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No-reference image quality assessment based on noise, blurring and blocking effect

Luo-yu Zhou*, Zheng-bing Zhang

College of Electronics and Information Engineering, Yangtze University, Jingzhou, Hubei 434023, China

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ABSTRACT

Since existing no-reference image quality assessment (IQA) algorithms are not consistent with subjective assessment, a novel no-reference image quality assessment method is proposed by introducing three types of image distortion, including noise, blur degree and blocking effects. Firstly, the standard deviation of image noise is estimated by modified wavelet medium estimation. Secondly, the blur degree of image is obtained by counting edge pixel points. Thirdly, blocking effect is represented by characteristics of image pixel blocks. Finally, the assessment model is established by combining these three distortion types. Combining the differential mean opinion scores (DMOS) provided in the LIVE IQA database, the weighting coefficients are obtained. The experimental results indicate that these evaluation values of this algorithm not only agree with PSNR in objective assessment, but also are consistent with the DMOS in subjective assessment.

1. Introduction

Image quality is a crucial index for evaluating the image and video processing system and algorithm performance. Therefore, image quality assessment is fundamental importance. However, subjective assessment is not a feasible solution because it is easy to be affected by subjective factors and observation environment. What is needed is a simple and effective objective assessment method that can assign quality scores to images in meaningful agreement with subjective human assessment of quality.

Objective assessment methods can be classified into three categories: full-reference image quality assessment (FR IQA), reduced-reference (RR) IQA and no-reference (NR) IQA. Reviews of the major approaches can be found in Refs. [1–4]. However, reference images may be too expensive to provide in the processing of quality assessment, which gives the limited success that FR IQA has achieved. So, NR IQA has recently received a great deal of attention.

For NR IQA, gradient of image and entropy of image are widely used because of their ability of reflecting image definition [5]. But with noise of image increasing, these assessment methods will produce error assessment results. Moorthy and Bovik [6] proposed the use of natural scene statistics to assess image quality. The experimental results show that their method could get perfect results. But, it is a pity that it needs to compute 88 parameters and therefore the processing of assessment is too complex. So it is of importance to seek an easy and effective method of IQA without reference image.

In this paper, the main contribution is to propose a novel NR IQA which considers contribution of noise, blurring and blocking effect. As is already known, noise, blurring and blocking effect are three key factors for evaluating image definition. But in the previous literatures, most NR IQA methods are aimed at measuring the distortions inherent in acquisition or display systems, such as the blurring and noise [7,8]. Blocking effect is often neglected and therefore the assessment results are not perfect. In this work, in order to produce better results, we add blocking effect into assessment method. Numerical examples confirm the performance of the proposed method is better than the previous methods.

This paper is organized as follows. In Section 2, we present the estimation method for noise, blurring and blocking effects. In Section 3, we present a novel way of assessing the quality of images. Experiments are demonstrated in Section 4, and conclusion is presented in Section 5.

2. No-reference assessment of noise, blurring and blocking effect

2.1. No-reference assessment of noise

As a common distortion mode, noise exists in most images. Human eyes are sensitive to noise. Therefore, noise is considered as a key index of image quality. In this work, the standard deviation of noise is estimated by using wavelet medium estimation, which is

* Corresponding author. Tel.: +86 15272356731.
E-mail address: luoyuzh85@gmail.com (L.-y. Zhou).

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Table 1
The standard deviation of noise of wavelet medium estimation (pepper).

SDN	2	4	6	8	11	14	20	28
EV: v	3.708	5.189	7.413	8.895	11.881	14.828	20.015	25.945
EE: e	85.3%	29.7%	28.6%	11.2%	7.83%	5.90%	0.08%	0.21%

Note: SDN, standard deviation of noise; EV, estimated value; EE, estimated error.

general and effective method in wavelet domain [9]. The medium estimation is

$$\text{noise}(\delta) = \frac{\text{Median}\left(\left|Y(i,j)\right|\right)}{0.6745}, \quad Y(i,j) \in HH_1 \tag{1}$$

where δ is the standard deviation of noise. The wavelet which is used in the method is *d*4 wavelet.

The method is widely used in many cases; however, the method has some shortage. In this method, the high-frequency sub-band coefficients are all regarded as noise. But the high-frequency sub-band coefficients not only contain noise, but also contain the high-frequency details of image. So wavelet medium estimation leads to over-estimation. The smaller the noise is, the bigger the proportion of the high-frequency details are, the bigger the error of the estimated standard deviation of noise. So it is necessary to modify the wavelet medium estimation.

