PSNR of Highest Distortion Region: An Effective Image Quality Assessment Method

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***Abstract*—Due to various reasons an image may get distorted. To measure the perceptual distortions, image quality assessment (IQA) metrics are required. Peak-signal-to-noise-ratio (PSNR) is one of the popular available IQA metric. It is usually measured by computing distortion in terms of mean-squared-error (MSE) between the reference image and its distorted version. Mean-squared-error (MSE) is measured over the entire image by giving equal weight to each corresponding pixel difference of the reference and distorted image. However, as per investigation done in this paper, it is found that instead of calculating MSE/PSNR on overall image, PSNR measured over the region of maximum distortion only is a better choice. The PSNR computed over the most distorted region (PSNR-MDR) reflects the image quality better than it computed over entire image. The PSNR-MDR is not only superior to the PSNR but also competitive to celebrated metric, SSIM (Structural Similarity Index).**

***Index Terms*—PSNR, IMAGE-QUALITY-ASSESSMENT, Blur, JPEG, JPEG2K**

I. Introduction

When an image is reproduced by means such as compression, enhancement and restoration or any other processes, the perceptual quality of the image is usually an important concern. To measure the image fidelity with respect to the reference image, Image quality assessment (IQA) metrics are required. IQA may be done by human vision directly or by using an algorithm. These two approaches are known as subjective and objective IQA. Generally, the real user of an image are human and therefore, subjective IQA are more reliable. However, due to its time consuming nature, it can't be used in real time. The objective metrics correlated with the subjective quality are used for automatic and real-time IQA [1]. The objective IQA metrics, which use reference image to compare the quality of the distorted image are known as full reference IQA (FR-IQA). The other two classes are reduced reference IQA (RR-IQA) and no-reference IQA (NR-IQA). In RR-IQA, some information about the reference image is available whereas in NR-IQA, nothing is known about the reference image. When the reference image is available, FR-IQA metrics are preferred as these are mostly consistent with the subjective IQA. Mean-squared-error (MSE) [2], peak-signal-to-noise-ratio (PSNR) [1], [2], structural similarity index (SSIM) [3], multiscale SSIM (MS-SSIM) [4], feature similarity (FSIM) [5], etc. are some state-of-the-art FR-IQA algorithms.

There are IQA algorithms that are specific to one or few distortion types and others are used for across the distortion types. The common distortions in the image are AWGN distortion, quantization distortion (blocking and ringing artefacts due to JPEG and JPEG2K compression respectively) and blurring. The accuracy of PSNR for AWGN distortion is very high, however, its performance is usually inferior to its peers over distortion types such as blur, JPEG and JPEG2K compression artifact [6].
In this paper, an algorithms is proposed which exploits the PSNR computed over the region of maximum distortion only. To identify the most distorted region in the image, distorted and reference image are subdivided into non-overlapping blocks of equal size and then MSEs are computed block by block. The block of distorted image with largest value of MSE is assumed as region of maximum distortion and PSNR is computed over this region only. It is observed that the computed PSNR over most distorted region (PSNR-MDR) reflects the subjective quality of the image more efficiently than the PSNR calculated over entire image at once.

The organization of this paper is as follows. Section II gives a brief overview of the proposed methodology. In section III, simulation result is presented along the discussion. The proposed methodoly is finally concluded in section 4.

II. Proposed Methodology

Mean-squared-error (MSE) and Peak-signal-to-noise-ratio (PSNR) is measured over the entire image by giving equal weight to each corresponding pixel difference of the reference and distorted image. However, the region (group of pixels) with maximum distortion in an image attracts the visual attention most [7]. Therefore, instead of taking averaging effect of the entire image, computing PSNR over the most distorted region (PSNR-MDR) only is computed and exploited to assess the image quality.

The basic approach of proposed method is shown in Fig. 1. The blockwise MSE which is defined in (1) is calculated

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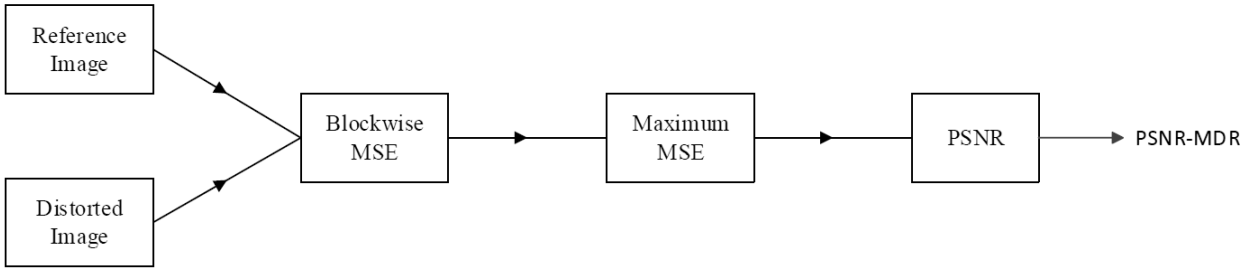

Fig. 1. Proposed Idea.

