What Statistics is PSNR Related using JPEG2000

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***Abstract*—JPEG2000 encoder is well designed, it makes full use of the redundant information among the images. Many of us may have the experience that when compress variety of images of different types using it, the peak signal-to-noise ratio (PSNR) values vary widely from image to image. This large variation in PSNR can only be attributed to the nature and inherent characteristics of the image, since everything else is fixed. In this paper, we analyze the statistics and features using a large set of images, which generally provide a good representation of the global nature of the image. It can show that most of the gray-level statistics we have measured are not related at all with the PSNR using JPEG2000 except for image activity measure(IAM).**

I. INTRODUCTION

There are four types of redundant information in images. One is redundance between pixel and pixel. For a gray-level image, the pixel intensity is the basic unit of the image. Many proposed encoders take advantage of this type of redundance among pixels. If one pixel can be estimated from the other pixels under a predetermined error, we can get an effective compression. The more this type of redundant information exists in one image, the easier one pixel can be predicted, the better peak signal-to noise ratio (PSNR) we get when using one fixed encoder. Another redundant information refers to image structure. As we all known, encoders based on fractal can obtain a surprising high compression ratio (CR). What's more, the compression is nearly lossless. The third type is coding redundance. When stored or transfered, the compressed data should be formed in a particular format for a higher CR. This step is always lossless, and the CR differs from 1 to 2. The fourth type is psychological visual redundancy. The compression of this redundant information is mainly based on human vision system (HVS).

JPEG2000 encoder is well designed. It makes full use of the first and the third types of redundant information in images. Many of us may have the experience that when we compress variety of images of different types using JPEG2000 encoder, the PSNR values vary widely from image to image. In paper [1] and [2] show that when compressing a variety of images using the popular CDF-9/7 wavelet filter, for a compression ratio say 16:1, they get widely varying PSNR values ranging from as low as 25 dB for the baboon image to as high as 56dB for the ball image. It has been observed that this large variation in PSNR is as much as 30dB when a fixed encoder based on wavelet filter is used. It is also a common sense that natural images will obtain higher value in PSNR than synthetic images. One possible reason is that natural images are continuous tone while synthetic images are discrete tone. Such images generally have some numerical structures that are well represented by smooth basis functions.

Following paper [2]'s method, we have used a large set of gray-level image statistics and features, and have analyzed these images. These include the first, second, and higher order statistics, viz. mean, median, range, standard deviation, coefficient of variation, energy, entropy, skewness, kurtosis, and image activity measure (IAM). These statistics generally provide a good representation of the global nature to the image. The coding performance measure which we use is the standard PSNR measured in dB. The statistical data shows that there is a strong relationship between the feature IAM and PSNR.

$$PSNR = 10\lg\frac{255^2 \times X \times Y}{\sum\limits_{i=1}^{X}\sum\limits_{j=1}^{Y}(I(i,j)-\hat{I}(i,j))^2} \tag{1}$$

where X and Y indicate the width and height of the image, $\hat{I}$ describes the decompressed image.

II. ANALYSIS

A. Histogram

The image histogram can provide many clues as to the character of the image. For example, a narrowly distributed histogram indicates a low-contrast image. It is likely that the image is natural when there's a smooth envelope line in histogram. Some features of histogram are used here to see if these features are PSNR related. We assume that $I(i)$ is the image intensity value of pixel i, N is the total number of pixels in the image.

1) Range: The Range of histogram can indicate the image content. An image of natural landscape always has a wide range in histogram, while a narrow range means that the content is sententious and low-contrast.

$$R = Max(I(i)) - Min(I(i)) \tag{2}$$

2) Median: The median of histogram together with range reflect the whole intensity of images. It is the value of histogram in middle position.

