New Full Reference Image Quality Assessment Method based on Edge Intensity

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Abstract
Despite the many methods, proposed in the literature, for application oriented situations (compression, distortion, etc.), more methods are still needed for the development of this field. From this point of view, a new full reference image quality assessment (IQA) method based on edge intensity has been proposed in this paper based on the usage of the multi-level 2-D wavelet decomposition for edge detection. The first level of the wavelet decomposition is used for the gray scaled image using the Daubechies 4. The algorithm tested using different image sets with different spatial details and degradation types. In addition, other full reference algorithms, which are used for image quality assessment, are investigated for possible applications in image quality assessment problem. We implemented and tested the proposed image quality assessment algorithm for detailed evaluation. In this paper, the result is compared with the questioner results and the proposed method result is the same result as provided by the questioner.

Key words:
image quality assessment, wavelet transform, edge intensity.

1. Introduction

Image Quality Assessment objective calculations attempt to estimate the human perception of image quality. The prediction of images' differences, as recognized by the human eye, is very poor, because the images are known to be sufficient to compare the classical criteria such as root mean error. To properly solve the problem, various Image Quality Measurement methods are proposed. Image quality metrics calculation to determine the correct image difference as people perceive traditional contains the Human Visual System (HVS) model. In this thesis, a reference image is known to assume full concern ourselves with full reference image quality measurements. Output that describes the visible differences between a map (Figure 1), a reference image and a distorted image [1, 2].

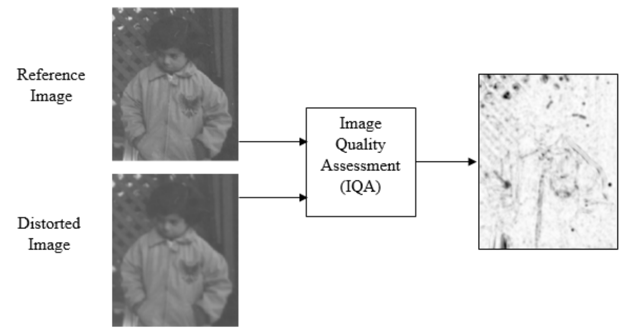

Fig. 1 Image quality assessment procedures.

2. Image Quality Assessment Techniques

There are two categories of image quality assessment methods, as shown in figure 2, which are subjective and objective. Subjective methods assess image quality based on subjective experiments, while objective methods depend, mainly, on mathematical measures to assess the image quality [3].

2.1 Subjective Methods

It is obvious that the human is the best judge of quality. This is the reason behind expecting precise measures from subjective methods of perceptual quality.

Assessing image quality by the subject can be achieved by the simple provision of a distorted medium, which is intended to assess its quality, to the subject. One more way is to provide an additional reference medium that can be used by the subject to assess the distorted medium.

Assessing image quality using subjective assessment methods is very expensive because it must be executed with enormous care to get meaningful results. These methods are also suitable for usage where real-time processing is needed [3].

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2.2 Objective Methods

Objective methods may be considered as quantitative approaches. The intensity of two images, one distorted image to be evaluated and a reference image, are used be these methods to calculate a number that is used as an image quality indicator. The objective Image Quality Assessment (IQA) consists of three categories, which are full-reference, reduced-reference and no-reference. The avialability of these reference images is the base of IQA. Image quality assessment models are used for automatic preceptual quality estimation for images that is similar to human appreciation. The objective model methods, which are classified according to the availability of the reference images into three categories, are shown below [3].

A. Full Reference IQMs

In full reference (FR) methods, a comparison between the original image and the image being investigated is directly performed. There is a limitation to the applicability of FR methods as the existence of the original image is mandatory to perform the computation. The simplest FR metrics that are widely used are Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). These metrics are widely used in applications; however the results of these algorithms do not compete with the subjective results and human visual system [4].

