

Image Quality Assessment Metrics based on Distortion Measures

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Abstract: Image quality could be a characteristic of an image that measures the perceived image degradation. It plays a vital role in numerous image processing applications. Measuring image quality becomes more and more necessary as a result of the various applications involving digital imaging and communications. Goal of image quality assessment is to produce quality metrics which will predict perceived image quality mechanically. Several techniques are planned for measuring the quality of the image however none of it is considered to be perfect for measuring the quality. The measures are categorized into Pixel difference based, and HVS-based (human visual –based) the great IQA be correct and consistent in predicting the quality. Most IQA metrics associated with the distinction between two images (the original and therefore the distorted image).

Keywords: Pixel difference Based measurement, Mean squared error (MSE), Peak signal-to noise ratio (PSNR), Human Visual System based (HVS), Measurement, Image quality measurement, Structural similarity index metric (SSIM).

I. Introduction

The quality of the image degrades from the minute it is captured to the time it is displayed to the human observer. The image is subject to many kinds of distortions during the stages that it might pass through such as storing, processing, compressing, and transmitting, etc. In evaluating image quality there are two followed methods, the subjective and the objective method.[1] The subjective method evaluation is considered costly, expensive, and time consuming; since we have to select a number of observers, show then a number of images and ask them to score images quality depending on their own opinion. The objective of automatic algorithms is to assess the image quality without human interfere.

Objective image quality metrics are divided into different categories depending on the existence of the original image: -

They are Full Reference Image Quality Assessment (FR-IQA) metrics, Reduced Reference Image Quality Assessment (RR-IQA) metrics and No Reference Image Quality Assessment (NR-IQA) metrics. [2] This paper will refer to full-reference image quality metrics. Mean Opinion Score (MOS) is the well-known approach for subjective image quality assessment. In this approach, we compare original images with distorted images in order to estimate the quality of the distorted image. The mean score is taken as the image quality index. [3] Despite that this process reflects human perception, it is considered time consuming and unpractical to use in conjunction with other image processing algorithms. Subjective assessment needs a strong metric to correlate.

II. Image Quality Metrics

Image quality metrics can be approached by following ways:

- Pixel difference-based measures such as mean square distortion.
- Correlation-based measures, that is, correlation of pixels, or of the vector angular directions.
- Edge-based measures, that is, displacement of edge positions or their consistency across resolution levels.
- Spectral distance-based measures that is Fourier magnitude and/or phase spectral discrepancy on a block basis.
- Context-based measures, that is penalties based on various functional of the multidimensional context probability.
- Human Visual System-based measures, measures either based on the HVS weighted spectral distortion measures or (dis)similarity criteria used in image database browsing functions.
- This paper is focuses on only Pixel Difference-based measures and Human Visual System-based measures.

2.1 Pixel Difference Measurement

MSE: The MSE gives a better square among the compressed and the original image. The distinction between reconstructed image and original image is termed as Distortion. It is denoted by victimization mean square error (MSE) in dB.

$$MSE(db) = 10 \log_{10} \left[\frac{1}{N \times N} \sum_{i=0}^{N \times N} (X_i - Y_i)^2 \right] \rightarrow 1$$

PSNR: The magnitude relation between the almost viable power of original image and therefore the power of noise displayed as a result of compression. The similarity between the reconstructed image and therefore the original image will be fidelity or defines the standard. It is measured victimization peak signal to noise ratio (PSNR) in dB.

$$PSNR = 10 \log_{10} \left(\frac{255^2}{MSE} \right) db \rightarrow 2$$

2.2 Human Visual Based Measurement

SSIM: The structural similarity (SSIM) index is a full reference metric, the perceived quality of predicting digital television and medium photos, additionally as other forms of digital images and videos. SSIM is employed for measurement the similarity between two images. In other words, an initial uncompressed or distortion-free image as reference based on prediction of image quality. Peak signal-to-noise ratio (PSNR) and mean squared error (MSE) SSIM is designed to improve on traditional methods. [4] Structural similarity index consists of three local comparison functions namely luminance comparison, contrast comparison, and structure comparison between two signals x and y :

$$l(x, y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1} \rightarrow 3$$

$$C(x, y) = \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2} \rightarrow 4$$

$$S(x, y) = \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3} \rightarrow 5$$

The general form of the SSIM index is given by combining the three comparison functions:

$$SSIM = l(x, y)^\alpha \cdot C(x, y)^\beta \cdot S(x, y)^\gamma \rightarrow 6$$

Where α , β and γ are parameters which define the relative importance of the three components. The performance of a image quality assessment measures the degradation in digital images in order to improve the quality of the resultant image also the original and therefore the distorted image.