3) Mean: The mean of image reflects the brightness of main regions of the image, which is called background.

$$m = \frac{1}{N}\sum_i I(i) \tag{3}$$

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Under most circumstances, the mean equals to median or nearly the same. We should take a look at the difference between them.

$$D = m - M \tag{4}$$

4) Variance: The variance is a measure of dispersion.

$$\sigma^2 = \frac{1}{N-1}\sum_i (I(i) - m)^2 \tag{5}$$

5) Coefficient of Variation: The coefficient of variation is a measure of relative dispersion.

$$\eta = \frac{\sigma}{m} \tag{6}$$

6) Skewness: Skewness refers to whether the histogram is symmetrical with respect to its dispersion from the mean or not. If one side of the mean has extreme scores while the other does not, the histogram is called skewed. If the dispersion of scores on either side of the mean is roughly symmetrical, the distribution is said to be not skewed.

$$s = \frac{1}{N}\sum_i (\frac{I(i) - m}{\sigma})^3 \tag{7}$$

7) Kurtosis: Kurtosis refers to the weight of the tails of a histogram. Histograms which a large proportion of the intensity value are towards the extremes are said to be platykurtic. On the other hand, if the intensities are bunched up near the mean, the histograms are called leptokurtic. A normally distributed histogram is mesokurtic, and the kurtosis is zero.

$$\kappa = \frac{1}{N}\sum_i (\frac{I(i) - m}{\sigma})^4 - 3 \tag{8}$$

Two histograms, may have a same variance, approximately a same skewness, but differ markedly in kurtosis.

B. Image Energy

Usually, a bright image will have more energy than a dark image.

$$E = \frac{1}{N}\sum_i I(i)^2 \tag{9}$$

C. Image Entropy

We use three different entropy measures. During our experiment, we find that paper [2] has some mistakes on these equations. So we examine several possible definition, and finally get the form what they used. In order to avoid ambiguity, the base of logarithm is marked.

As the binary probability space is the simplest probability space, we can take the entropy of that space under equiprobably circumstances as a unit of entropy. The unit is called bit, the base of logarithm should take 2. In some binary digital system, such as digital computers and digital communication systems, when it is used in analysis and design, bit is suitable. In addition, it is introduced that the e can also be used as the base of logarithm, while the units is nat. And sometimes 10 is used here when the unit is Hartley. In some theoretical derivation of information theory, it is more convenient to use e as the base of logarithm.

- Normal entropy

$$E_n = \frac{1}{N}\sum_i I(i)\log_2 I(i) \tag{10}$$

which in paper [2] is

$$E_n = I(i)\log I(i)$$

- Shannon entropy

$$E_s = -\frac{1}{N}\sum_i I(i)^2 \log_e(I(i)^2) \tag{11}$$

which in paper [2] is

$$E_s = -\frac{1}{N}\sum_i I(i)^2 \log(I(i)^2)$$

- Log Energy entropy

$$E_{le} = \frac{1}{N}\sum_i \log_e(I(i)^2) \tag{12}$$

which in paper [2] is

$$E_{le} = -\frac{1}{N}\sum_i \log(I(i)^2)$$

D. Image Activity Measure

We notice that in paper [2], IAM is defined as follows:

$$\begin{aligned} IAM &= \frac{1}{X \times Y}\Bigg[\sum_{i=1}^{X-1}\sum_{j=1}^{Y}|I(i,j) - I(i+1,j)| \\ &\quad -\sum_{i=1}^{X}\sum_{j=1}^{Y-1}|I(i,j) - I(i,j+1)|\Bigg] \end{aligned} \tag{13}$$

TABLE I
COMPARISON BETWEEN (13) AND (14)

Images	Eq. (13)	IAM in Table 1 of [2]	Eq. (14)
lena	-1.1114	11.3	9.8526
peppers	-0.259	12.8	12.709
airplane	0.21056	11.2	10.671
baboon	1.0529	34.4	21.413
camera	-0.60558	17.2	8.8134
bridge	0.58543	28.3	24.715

In our experiment done exactly under paper [2]'s instructions, we find that we couldn't come to their conclusion. When changing to this definition, we get the approximately equal result. Refer to table I. And we think that it may be the author's clerical error.

$$\begin{aligned} IAM &= \frac{1}{X \times Y}\Bigg[\sum_{i=1}^{X-1}\sum_{j=1}^{Y}|I(i,j) - I(i+1,j)| \\ &\quad +\sum_{i=1}^{X}\sum_{j=1}^{Y-1}|I(i,j) - I(i,j+1)|\Bigg] \end{aligned} \tag{14}$$

III. EXPERIMENT

To find out the relationship between PSNR and features proposed above, we pick up 100 images to perform an experiment. Sixteen of them are from [4]. These images are usually used to test whether an algorithm about image processing is excellent or poor. Thirty of them are kinds of types gathered from internet. The rest of them are cut from remote sensing images. All the images are "bmp" formatted, 512×512 size, gray-level.

