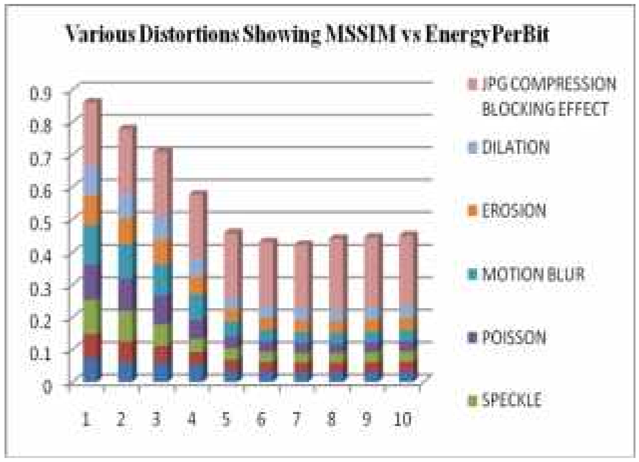

Fig.1 Plot represents various distortions showing MSSIM

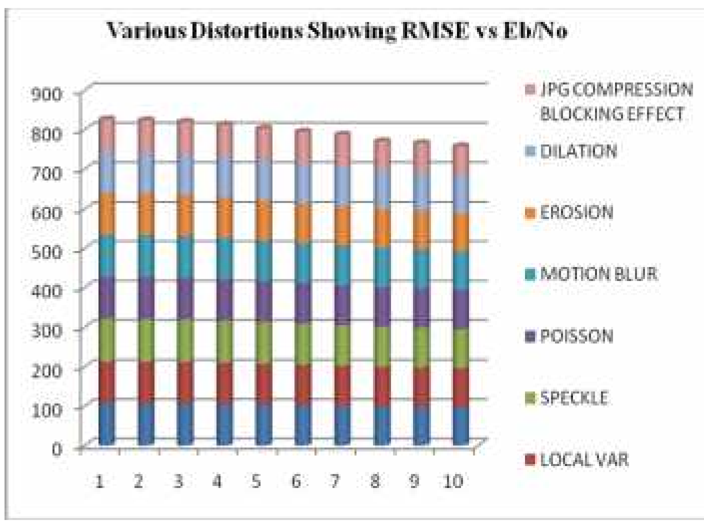

Fig.2 Plot represents various distortions showing RMSE

The MSE remains the same in most of the cases the MSSIM is different depending on the contrast and quality of the image.Fig.1 and Fig.2 represents various distortions showing MSSIM, RMSE and PSNR.In the plots, it clearly shows that out of all distortions discussed in the paper,JPEG compression blocking effect shows better MSSIM value. The Quality of the image is also better in JPEG compression blocking effect distortion, which is shown in fig.3.The MSSIM value is also higher in JPEG Compression distortion which is shown in table (h).Tables (a) ,(b),(c),(d),(e),(f),(g) shows the MSSIM,RMSE and PSNR values.

Distortion can be further reduced by different ways. In this Paper, an image transmitted through various distortion analysis is presented. First, an image is considered and converted to digital form. It is then transmitted through different distortions. Maximum Power adaptation vector is transmitted to optimize the root mean square error. In this QPSK type modulation is applied.

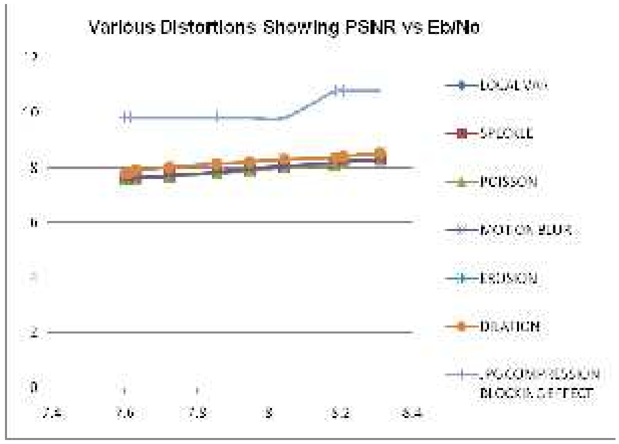

Fig.3 Plot represents various distortions showing PSNR

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