The pepper image is added by different noise. The standard deviations of noise are 2, 4, 6, 8, 11, 14, 20 and 26. Then the noises of these images are estimated by using the wavelet medium estimation. The estimation results are listed in Table 1.

It is observed that the estimated value and the estimated error follows a negative power law of time, as showed in Fig. 1. So, the fitting form is followed as

$$e = a * v^b \tag{2}$$

After fitting, we obtain the fitting results: $a = 17.64$; $b = -2.331$. Then, the modified wavelet medium estimation is:

$$\delta = \frac{\text{Median}\left(|Y(i,j)|\right)}{0.6745} \tag{3}$$

$$\delta_{\text{mod}} = \frac{\delta}{(1 + 17.64 * \delta^{-2.331})} \tag{4}$$

To demonstrate the validity of the modified wavelet medium estimation, we test the method on the 256 × 256 Boat and 512 × 512 airport, which are respectively added by different noise. The standard deviations of noise are 2, 6, 10, 14 and 18. Then the noises of these images are estimated by using the wavelet medium estimation and modified wavelet medium estimation. The estimation results are listed in Tables 2 and 3.

It is observed that compared with wavelet medium estimation, the error of estimated standard deviation of noise of modified wavelet medium estimation decreases greatly. So, the standard deviation of noise will be estimated by using modified wavelet medium estimation in the following text.

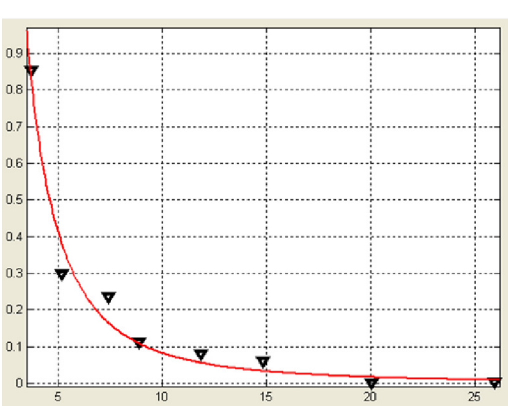

Fig. 1. The fitting curve of the estimated error versus the estimated value.

2.2. No-reference assessment of blurring

Blurring can be measured by image contrast and edge strength. Image contrast is estimated by GMG (Gray Mean Grads). It should be clear that the blurring is bigger, the image contrast is smaller. But with the addition noise, instead, image contrast becomes great. In the same way, high quality images have clear edges and edge strength is relatively small. For blurring image, the edge strength becomes wider. However, false edges which result from noise influence the computation of edge strength. So, we have to exclude the influence of noise in the processing of estimating blurring. In this paper, we put forward a blurring estimation method through counting the edge points. In order to accurately assess edge points of image, we introduce self-adaptive threshold that is decided by noise. With this threshold, we can eliminate false edges and obtain real edges points.

The concrete steps for evaluating blurring of image:

1) Firstly the sobel operator is performed on the distortion image to get the edge image E;
2) Compute the threshold:

$$Th = Me(E) + \delta \tag{5}$$

where $Me(E)$ is the mean of edge image E, δ is standard deviation of noise of distortion image;
3) The edge image E is processed through threshold transform to get the new edge image E';
4) Count the edge points: when point $E'(i,j)$ is all greater or less than four proximal points, it is considered as a singular point that results from noise and should be rejected. Otherwise, it is considered as an edge point.
5) The blurring is computed by normalizing the statistical edge points.

To demonstrate the validity of the proposed method, we tried an experiment on 9 synthetically focal blurred images with different noise. The sizes of blurring diameter are respectively 3, 5 and 7. The standard deviations of noise are respectively 8 and 25.

Table 2
The standard deviation of noise of the wavelet medium estimation.

Actual value		2	6	10	14	18
Boat	EV	3.706	7.413	11.119	14.826	18.532
	EE	85.3%	23.6%	11.2%	5.90%	2.96%
Airport	EV	2.965	6.672	10.378	14.085	17.791
	EE	48.2%	11.2%	3.78%	0.61%	1.16%

Table 3
The standard deviation of noise of the modified wavelet medium estimation.

Actual value		2	6	10	14	18
Boat	EV	2.023	6.361	10.448	14.352	18.177
	EE	1.15%	6.02%	4.48%	2.51%	0.98%
Airport	EV	1.436	5.507	9.650	13.782	17.417
	EE	39.3%	8.95%	3.63%	1.58%	3.35%