The experimental environment is built like this:

- SUN server: SPARC IIIi × 2, 8GB memory
- OS: Solaris 10
- Java environment: JRE 6.0 update 3
- Encoder: JJ2000 v4.1 [5]

JJ2000 is an implementation of the JPEG2000 standard in Java$^{\text{TM}}$. Version 4.1 is the last release of the JJ2000 project, which officially is terminated in September 2001. In the following encoding and decoding operations, all the parameters are used as default. The code rate of original images and decompressed images are 8bpp. The code rate of compressed images are 0.5bpp. So we get a CR of 16:1.

All the data about statistics and features and the PSNR value is listed in table III. Then these data is plotted (Fig. 3) to see if there is a connection between any of these statistics and the PSNR value.

As we can see from these scatter plots, none of the gray-level statistics we have measured viz. range, median, mean, difference, standard deviation, coefficient of variance, skewness, kurtosis, energy, normal entropy, shannon entropy, log energy entropy seem to relate at all with the JPEG2000 coding performance. In other words, none of these statistics does explain the reason for the wide variation in PSNR for different images using the same JPEG2000 encoder.

Finally, the PSNR values have been plotted against the image activity measures as shown in Fig. 1. As we can see there is a clear relationship between the IAM and the PSNR values. Images with low IAM gains a much higher PSNR than images with high IAM. Paper [2] get a conclusion that this relationship is logarithmic, which can be expressed as follows:

$$y = \alpha \ln(x) + \beta \tag{15}$$

where

$$\alpha = -9.7314 \qquad \beta = 58.879$$

That was calculated with R-squared values, which reflects the proportion of variation explained by the regression curve, of 0.9694. It is obvious that we can not use paper [2]'s result. We try to fit the data with Eq. (15). Fig. 1 shows the fitting curve. Curve ends are too divergent, which obviously leave the distribution of data points.

Then, we find that the relationship between IAM and PSNR is exponential, not logarithmic. Fig. 2 is generated with the following equation:

$$y = a \cdot x^b + c \tag{16}$$

TABLE II
EXPERIMENTAL CONDITIONS AND RESULTS ANALYSIS OF CURVE FITTING IN MATLAB 7. 0

Item	Fig. 1	Fig. 2
Method	Nonlinear Least Squares	
Robust	On	
Algorithm	Trust-Region	
DiffMinChange	$1.0E-8$	
DiffMaxChange	0.1	
MaxFunEvals	1000	
MaxIter	400	
TolFun	$1.0E-6$	
TolX	$1.0E-6$	
Confidence Bounds	99.9%	
SSE	140	49.7
R-square	0.9479	0.9815
Adjusted R-Square	0.9474	0.9811
RMSE	1.195	0.7158
DFE	98.0	97.0
Coeff	2.0	3.0