TABLE I
SROCC COMPARISON OF PROPOSED METRIC WITH PSNR OVER VARIOUS DATABASES

Database	Distortion	PSNR-MDR	PSNR	% improvement
LIVE	Blur	0.9318	0.8536	9.16
	JPEG-compression	0.9699	0.9424	2.92
	JPEG2K-compression	0.9813	0.9555	2.70
CSIQ	Blur	0.9504	0.9246	2.79
	JPEG-compression	0.9180	0.8875	3.44
	JPEG2K-compression	0.9676	0.9360	3.38
TID2008	Blur	0.8940	0.9335	-4.23
	JPEG-compression	0.8954	0.8717	2.72
	JPEG2K-compression	0.9173	0.8132	12.80
TID2013	Blur	0.8922	0.9149	-2.48
	JPEG-compression	0.9285	0.9189	1.04
	JPEG2K-compression	0.9339	0.8840	5.64

between the reference and distorted image. $I_r(i,j)$ & $I_d(i,j)$ are pixel intensity at location of ith row & jth column in the block of reference image and distorted image of size M $\times$ N, respectively. The proposed method exploits the region of maximum distortion in the image and it is identified by the block with maximum MSE.

$$MSE = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} [I_r(i,j) - I_d(i,j)]^2 \qquad (1)$$

The PSNR as defined in (2) is calculated for this block. The PSNR [1] computed for the block with maximum distortion is referred in this paper as PSNR-MDR.

$$PSNR = 10log_{10} \frac{255^2}{MSE} \qquad (2)$$

III. RESULT AND DISCUSSION

The common artefact that are produced in the image are due to blurring, additive white Gaussian noise (AWGN), JPEG compression and JPEG2K compression. The correlation of PSNR with subjective quality of AWGN image is very high [8], therefore, PSNR-MDR is tested for other than AWGN contaminated images . The validation of the proposed method is done on four popular databases of LIVE [9], CSIQ [10], TID2008 [11] and TID2013 [12]. The popular correlation metric SROCC [13] (Spearman's-rank-order-correlation-coefficient) of proposed metric PSNR-MDR with subjective rating of the image is given in Table I. The magnitude of minimum and maximum value of SROCC are 0 and 1 respectively. The higher value of SROCC implies higher accuracy of an IQA method.

It can be observed that PSNR-MDR outperforms the PSNR over most of the databases for all the three distortion types. In order to compare, the percentage improvement of PSNR-MDR over PSNR is given in Table I. The proposed metric is only lagging for blur distortion over TID2008 and TID2013, indicated by negative sign (-) in the table. To make the proposed method more clear, the PSNR and PSNR-MDR are also computed and compared with subjective rating for one reference image and its distorted versions (from LIVE database) across the distortion types of blur, JPEG and JPEG2K. Their corresponding PSNR, PSNR-MDR and subjective ratings are given in Table II, III and IV. The subjective rating of images in LIVE database are in the range of [0,100] with lower value indicating higher quality of the image. From the Table II-Table IV, it can be observed that PSNR-MDR increases with the quality of image and therefore, following the right trend. To visualize the quality of image and the computed metrics (PSNR and PSNR-MDR) value, image with different level and types of distortion are also shown in Fig. 2, Fig. 3 and Fig. 4.

