EPSNR FOR OBJECTIVE IMAGE QUALITY MEASUREMENTS

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Abstract: In this paper, we explore the possibility to apply a recently standardized method for objective video quality measurements to measure perceptual quality of still images. It has been known that the human visual system is more sensitive to edge degradation. We apply this standardized method to several image data sets which have subjective scores. The standardized method is compared with existing objective models for still images. Experimental results show that the standardized method shows better performance than the conventional PSNR and show similar performance compared to top-performance models.

1 INTRODUCTION

Objective quality assessment emerges an important problem. As multimedia services, such as mobile broadcasting, video on demand (VOD) and videophones, over channels where bandwidth can not be guaranteed become widely available, quality monitoring becomes a critical issue. Traditionally, perceptual video quality has been measured by a number of evaluators who subjectively evaluate video quality. Although this subjective evaluation is considered to be the most accurate method, it is expensive and cannot be done in real time. As a result, efforts have been made to develop objective models for perceptual video quality measurement.

These efforts have resulted in several international standards (ITU-R, 2003, ITU-T, 2004). For example, in (ITU-R, 2003, ITU-T, 2004), four objective models are included. Although these models are developed to measure perceptual quality of video signals, they also might be used to measure perceptual quality of still images.

Traditionally, codec optimization has been done by minimizing mean square errors (equivalently PSNR). However, it has been known that the correlation between PSNR and perceptual quality is not high and efforts are made to better metrics to measure perceptual quality. These metrics can be used for parameter optimization during encoding process. They can be also used to evaluate new codecs, video transmission systems, traffic optimization, etc. In this paper, we explore the possibility to apply the standardized method to measure perceptual quality of still images. Among the four models of (ITU-R, 2003, ITU-T, 2004), we tested the model developed by Yonsei. The model is easy to implement and very fast. Consequently, it can be used for codec optimization which requires a large number of computations of the metric. We applied the method the database which has been widely used for quality measurement of still images. We also conducted our own subjective test and evaluate the performance of the model.

2 EPSNR

It has been known that the human visual system is more sensitive to edge degradation. Thus, in (ITU-R, 2003, ITU-T, 2004), an edge detection algorithm is first applied to find edge areas. For example, the horizontal gradient image and the vertical gradient image are first computed using gradient operators. Then, the magnitude gradient image is computed as follows:

$$g(m,n) = \left|g_{horizontal}(m,n)\right| + \left|g_{vertical}(m,n)\right|. \quad (1)$$

Then, thresholding operation is applied to the magnitude gradient image to determine edge pixels. In (ITU-R, 2003, ITU-T, 2004), the Sobel operator is recommended.

Alternatively, it is possible to use the successive edge detection procedure. First, a vertical gradient operator is applied to the reference image, producing a vertical gradient image. Then, a horizontal gradient operator is applied to the vertical gradient image,

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producing a horizontal and vertical gradient image. Then, a thresholding operation produces edge areas. Figs. 2-4 illustrate this procedure.

Figure 1: An original image.

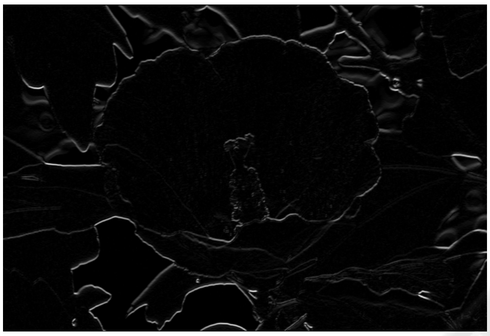


Figure 2: A vertical gradient image.

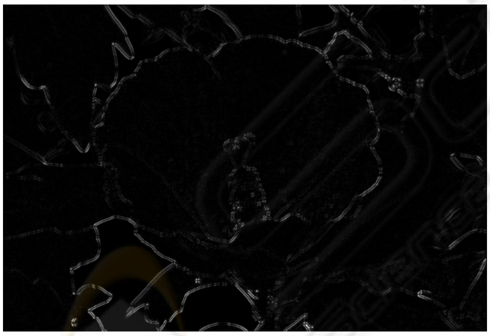


Figure 3: A horizontal and vertical gradient image.

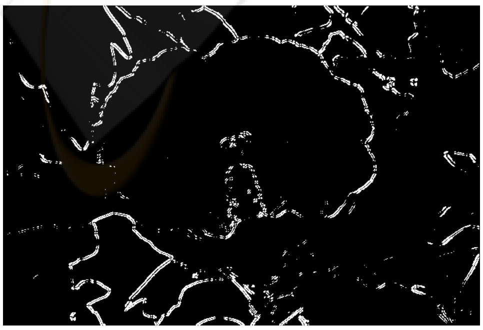


Figure 4: Edge pixels.