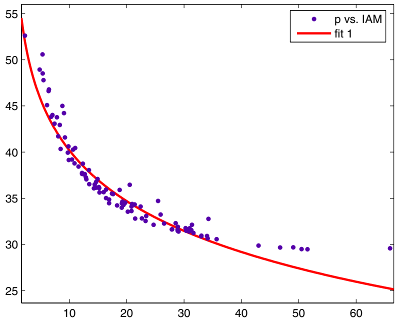


Fig. 1. Curve fitting: IAM—PSNR, logarithmic

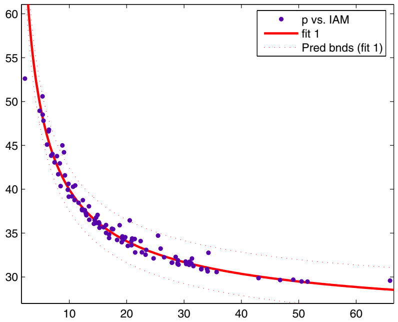
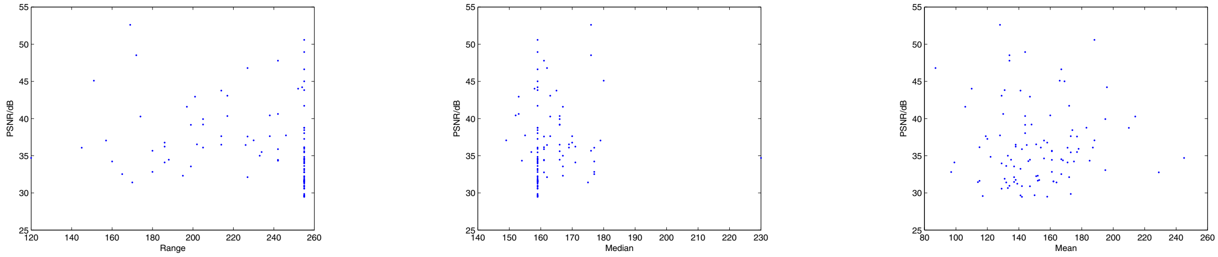
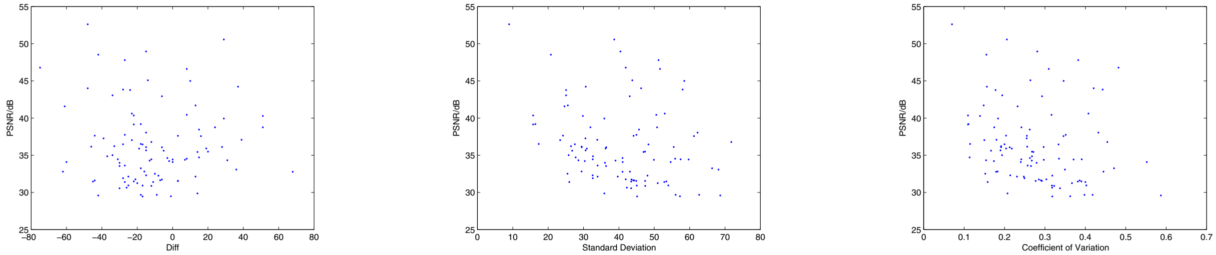


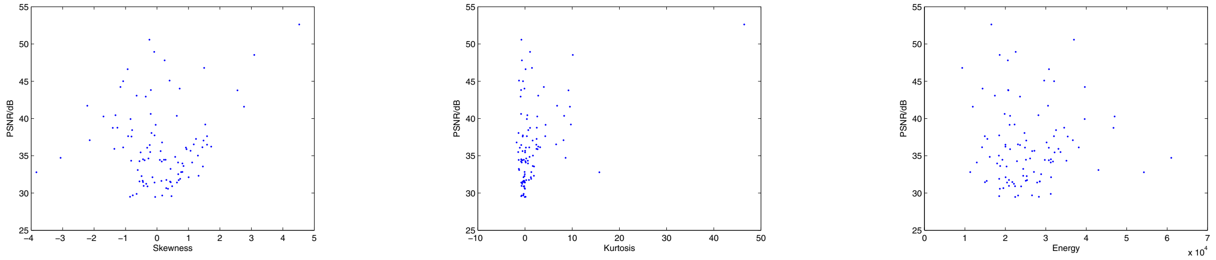
Fig. 2. Curve fitting: IAM—PSNR, exponential



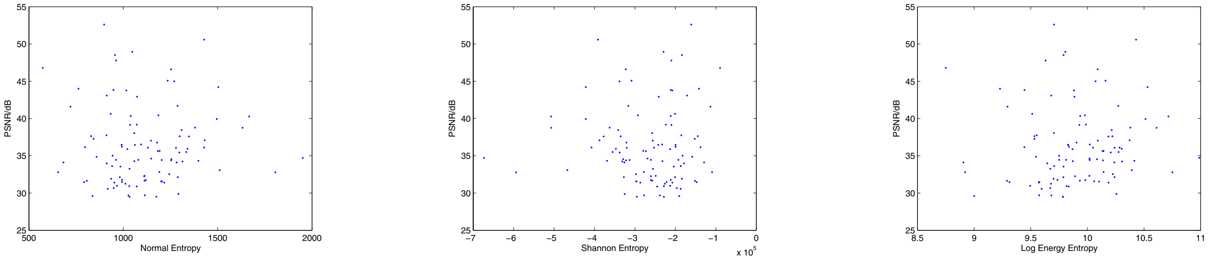
(a) Range—PSNR (b) Median—PSNR (c) Mean—PSNR



(d) Difference—PSNR (e) Standard Deviation—PSNR (f) Coefficient of variance—PSNR



(g) Skewness—PSNR (h) Kurtosis—PSNR (i) Energy—PSNR



(j) Normal entropy—PSNR (k) Shannon entropy—PSNR (l) Log energy entropy—PSNR

Fig. 3. Scatter plots between statistics and PSNR values

where

$$a = 73.67 \quad b = -0.6636 \quad c = 23.99$$

And the experimental conditions and results analysis of curve fitting in Matlab are listed in table II.

