Blind Image Quality Metric for Blurry and Noisy Image

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***Abstract*—in this paper, an objective assessment of image quality is considered. Principal human eyes function is to take out the region or edge information from the vision field. Based on this function, a new no-reference image quality measure is proposed. First, we identify the image edges using canny operator. Secondly, we compute the absolute difference mask. Then, the two operators are used to compute the entire metric. Experimental results show the efficiency of the suggested measure.**

Keywords—canny operator; fusion; absolute difference mask; image quality

I. Introduction

Subjective and objective measures are the principal metrics for image quality [1-4] assessment (IQA). Dissimilarity between the original and a distorted image is computed using the objective image quality measures. The subjective measures are the most reliable judgment of the assessment for the image quality assessment. It is carried out by the human observers. The working group includes expert and non-experts observers. A non-expert observer focuses its attention on the total sight; however a qualified observer can concentrate on the details.

Most methods that have been proposed for assessment of image quality in objective manner can be divided into three groups; full-reference, the no-reference and the reduced-reference methods. The initial category addresses the full-reference methods, in which the metric exploits an ideal version of the image to compare the deformed version. Hence, the no-reference methods do not require the reference image for IQA and has access only to the tested image and must evaluate the image quality without the ideal version. The third class of image quality assessment is the reduced-reference method where the reference image is partially available; this type of measure requires only some characteristics of the original image. Moreover, no priori information is generally exploited. They remain the least developed methods.

In this paper, edge detection is exploited in IQA with no-reference image. The tests are carried on deformed images from LIVE database [5]. Performance of the proposed measure is compared to the Peak Signal to Noise Ratio (*PSNR*), the quality of images compressed by JPEG2000 image coder (*jp2knr*) [12] and the Mean Structural Similarity Index (*MSSIM*) [6].

This work is structured as follows. In Section 2, some image quality measures are introduced. Section 3 presents the proposed metric. In Section 4, the proposed method performance will be demonstrated by instances of images including various distortion types, followed by the conclusion.

II. Previous Works

In this part, some methods to assess image quality will be visited. The Mean Square Error (MSE) is always used to compare the degraded and original image to determine the resemblance ratio. In Peak Signal to Noise Ratio measure (*PSNR*) fidelity is computed, instead of the distortion measurement. Since, it is proportional to the quality; it depends on *MSE* measure; the definition and use is inspired from the signal processing field. Because their simplicity, *MSE* and *PSNR* are usually used. However, they are not very well correlated to perceived visual quality. Authors in [6] presented a new metric called *MSSIM* (the Mean Structural Similarity Index). It is based on the hypothesis that the HVS (human vision system) is extremely comforted to take out structural information from the viewing field. On the other hand, *MSSIM* was unsuccessful in quantifying badly blurred images [3]. The *PSNR* and *MSSIM* are used to judge the image quality with full-reference measure. In [12], A Natural Scene Statistics (NSS) to blindly measure the quality of images compressed by JPEG2000 image coder (*jp2knr*) is proposed. It measures only JPEG2000 distorted image, and fails to evaluate others deformed images.

In [13], no-reference image quality measure for JPEG2000 is proposed. Promoted results were found with this type of distortion.

Based on this study, a novel no-reference metric for image quality assessment is proposed. Blurred, noisy and JPEG2000 images are assessed with this metric.

III. Proposed Metric

Deformed image quality is evaluated by a no-reference metric. The error is computed from the deformed image. Several researches confirmed that the main human eyes function is to take out the structure or border information from the vision field. Therefore, HVS is entirely adapted for this reason. Consequently, in this research, a new measure of the

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quality evaluation based on the edge information and the natural Scene Statistics metric of Ruderman [7] is developed.

Before presenting the idea of our method, various useful concepts must be visited. *I* is the deformed image with *M* row and *N* column. The image has $M \times N$ pixels. Where, *M, N* are the image height and width respectively. A flowchart depicting computation of the proposed measure is presented in Fig. 1.