In this paper we have gathered information as follows: Section 4 planned methodology, Section 5 image quality assessment, Section 6 image quality assessment techniques, Section 7 Flow chart, Section 8 experimental results, Section 9 describes conclusion and future.

III. Literature Survey

Megha Goyal et al., [1], popular assessment techniques i.e. Pixel difference-based measurement metrics and HVS based metric shows that, of course calculating the image quality metric with the help of MSE or PSNR is very simple as compared to SSIM. But the results which satisfy the need of human eye are provided by Structural Similarity (SSIM).

Sejal Patil et al., [2], presented quality of an image is fundamental problem in image and video handling, and various methods have been projected for image quality assessment (IQA). Quality of an image can be dignified in two ways: subjective IQA and objective IQA method. Objective method is friendly than subjective method because most of the time the reference image is not available for the comparison.

Yusra A. Y. Al-Najjar et al., [3], proposed for measuring the quality of the image but none of it is considered to be perfect for measuring the quality. Image quality assessment plays an important role in the field of image processing.

Alain Horé et al., [4], analyze two well-known objective image quality metrics, the peak-signal-to-noise ratio (PSNR) as well as the structural similarity index measure (SSIM), and we derive a simple mathematical relationship between them which works for various kinds of image degradations such as Gaussian blur, additive Gaussian white noise, jpeg and jpeg2000 compression.

Hiray Yogita V et al., [5], proposed an algorithm which computes universal quality index of distorted image which is calculated.

J. Preiss et al., [6], proposed where image quality assessment (IQA) comes into play. IQA is an objective and quantitative measure which automatically predicts perceived image quality Over the last several decades, numerous algorithms for IQA have been investigated.

Parineeta Sachin Gengaje et al., [7], present a brief survey of first two approaches and discuss structural similarity approach in detail. Structural information in an image is defined as those attributes that represent the structure of the object in the scene, independent of the average luminance and contrast. The structural similarity approach incorporates image structures along with perceptual modeling in calculating image fidelity values.

Mariusz Oszust et al., [8], proposed approach is significantly better than popular state-of-the-art IQA measures and better than fusion approaches. an approach to the fusion of full-reference IQA measures was presented.

Mariusz Oszust et al., [9], proposed family of multi measures aggregates different IQA measures. Therefore, it is worth examining their time- and memory-consumption. The processing time and memory requirements have been determined for all aggregated IQA measures assessing an exemplary image from TID2013 dataset.

Mariusz Oszust et al., [10], proposed technique is able to find well-performing models without access to newly introduced best IQA approaches. The proliferation of electronic means of communication entails distortion of visual information carried by processed images. Therefore, automatic evaluation of image perceptual quality in a way that is consistent with human perception is important.

IV. Methodology

In this paper, we propose a mathematically defined image quality index. We mean that the quality measurement approach does not depend on the images being tested, the viewing conditions or the individual observers. More importantly, it must be applicable to various image processing applications and provide meaningful comparison across different types of image distortions. Currently, the PSNR and MSE are still employed. We derive a simple mathematical relationship between them which works for various kinds of image degradations such as Salt and Pepper, Additive Gaussian noise, Multiplicative speckle noise, Mean shift algorithm, Contrast Stretching, Blurred image, Jpeg compressed image.[4] The metrics were implemented upon these images and last a comparison has been done between four objective evaluations: pixel-difference based measurement Peak Signal-to-Noise Ratio (PSNR), Mean squared error (MSE), HVS using Structural Similarity Index (SSIM) metrics by simulating them using MATLAB software.