TABLE II
QUALITY METRIC AND ITS SUBJECTIVE RATING FOR A SET OF IMAGES WITH DIFFERENT DEGREE OF BLURRINES

Subjective rating	0	23.74	37.03	52.16	69.29	79.76
PSNR	∞	35.71	31.88	28.86	26.77	24.83
PSNR-MDR (*proposed*)	∞	16.73	13.53	11.54	9.51	8.40

TABLE III
QUALITY METRIC AND ITS SUBJECTIVE RATING FOR A SET OF IMAGES WITH DIFFERENT DEGREE OF JPEG COMPRESSION

Subjective rating	0	12.00	33.49	37.78	63.46	87.78	91.59
PSNR	∞	40.32	34.56	31.03	30.72	25.36	25.36
PSNR-MDR (*proposed*)	∞	28.75	19.85	21.92	17.34	13.53	13.53

TABLE IV
QUALITY METRIC AND ITS SUBJECTIVE RATING FOR A SET OF IMAGES WITH DIFFERENT DEGREE OF JPEG2K COMPRESSION

Subjective rating	0	10.23	18.56	32.25	46.32	62.58	74.95
PSNR	∞	41.35	38.52	36.01	33.58	29.76	28.79
PSNR-MDR (*proposed*)	∞	35.19	29.27	23.81	21.91	15.82	14.92

As stated earlier, the proposed method is based on blockwise computation of PSNR, therefore, effect of different block sizes on the accuracy of the proposed approach is also tabulated in Table V. The accuracy at smaller block size across the distortion types are usually high, as shown in the Table V. The value of PSNR-MDR given in Table I are computed over non-overlapping block size of 8×8. The reason for the accuracy of

TABLE V
SROCC AT DIFFERENT BLOCK SIZE (LIVE DATABASE)

Block size	Blur	JPEG-compression	JPEG2K-compression
8×8	0.9318	0.9699	0.9813
16×16	0.9189	0.9681	0.9821
24×24	0.9015	0.9632	0.9813
32×32	0.9031	0.9621	0.9824
40×40	0.9017	0.9604	0.9813
48×48	0.8904	0.9570	0.9804
56×56	0.8931	0.9580	0.9803
64×64	0.9009	0.9584	0.9793

PSNR-MDR over PSNR is given as follows. The MSE/PSNR calculated over entire image at once gives equal weight to each pixel, however, the region of image with maximum distortion attracts most of the visual attention [7]. Therefore, block with maximum distortion is the determining factor of overall quality of an image. As far as block size is concern, the larger block has averaging effect similar to full size image in computation of MSE/PSNR, thus smaller block size estimate the perceptual quality with higher accuracy.

By adopting the methodology stated in this paper, the accuracy of the PSNR-MDR metric is even competitive to structural similarity index (SSIM), one of the state-of-the-art and celebrated IQA metric. The comparison is tabulated in Table VI. From this table, it can be observed that PSNR-MDR outperforms SSIM for the distortion due to JPEG2K compression across all four databases and competitive to other distortion types except blur distortion in TID2008 and TID2013 databases.

The quality assessment method discussed in this paper requires blockwise computation of MSE as well as searching the maximum value among to compute the local PSNR/ PSNR-MDR. Therefore, the computational complexity of the proposed algorithm is relatively higher than PSNR (computed over entire image at once).

TABLE VI
SROCC COMPARISON OF THE PROPOSED METRIC WITH STATE-OF-THE-ART SSIM METRIC OVER VARIOUS DATABASES

Database	Distortion	PSNR-MDR (*proposed*)	SSIM
LIVE	Blur	0.9318	0.9363
	JPEG-compression	0.9699	0.9700
	JPEG2K-compression	0.9813	0.9732
CSIQ	Blur	0.9504	0.9327
	JPEG-compression	0.9180	0.9198
	JPEG2K-compression	0.9676	0.9260
TID2008	Blur	0.8940	0.9439
	JPEG-compression	0.8954	0.8995
	JPEG2K-compression	0.9173	0.8903
TID2013	Blur	0.8922	0.9608
	JPEG-compression	0.9285	0.9111
	JPEG2K-compression	0.9339	0.9060

Fig. 2. Blurred image: Subjective rating=79.76, PSNR=24.83, PSNR-MDR (*proposed*)= 8.40

IV. CONCLUSION

In this paper, an image quality assessment (IQA) algorithm inspired by PSNR is proposed. As the region of maximum distortion attract the visual attention of the human most, therefore, the PSNR is computed over the region of maximum distortion instead of entire image. From the simulation result, it has been found to be a better alternative IQA algorithm for estimating the perceptual quality of image. As a future work, the concept used in the proposed method may also be extended for other IQA algorithms. It may improve the accuracy of IQA

Fig. 3. JPEG compressed image: Subjective rating=87.78, PSNR=25.36, PSNR-MDR (*proposed*)= 13.53

Fig. 4. JPEG2K compressed image: Subjective rating=46.32, PSNR=33.58, PSNR-MDR (*proposed*)= 21.91

algorithms across the types and degree of distortion in the Image.

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