A. Edge detection

The Canny filter (or Canny detector) (1986) [8] is utilized in image processing. This operator is developed by the author to be optimal according to three clearly criteria:

1. Good detection: weak error rate in the indication of edges,
2. Good localization: the distances minimization between true boundaries and identified boundaries,
3. The answer clarity: a given boundary must be unique, and image noise must not produce false boundaries.

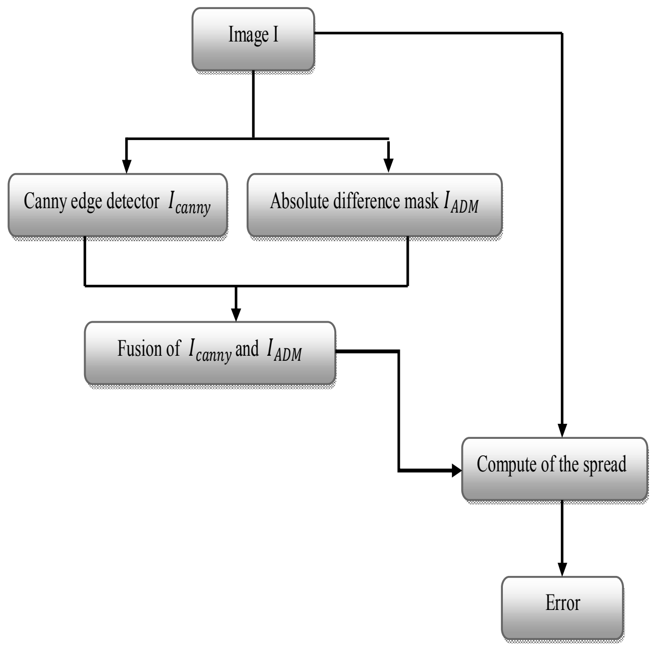


Fig. 1. Flowchart for calculating *proposed metric*

In the primary step, the noise of the image is reduced before the edge detection. The insulated pixels which could induce strong answers during the computation of the gradient are eliminated. A Gaussian filtering 2D is used; the operator of convolution is defined as:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{1}$$

An illustration of a 5x5 Gaussian filter, used to generate the image to the right, with $\sigma = 1.4$.

$$B = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * I \tag{2}$$

The following stage is the uses of gradient operator which turns the edges intensity. The operator calculates the gradient according to tow directions X and Y. A pair of two masks of convolution are applied, one of dimension 3×1 and the other 1×3

$$G_x = [-1 \quad 0 \quad 1]\,;\, G_y = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} \tag{3}$$

The value of the gradient in a point is approximated by the formula:

$$|G| = |G_x| + |G_y| \tag{4}$$

The edges orientations are determined by the formula:

$$\theta = arctan\left(\frac{G_y}{G_x}\right) \tag{5}$$

The deformed image which underwent a transformation by canny operator is determined by the following formula:

$$I_{canny} = canny(I) \tag{6}$$

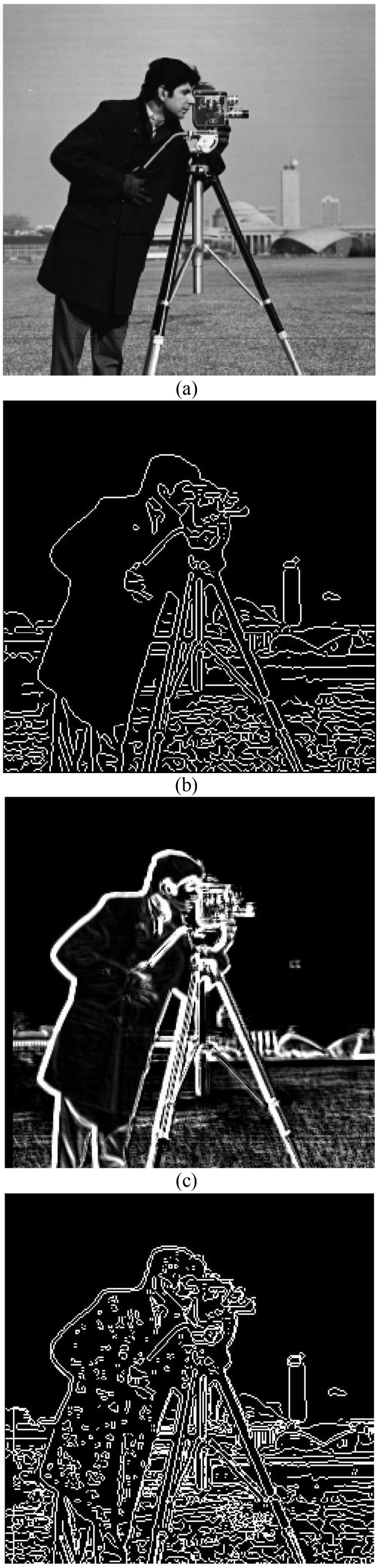
Where '$Canny(.)$' is Canny operator.

Fig.2. shows the edge image of original image (Fig.2 b).

B. Absolute difference mask

Absolute Difference Mask algorithm (ADM) [9, 10] carries out three processing phases for edges detection. The created boundaries and single-pixel wide are localized. The steps are:

- the semi-Gaussian filter is applied on the image to reduce noise,
- at each pixel, the edge direction and strength are found,
- Produce last boundary map that is used in the computer vision.



(a) (b) (c) (d)

Fig.2. (a) Original image (b) Absolute difference mask (c) Canny edge detector (d) Fusion

Edge direction and strength are computed as follows:

- Absolute differences for I(i,j) are organized :

$$
\begin{aligned}
V_r &= I(i,j-1) + I(i,j-2)\\
V_l &= I(i,j+1) + I(i,j+2)\\
H_r &= I(i+1,j) + I(i+2,j)\\
H_l &= I(i-1,j) + I(i-2,j)\\
Qd_u &= I(i-1,j-1) + I(i-2,j-2)\\
Qd_l &= I(i+1,j+1) + I(i+2,j+2)\\
Td_u &= I(i+1,j-1) + I(i+2,j-2)\\
Td_l &= I(i-1,j+1) + I(i-2,j+2)
\end{aligned}
$$

- Every absolute differences for *I (i , j)* are computed

$$
\begin{aligned}
V &= |\ V_r - V_l\ |\\
H &= |\ H_r - H_l\ |\\
Qd &= |\ Qd_u - Qd_l\ |\\
Tb &= |\ Td_u - Td_l\ |
\end{aligned}
$$

- Boundary direction and strength is calculated by:

$$Edge\ (i,j) = max(V, H, Qd, Tb)/2 \tag{7}$$

$$dir\ (i,j) = dir(min(V, H, Qd, Tb)) \tag{8}$$

In our implementation, we propose the following formula:

$$I_{ADM}(i,j) = max(V, H, Qd, Tb) \tag{9}$$

Fig.2. shows the Absolute Difference Mask image of original image (Fig.2 c).

C. Fusion of I_{canny} and I_{ADM}

In this stage the edge image I_{canny} and the Absolute Difference Mask image I_{ADM} are merged using 'OR' operator:

$$I_{Fusion} = I_{canny} + I_{ADM} \tag{10}$$

Where '+' is 'OR' operator

Fig.2. shows the fusion image of original image (Fig.2 d).

D. Compute of the spread

To compute the spread of the edge, a measure inspired from Ruderman [7] operator is used. This process can be applied to image *I (i, j)* to create:

$$\hat{I}(i,j) = \frac{I(i,j) - \mu(i,j)}{\sigma(i,j) + 1} \tag{11}$$

Where, $i \in 1, 2 \dots M, j \in 1, 2 \dots N$ are spatial indices, and

$$\mu(i,j) = \sum_{k=-K}^{K} \sum_{l=-L}^{L} I(i+k, j+l) \tag{12}$$

$$\sigma(i,j) = \sqrt{\sum_{k=-K}^{K} \sum_{l=-L}^{L} [I(i+k, j+l) - \mu(i,j)]^2} \tag{13}$$

In our implementation, $K = L = 5$.