According to figure 2 FR can be grouped into three methods depending on their strategies:

- Mathematical metrics
  In this method, the quality (distortion) measure of the image is calculated from the similarity (dissimilarity) of the distorted image when compared to the reference image after regarding the image into a 2D signal. (e.g. Minkowski metric)
- HVS based metrics
  In this method, the error signal, which is the difference between the distorted and reference images, is normalized depending on its visibility, as recognized by human perception's psychophysics. Most commonly used HVS features in IQ Metrics are the contrast sensitivity function (CSF), luminance contrast sensitivity and contrast masking.
- Other Metrics
  The structural similarity approach is based on the assumption that HVS is highly adapted to the natural information of the scenes, which is highly structured. Thus, a good approximation of the perceived distortion in the image can be obtained from measuring the change of the structural information.

  On the other hand, the visual fidelity information (VIF) quantizes the mutual information between the investigated and reference images to relate with visual quality [5].

B. Reduced Reference IQMs

In reduced reference (RR) metrics, only partial information about the original image is available while quantifying the quality of the image under test. Therefore RR metrics lie in between the no reference and full reference metrics in terms of available information about the original image. RR methods just extract some features from both the original and the processed image and quantify the quality of the image corresponding to these features, which are the representatives of all the information in the images. Extracted features mostly describe the image content or distortion based properties. Compared to FR and NR metrics, only a few RR metrics are available in the literature which correlates well with human perception of quality [6].

C. No Reference IQMs

No reference (NR) metrics are also known as blind metrics as there is no way of comparing the investigated image and reference images directly; because the original image is not available. In image processing applications such as super resolution, the original image is not available for direct comparison. Therefore no-reference metrics are highly applicable in the subject of super resolution image quality assessment. Most of the NR IQA algorithms do not exploit natural image modeling but they assume that distortion type affecting the image quality is known. Some of them estimate image blur or JPEG/JPEG2000 compression artifacts by investigating the features of the artifact in spatial and frequency domain. These NR metrics are designed to distinguish specific image degradation types and quantify their presence from specific properties of the characterized artifacts. Therefore most NR methods can be classified as distortion-aware since they can handle only one or few specific degradation types [7].

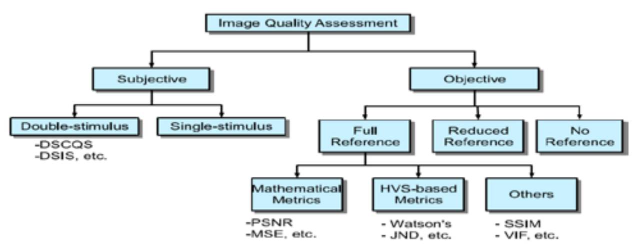

Fig. 2 Image Quality Assessment.

3. Experimental Results of The Proposed Method

The original Lena image alongside with six of its distorted versions, shown in Fig. 3, are used to conduct the experiments in this study. The distorted versions are generated by applying some well-known image filters (i.e. gaussian noise, compression, sharping, blurring, sharpen and salt & pepper) to keep the PSNR values similar to the original image. The HPQA and the classical PSNR results for all images are shown in Fig. 3. The PSNR results for Fig. 3b, 3c, 3d, 3e, 3f and 3g are equal (i.e., 27.67 dB), which means that the contrary of the test image is equally affected by imposed different distortions. This shows that the PSNR parameter is not sufficient for distinguishing the difference between the original and the distorted images [2]. Thus, its performance is considered very poor as a numeric IQA.