IV. CONCLUSION

In this paper, we have discussed which one of various statistics and features impacts the performance of JPEG2000 encoder prominently. Through analyzing a large variety of test images, it's obviously that there is some fault in paper [2]. We have corrected the IAM formula and got a more compellent result. The relationship between IAM and PSNR is exponential, not logarithmic. And it is IAM which impact the performance of JPEG2000 encoder deeply.

With the conclusions of this paper, for different images with different IAMs, when the JPEG2000 image compression algorithm and other improved algorithm have different effects, we can have a more objective evaluation on the proposed algorithm. In our next paper, we will propose a new method by which an image with high IAM can also be compressed well to achieve a high PSNR.

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[3] R C. Gonzalez and R E. Woods, *Digital Image Processing*, 2nd ed. Prentice Hall, 2002

[4] http://www.ece.utk.edu/~gonzalez/ipweb2e/downloads/standard_test_images/standard_test_images.zip

[5] http://jj2000.epfl.ch/jj_download/software/version_4_1/jj2000_4.1.tar.gz

TABLE III

STATISTICS AND FEATURES OF GRAY-LEVEL IMAGES AND PSNR BY USING JPEG2000 ENCODER/DECODER

Images	R	M	m	D	σ	η	s	κ	E	E_n	E_s	E_{le}	IAM	PSNR
1	255	159	134	-25	53.939	0.40253	-0.42628	-0.7444	20903	966.56	-2.1294e+005	9.4952	33.031	30.95
2	255	159	158	-1	57.255	0.36237	-0.85365	0.11668	28304	1175	-2.9545e+005	9.7833	50.488	29.491
3	255	159	141	-18	56.067	0.39764	0.16494	-0.71595	23151	1027.6	-2.3862e+005	9.6821	46.762	29.669
4	255	159	97	-62	43.13	0.44464	0.7655	1.3398	11301	655.46	-1.0922e+005	8.9197	21.493	32.803
5	186	171	171	0	41.094	0.24031	0.67204	-0.70544	31214	1282.7	-3.2649e+005	10.238	20.849	34.093
6	255	159	139	-20	51.004	0.36693	-0.34441	-0.58337	22133	1011.3	-2.2605e+005	9.6786	31.633	31.242
7	255	159	147	-12	47.452	0.3228	-0.30137	-0.2795	23888	1071.4	-2.4493e+005	9.8346	33.02	30.882
8	255	159	152	-7	44.07	0.28993	-0.45658	-0.20144	25050	1112	-2.5727e+005	9.9332	27.913	31.641
9	255	159	137	-22	53.436	0.39004	-0.44615	-0.52131	21712	992.86	-2.2173e+005	9.5762	30.365	31.481
10	255	159	162	3	47.394	0.29256	-0.55811	-0.40354	28513	1200.8	-2.9654e+005	10.06	28.862	31.559
11	255	159	156	-3	41.026	0.26299	-0.27021	0.23782	26132	1148	-2.6894e+005	10.018	19.252	34.632
12	255	159	183	24	31.928	0.17447	-1.2563	2.4953	34536	1380.6	-3.6274e+005	10.379	10.937	38.768
13	255	159	173	14	46.964	0.27147	-0.51821	0.0028432	32170	1297.3	-3.3791e+005	10.207	17.65	35.449
14	255	159	151	-8	48.063	0.3183	-0.49292	-0.14426	25293	1110.8	-2.6054e+005	9.8913	26.521	32.259
15	255	159	167	8	55.919	0.33485	-0.44671	-0.80715	31246	1254.3	-3.2897e+005	10.085	19.759	34.535
16	255	159	146	-13	39.039	0.26739	-0.55695	0.088527	22864	1058.8	-2.3227e+005	9.8717	19.457	34.267
17	255	166	161	-5	26.789	0.16639	0.11669	-0.54488	26647	1183.7	-2.7297e+005	10.135	15.277	35.612
18	205	169	154	-15	29.499	0.19155	0.91945	0.18617	24834	1130	-2.5312e+005	10.05	15.186	36.09
19	217	163	129	-34	25.065	0.1943	-0.64978	2.7873	17396	912.41	-1.7102e+005	9.6813	7.438	43.072
20	214	165	141	-24	25.073	0.17783	2.5593	9.1972	20724	1016.1	-2.0738e+005	9.8821	7.8538	43.772
21	227	162	137	-25	33.965	0.24792	1.0031	1.2304	20046	982.09	-2.0099e+005	9.789	31.368	32.118