E. Edge information measure

The proposed measure *BNBM* (Blind Noisy and Blur Measure) of deformed image is computed as:

$$diff(i,j) = \begin{cases} 0 \;\; if \;\; I_{Fusion}(\mathrm{i,j}) = 0 \\ \hat{I}(i,j) \;\; if \;\; I_{Fusion}(\mathrm{i,j}) = 255 \end{cases} \tag{14}$$

Standardized measure is defined as:

$$diff\_all = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} diff(i,j)}{EN} \tag{15}$$

Where, EN is pixels number of all edges in I_{Fusion}.

IV. Results

To test efficiency of the proposed method, experiments are carried on different images set. Three kind of distorted and compression methods are compared [5]: 174 images for White noise, 174 images for Gaussian blur and 227 images JPEG2000.

The standard performance assessment procedures utilized in the video quality experts group (VQEG) FR-TV Phase II test [11] is followed. To present quantitative measures of the proposed performance measure four mainly assessment metrics are used: *RMS* (Root mean square prediction error), *ROCC* (Spearman rank-order correlations coefficient), *CC* (Pearson linear correlation coefficient), and *MAE* (Maximum absolute prediction error). These measures evaluate an objective aptitude model to yield consistently perfect predictions for every kind of images.

ROCC with higher value means the better prediction monotonicity. *CC* with larger value means the better accuracy. While smaller *MAE* and *RMS* values mean the better performance.

Non-linear mapping has carried out between objective and subjective scores [11]. Five non-linear parameters mapping (θ_1, θ_2, θ_3, θ_4 and θ_5) are utilized to convert the set of quality ratings to a set of the predicted Difference Mean Opinion Score (*DMOS*) values denoted $DMOS_P$. Mapping function which consists in logistic is introduced in (16).

$$DMOS_p = \theta_1 \mathrm{logistic}(\theta_2, (VQR - \theta_3)) + \theta_4 + \theta_5 \tag{16}$$

$$\mathrm{logistic}(x, VQR) = \frac{1}{2} - \frac{1}{1 + \exp(VQR\ x)} \tag{17}$$

Where VQR is the quality rating by the objective method (*BNBM*, *jp2knr*, *MSSIM* or *PSNR*) and θ_1, θ_2, θ_3, θ_4, θ_5 are selected for most excellent fit. The MATLAB function *fminsearch* has been used for the fitting (optimization of θ parameters).

TABLE I. Performance comparisons of IQA metrics (*MSSIM*, BNBM, *jp2knr* and PSNR) on deformed images of Gaussian blur.

Metric	*CC*	*ROCC*	*MAE*	*RMS*
PSNR	0.8666	0.8731	10.6273	13.4872
MSSIM	0.9424	0.9462	7.1146	9.0455
jp2knr	0.0307	0.0404	15.3198	18.4623
BNBM	0.9052	0.9064	6.2456	7.8514

TABLE II. Performance comparison of IQA metrics (*MSSIM*, *BNBM*, *jp2knr* and *PSNR*) on deformed images of white noise.

Metric	*CC*	*ROCC*	*MAE*	*RMS*
PSNR	0.8885	0.8903	10.6307	13.3144
MSSIM	0.9461	0.9402	7.232	9.4043
jp2knr	0.6481	0.8875	16.6355	21.3609
BNBM	**0.9779**	**0.9688**	**2.5832**	**3.3421**

TABLE III. Performance comparison of IQA metrics (*MSSIM*, *BNBM*, *jp2knr* and *PSNR*) on deformed images of JPEG2000.