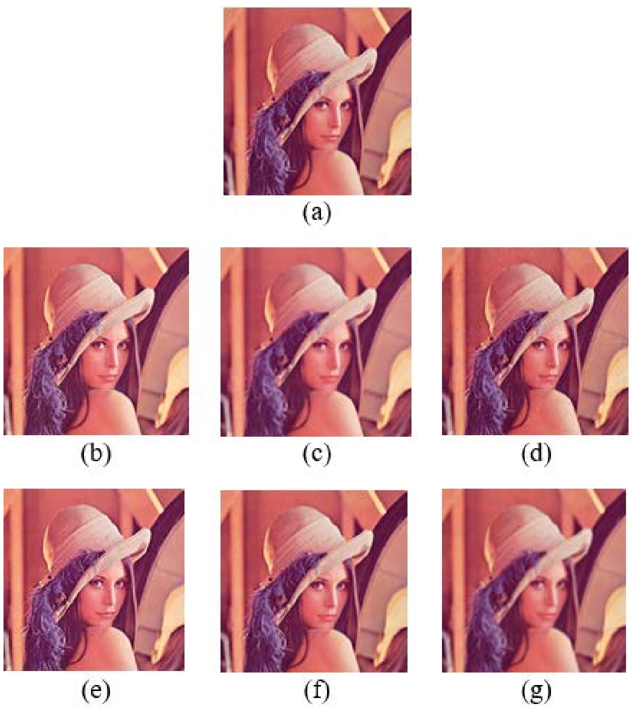

Fig. 3 Lena original test image contaminated by some distortions: (a) Original Lena image, 512 × 512, 24 bits/pixel; (b) sharpened, PSNR = 27.67, (c) median noise, PSNR = 27.67, (d) salt & pepper noise, PSNR = 27.67, (e) JPEG compression, PSNR = 27.67, (f) Gaussian noise, PSNR = 27.67, (g) Blurring noise, PSNR = 27.67.

In addition to the results shown above, another 24 test images, which are downloaded from Stanford Center for Image Systems Engineering [6], have been used to conduct more experiments to evaluate the well-known methods. All test images are coded using the Least Significant Bit (LSB) data hiding method with the same data hiding rate (1.5 bits per pixel) because this method produces least effect than other distortions [7]. This creates real challenges to evaluate the sensitivity of IQA methods against such minor distortions.

In this study at first step the original image is read and then this original image is distorted by Gaussian noise, Poisson, salt & pepper noise, speckle and JPEG compression. For edge detection method the Sobel, Laplacian of Gaussian, Canny, zerocross and prewitt are used. For each one the result is get and shown in following table [3].

The Peak Signal to Noise Ratio (PSNR) for each operator is get and shown in following table. The Lena image and the Paint house image is used for evaluation of the algorithm. The questioner result for Lena image for Lena image is shown in table 2.

Table 1: The questioner result for Lena image

Sharpen	Median	Salt & Pepper	JPG	Gaussian	Blurring
0.0%	**92.3%**	0.0%	3.8%	0.0%	3.8%
0.0%	3.8%	1.9%	17.3%	0.0%	**76.9%**
0.0%	0.0%	17.3%	**67.3%**	1.9%	11.5%
0.0%	1.9%	**59.6%**	9.6%	25.0%	5.8%
0.0%	1.9%	21.2%	1.9%	**73.1%**	1.9%
100.0%	0.0%	0.0%	0.0%	0.0%	0.0%

The proposed method result for Lena with Pearson method is shown in table 3.

Table 2: Result for Lena with Pearson method

Gaussian	0.595136
Blurring	0.167521
Median	0.256644
Sharpen	0.980369
salt & pepper	0.586825
JPEG compression	0.285663

As results, the best result and high PSNR is get for prewitt method and this value is for JPEG compression distortion.

In HSI, also the best result is get for prewitt method but here the distortion method is Gaussian noise distortion method.

In YUV the best result is get for prewitt and the distortion method is Poison method.

In this work all color space is used for testing and comparing that which one is the high performance. Because we are going to know which color the best performance has.

Also in this study the famous image edge detection algorithm are used. These algorithm are Sobel, Laplacian and Gaussian, Canny, Zerocross, Prewitt and Robert. For getting the accuracy of assessment we need to implement all edge detection algorithm. After simulation result we will get the best performance that depended for which edge detection algorithm.

For comparing of between original image and distortion image we will use Spearman Rank Order Correlation Coefficient.

A Spearman Rank Order Correlation Coefficient is a measurement parameter of correlations, that is, it measures how well an arbitrary monotonic function can describe the relationship between two variables (image and distorted image), without making any assumptions about the probability distribution of the variables.

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \quad (1)$$

In this formulation x_i is original image and arranged in 1-D vector and y_i is distorted image also this 2-D image is arranged in 1-D vector.

If the x_i and y_i is same value the ρ will be equal 1.

4. Conclusions

In this paper, we proposed a Full Reference image quality assessment metric for image resolution which correlates well with human perception as well as being robust against any type of degradation. We used the edge feature for assessment. In this paper we used very famous datasets, LIVE2, TID2008, and CSIQ.

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