22	199	167	137	-30	36.396	0.26567	1.4588	1.9012	20285	984.79	-2.0406e+005	9.7898	20.206	33.547
23	197	167	106	-61	24.606	0.23214	2.7695	9.5266	11938	720.42	-1.1347e+005	9.2948	9.2573	41.579
24	214	163	119	-44	24.224	0.20356	1.5901	4.285	14914	829.63	-1.4459e+005	9.5332	12.23	37.625
25	255	159	129	-30	36.045	0.27942	0.80719	0.64428	17956	911.98	-1.7858e+005	9.645	19.159	33.97
26	255	161	115	-46	29.425	0.25587	1.4429	3.2078	14240	797.66	-1.3805e+005	9.4427	14.645	36.155
27	255	159	120	-39	30.557	0.25464	1.2382	2.4346	15572	842.41	-1.523e+005	9.532	12.897	37.266
28	255	159	122	-37	32.672	0.26781	0.57871	0.98573	16160	859	-1.5874e+005	9.5467	16.952	34.856
29	214	166	138	-28	27.571	0.19979	1.5908	2.4113	20006	990.91	-1.9977e+005	9.8306	14.422	36.478
30	186	171	138	-33	26.457	0.19172	1.72	2.7959	20017	992.82	-1.9977e+005	9.8375	15.147	36.217
31	233	167	133	-34	25.79	0.19391	1.2968	1.6912	18399	943.18	-1.8209e+005	9.7495	16.416	35.016
32	172	176	134	-42	20.769	0.15499	3.0922	10.105	18607	955.9	-1.8391e+005	9.7891	5.3726	48.517
33	180	177	161	-16	29.449	0.18291	0.80398	-0.074031	27066	1191.6	-2.7802e+005	10.142	22.659	32.823
34	180	176	161	-15	30.602	0.19007	1.0654	0.015324	27176	1192.9	-2.7943e+005	10.142	16.002	35.665
35	169	176	128	-48	8.9465	0.069895	4.5193	46.457	16536	898.8	-1.608e+005	9.7043	2.2851	52.611
36	157	179	156	-23	23.411	0.15007	1.4774	1.6053	25181	1147.2	-2.5634e+005	10.092	12.984	37.038
37	160	177	175	-2	30.365	0.17351	0.15167	-0.85205	31788	1313.9	-3.3137e+005	10.307	18.348	34.221
38	170	175	164	-11	25.957	0.15827	0.63187	-0.03453	27858	1217.3	-2.8649e+005	10.186	29.022	31.404
39	165	177	167	-10	25.472	0.15253	0.67392	-0.0545	28843	1243.9	-2.9754e+005	10.225	23.324	32.534
40	255	159	187	28	55.525	0.29692	-1.0776	0.88897	38158	1428.6	-4.0764e+005	10.284	15.196	36.115
41	255	159	150	-9	62.676	0.41784	-0.76944	-0.37507	26596	1113.8	-2.7716e+005	9.5743	49.041	29.686
42	255	159	173	14	35.883	0.20741	-0.64838	-0.28629	31226	1292.2	-3.2556e+005	10.256	43.009	29.869
43	255	159	115	-44	44.355	0.3857	0.13785	-0.33304	15365	806.71	-1.5182e+005	9.2912	27.873	31.619
44	255	159	133	-26	42.258	0.31773	0.29357	-0.079384	19522	949.74	-1.9637e+005	9.6718	34.123	30.654
45	255	159	129	-30	43.49	0.33713	0.34757	-0.040571	18624	918.24	-1.8683e+005	9.5957	35.67	30.56
46	255	159	114	-45	43.493	0.38151	0.43575	-0.18912	14938	792.9	-1.4732e+005	9.3121	28.907	31.463
47	255	159	132	-27	33.968	0.25733	0.84073	1.6423	18720	940.58	-1.8653e+005	9.7071	20.855	33.623
48	255	159	131	-28	32.644	0.24919	0.73442	1.3039	18485	935.51	-1.8378e+005	9.7017	28.951	31.906
49	255	159	142	-17	45.165	0.31806	-0.05979	-0.062244	22431	1033.3	-2.2853e+005	9.7838	51.534	29.473
50	255	159	138	-21	41.917	0.30375	0.29771	0.81811	20908	993.95	-2.1141e+005	9.7365	30.251	31.758
51	202	169	151	-18	17.32	0.1147	1.1682	6.583	23108	1094.6	-2.3281e+005	10.022	13.474	36.518
52	199	166	144	-22	15.765	0.10948	-0.04152	4.3444	21046	1035.6	-2.1e+005	9.9301	9.9056	39.144
53	217	166	144	-22	15.771	0.10952	0.62779	8.3	21170	1039.3	-2.1136e+005	9.9365	8.4913	40.349
54	205	166	148	-18	16.386	0.11072	1.5375	9.7328	22287	1071.6	-2.237e+005	9.9881	10.465	39.185
55	242	153	130	-2.3	52.986	0.40758	-0.20077	-0.83911	19801	933.26	-2.0094e+005	9.513	9.8526	40.62
56	255	159	178	19	36.235	0.20357	-1.3588	2.4229	33135	1340.3	-3.4716e+005	10.303	16.419	35.922