Metric	*CC*	*ROCC*	*MAE*	*RMS*
PSNR	0.8996	0.8954	8.4551	11.0174
MSSIM	**0.9669**	**0.9614**	**5.1855**	**6.4366**
jp2knr	0.5570	0.5457	17.4664	20.9423
BNBM	0.8136	0.8069	7.3871	9.4181

Tables I-III summarize the validation results.

Looking at the curves (Fig.3), the *BNBM* values are very closer to *DMOS*, proving the efficiency of this measure. However an interesting result is obtained from the comparison of the *BNBM* with *PSNR*, *jp2knr* and *MSSIM* in Tables I-III. The values of *CC* and *ROOC* are closer to 1; this means that *BNBM* has a similar performance as the methods or earlier works. Furthermore, the performance of the *PSNR* in TableI is more less than previous one, for instance the *CC*=0.8666 and *ROOC*=0.8731. This one indicates that *PSNR* is not adapted to perceived visual quality. The examination of the results obtained with *MSSIM* and *jp2knr* lead us to say that *BNBM* has a significant performance and this one is similar as *MSSIM* and *jp2knr*.

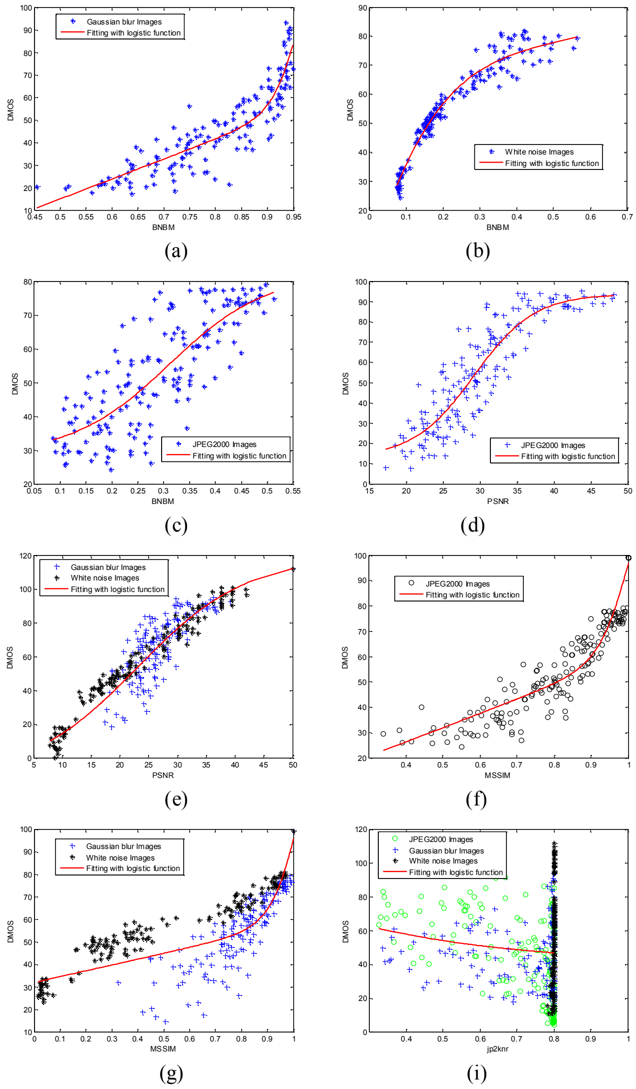


Fig.3. Scatter plots of *DMOS* versus model prediction for JPEG2000, Gaussian blur and white noise distorted images. (a-c) BNBM (d-e) PSNR (f-g) MSSIM (i) jp2knr.

V. CONCLUSION

In this paper a canny edge detector is used for IQA. After, the computation of the Absolute Difference Mask and the canny detector, the two images are emerged. The spread error is calculated using Ruderman operator.

Comparative study was done in this work. The obtained results were competitive with the previous works.

Future works following this study will include the expansion of *BNBM* for all kinds of distortion.

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