Next, errors between the edge pixels of the source image and those of the processed image are computed. For example, the squared error of edge areas of the l-th frame can be computed as follows:

$$se_e^l = \sum_i \sum_j \{S^l(i,j) - P^l(i,j)\}^2 \quad \text{if } S^l(i,j) \text{ is an edge pixel} \tag{2}$$

where $S^l(i,j)$ is the l-th image of the source video sequence, $P^l(i,j)$ represents the l-th image of the processed video sequence. Finally, the global edge mean squared error is computed as follows:

$$mse_e = \frac{1}{K}\sum_{l=1}^{L} se_e^l$$

where K is the total number of pixels of the edge areas. Finally, the edge PSNR (EPSNR) is computed as follows:

$$EPSNR = 10\log_{10}\left(\frac{P^2}{mse_e}\right)$$

where P is the peak value. If the number of edge pixels is smaller than a certain value, the threshold value is reduced by 20 until a sufficient number of edge pixels are obtained. In the Yonsei model, this EPSNR is used as a base objective video quality metric after some posting-processing (C. Lee et al., 2006). The model was validated by independent laboratories and significantly outperformed PSNR (Table 1).

Table 1: Performance comparison on the VQEG Phase II Data.

		correlation
The Yonsei model	525	0.9086
	625	0.8519
PSNR	525	0.7573
	625	0.6954

3 EXPERIMENTAL RESULTS

We applied the Yonsei model to the database provided by LIVE Lab (H. R. Sheikh, et al. 2005). In (H. Sheikh, 2006), a number of perceptual quality metrics for still images are compared using the same database. Thus, we compared the Yonsei model with the models of (H. Sheikh, 2006). Table 2 shows performance comparison. It is noted that all the other metrics are taken from (H. Sheikh, 2006) except for

EPSNR. As can be seen, EPSNR provides high correlations.

Table 2: Performance comparison (H. Sheikh, 2006).

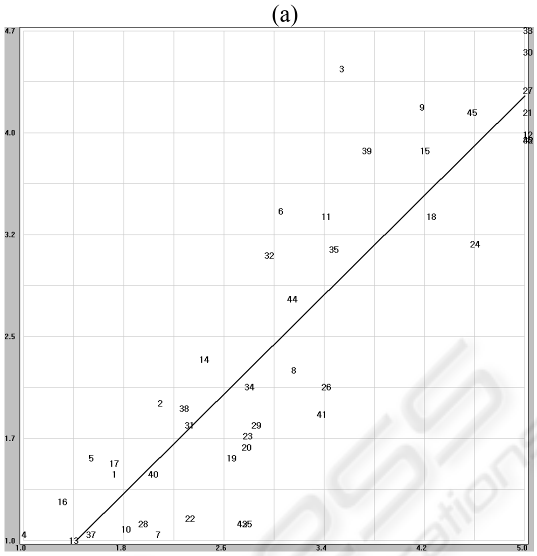
	jp2k#2	jpeg#2
PSNR	0.8740	0.9167
JND	0.9734	0.9870
DCTune	0.7834	0.9418
PQS	0.9364	0.9777
NQM	0.9463	0.9783
Fuzzy	0.9133	0.9509
BSDM	0.9450	0.9747
SSIM(MS)	0.9711	0.9879
IFC	0.9626	0.9744
VIF	0.9787	0.9885
EPSNR	**0.9515**	**0.9457**

In the next test, we printed some of the LIVE data set using two colour printers. Using the printed images, we performed subjective tests. Fig. 5 shows the scatter plots between the subjective scores and EPSNR. As can be seen, EPSNR shows high correlations.

5 CONCLUSIONS

In this paper, we applied the recently standardized method for objective video quality measurements to measure perceptual quality of still images. Experimental results show that it would be possible to use the model for still images. By taking into account the characteristics of still images, it would be also possible to improve the performance of the model.

(a)



(b)

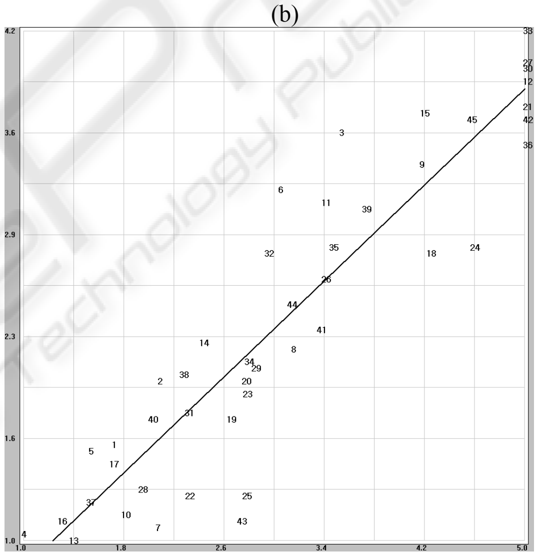


Figure 5: Scatter plot between EPSNR and subjective scores of the printed images (a) Printer A, correlation coefficient: 0.894179 (b) Printer B, correlation coefficient: 0.918683.

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