Images	R	M	m	D	σ	η	s	κ	E	E_n	E_s	E_{le}	IAM	PSNR
57	145	177	171	-6	36.419	0.21297	-0.31238	-1.1081	30763	1279.3	-3.2044e+005	10.24	14.281	36.069
58	151	180	166	-14	43.795	0.26383	0.39757	-1.2681	29599	1235.8	-3.0861e+005	10.16	6.1221	45.087
59	230	149	188	39	33.872	0.18017	-2.1401	8.1649	36687	1430.8	-3.8744e+005	10.373	14.913	37.072
60	255	159	169	10	58.487	0.34607	-1.0757	-0.43894	32063	1270.6	-3.3822e+005	10.072	8.8134	45.002
61	226	162	145	-17	48.36	0.33352	-0.23264	-0.82162	23634	1061.7	-2.423e+005	9.8296	20.543	36.449
62	201	153	147	-6	43.051	0.29287	-0.35822	-0.95439	23622	1072.8	-2.413e+005	9.8853	8.3525	42.939
63	242	161	161	0	59.687	0.37073	0.087312	-1.3496	29757	1204.2	-3.1332e+005	10.02	19.167	34.438
64	255	159	167	8	51.639	0.30921	-0.93346	0.12768	30782	1252.8	-3.2262e+005	10.09	6.3997	46.612
65	242	161	134	-27	51.224	0.38227	0.24059	-0.67594	20599	962.01	-2.0969e+005	9.6308	5.5324	47.796
66	255	159	144	-15	62.246	0.43226	-0.17557	-1.3656	24748	1057.8	-2.5733e+005	9.7044	13.406	38.05
67	255	159	131	-28	58.044	0.44309	-0.1994	-0.8426	20685	947.57	-2.1146e+005	9.4455	6.8542	43.829
68	238	170	173	3	44.161	0.25527	-0.91791	0.3877	32001	1298.6	-3.354e+005	10.22	12.709	37.617
69	255	159	188	29	38.687	0.20578	-0.23896	-0.77057	36960	1429.1	-3.9162e+005	10.43	5.3463	50.58
70	242	154	185	31	28.543	0.15429	-0.81917	0.57505	35092	1397.9	-3.688e+005	10.415	21.413	34.326
71	255	159	210	51	50.796	0.24189	-1.4104	1.0619	46760	1632.2	-5.0716e+005	10.61	12.379	38.749
72	255	159	147	-12	57.47	0.39095	0.22092	-0.77366	25087	1080.3	-2.6047e+005	9.8128	19.649	34.452
73	252	158	110	-48	46.291	0.42083	0.71707	-0.10552	14347	763.5	-1.4169e+005	9.2279	7.0455	44.016
74	255	159	172	13	25.536	0.14846	-2.2174	6.7783	30532	1288.2	-3.1641e+005	10.273	8.0787	41.707
75	255	159	144	-15	40.451	0.28091	-0.089497	1.0618	22568	1047.5	-2.2929e+005	9.8053	4.8205	48.946
76	205	166	195	29	35.862	0.18391	-0.84344	0.40408	39602	1495.3	-4.2164e+005	10.513	9.7467	39.938
77	227	161	177	16	61.248	0.34604	-0.81126	-0.49876	35425	1348.4	-3.7739e+005	10.186	12.569	37.584
78	242	161	168	7	49.912	0.2971	-0.39473	-0.55626	30726	1253.9	-3.2207e+005	10.137	20.95	34.389
79	120	230	245	15	27.801	0.11347	-3.0637	8.605	60998	1950.9	-6.7345e+005	10.988	25.47	34.711
80	255	161	229	68	41.04	0.17921	-3.8325	15.752	54251	1805.8	-5.9369e+005	10.75	34.257	32.769
81	227	162	87	-75	41.924	0.48189	1.4968	1.4817	9339	573.71	-89342	8.7492	6.4373	46.785
82	242	161	142	-19	30.947	0.21794	0.94035	2.6521	21180	1021.8	-2.1296e+005	9.8682	18.78	35.892
83	255	159	153	-6	43.554	0.28467	0.69127	0.26223	25334	1119.9	-2.6077e+005	9.9814	30.966	31.734
84	255	159	162	3	44.895	0.27713	0.41471	-0.1069	28496	1204.5	-2.9632e+005	10.104	31.281	31.547
85	195	167	152	-15	32.562	0.21422	1.3174	1.8787	24405	1113.3	-2.488e+005	10.017	28.548	32.302
86	255	159	141	-18	66.367	0.47069	0.43258	-1.3044	24434	1033.6	-2.5555e+005	9.6719	25.947	33.236
87	255	159	99	-60	54.638	0.5519	1.1179	0.15087	12956	683.09	-1.2906e+005	8.9066	22.436	34.096
88	255	159	117	-42	68.653	0.58678	0.45937	-0.81437	18485	837.47	-1.9055e+005	9.0007	65.915	29.575
89	255	159	172	13	39.67	0.23064	-0.14594	-0.33972	31323	1288.5	-3.2728e+005	10.241	24.715	32.125
90	234	157	177	20	47.426	0.26794	-0.2153	-1.4509	33657	1333.3	-3.5512e+005	10.275	17.426	35.498
91	255	159	174	15	45.68	0.26253	-0.7915	0.71044	32515	1308.9	-3.415e+005	10.215	11.623	38.446
92	255	159	132	-27	52.82	0.40015	-0.075849	-0.78238	20416	952.92	-2.0771e+005	9.5706	30.909	31.399
93	246	155	128	-27	44.981	0.35141	-0.077215	-0.46664	18492	911.08	-1.8545e+005	9.5531	12.233	37.735
94	186	170	158	-12	71.784	0.45433	0.16322	-1.7752	30170	1179.4	-3.2104e+005	9.9039	14.684	36.771
95	238	152	160	8	50.578	0.31611	-1.3192	0.50772	28167	1186.2	-2.9267e+005	9.9771	11.028	40.435
96	188	166	135	-31	32.602	0.2415	0.27358	-0.25465	19295	961.3	-1.9252e+005	9.7508	16.929	34.455
97	255	159	142	-17	45.052	0.31727	0.48376	-0.15821	22404	1031.9	-2.2848e+005	9.8165	33.996	30.909
98	255	159	195	36	68.151	0.34949	-0.61366	-1.224	43030	1511.1	-4.6722e+005	10.392	23.409	33.079
99	174	163	214	51	29.812	0.13931	-1.699	2.579	47016	1667.1	-5.0742e+005	10.715	10.671	40.277
100	254	159	196	37	30.621	0.15623	-1.1624	3.9947	39649	1503.2	-4.2151e+005	10.532	9.0958	44.216