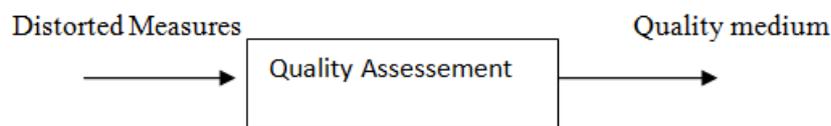


Fig 1. Block Diagram

V. Image Quality Assessment

Image quality measures the perceived image degradation imaging systems might introduce some amounts of distortion or artifacts within the signal. Essentially image quality is measured in two ways in which subjective and objective methodology. The subjective methodology evaluation [7] is taken into account expensive, expensive, and time consuming; since we have to pick out variety of observers, show then variety of images and raise them to attain image quality looking on their own opinion. The target analysis uses automatic algorithms to assess the standard of the image while not human interfere. In Subjective image quality assessment the analysis of quality by humans is obtained by mean opinion score (MOS) methodology wherever in objective analysis of quality is finished by algorithms. Involved image is perceived by a viewer and provides his opinion on a selected image and decide quality of the multimedia system content. The human eyes extract structural info from the viewing field; therefore the human sensory system is very custom-made for this purpose. Therefore, the measuring of structural distortion ought to be an honest approximation of perceived image distortion .So the correct and additional economical IQA measures will definitely enhance their applicability in real-world applications.

VI. Image Quality Assessment Techniques

6.1 Subjective Methods

In subjective quality assessment, images square measure provided to variety of observers and square measure asked to check original images with distorted pictures so as to evaluate the standard of the distorted pictures. Supported analysis, mean opinion score (MOS) is calculated that is taken because the image quality index. Every image is shown to the observer that is asked to attain the image.[5] There are three different factor used: luminance, viewing distance from observer to show and show properties square measure taken under consideration whereas conducting the subjective quality check.

According to tests methods, there are two common classes of assessments:

- Quality assessments - it establish the performance of systems under optimal conditions;
- Impairment assessments - it establish the ability of systems to retain quality under non-optimal conditions that relate to transmission or emission.

One of most used procedures for subjective quality evaluation is double-stimulus impairment scale (DSIS) method, also used in this work. It is a cyclic method in which viewer is firstly presented with an unimpaired reference, and then with the same picture impaired. In this work, the second picture is distorted by adding Gaussian noise, blur or using JPEG compression.

6.2 Objective Methods

Objective method is a quantitative approach where we are using two images in which intensity of two images; reference and distorted type are used to calculate a number which indicate the image quality. [6] Objective method is classified into three types' full-reference, reduced-reference and no-reference on basis of availability of reference image. The goal of these models is to automatically estimate the perceptual quality of images, in a way correlated with the human appreciation.

1. No Reference (NR) models: The NR-IQA algorithm is developed by focusing the possible impairments in the image that would have been caused due to distortion. Fortunately, type of distortion is known in most of the applications. For example, JPEG 2000 images suffer from ringing and blurring artifacts. This method also called "blind models" methods.
2. Reference (RR) models: The framework of RR-IQA makes use of partial information carried by extracted features of original image. Prediction of image quality is done by comparing such features with the image features of original image. Such features must provide summary of original image in brief. They should be able to reflect different types of distortions.
3. Full Reference (FR) model: In full reference, the known IQA reference image and predicted visual quality by comparing the distorted signal against the reference image Mean Square error (MSE) and peak signal to noise ratio (PSNR) are mostly used.

VII. Proposed Method Flow Chart

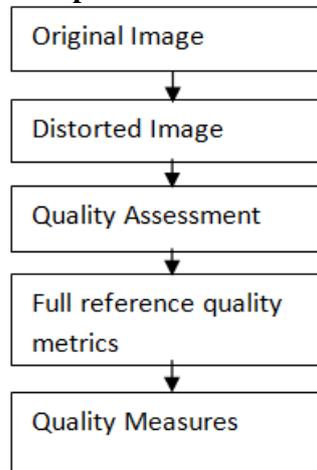


Fig 2. Flow chart

Steps involved in the process

Step 1: Consideration of Original Image

Firstly, image quality Index process the original image is applied, the original 24-bit color 512x384 test image distorted by a wide variety of corruptions. The IQA method for distortion measures provides glorious results. By selecting appropriate metrics worth for SSIM, PSNR and MSE as high as will be achieved.

Step 2: Distorted Image

Distortions that are considered which are additive gaussian noise, additive noise in color components, impulsive salt-pepper noise, blurring, JPEG compression.

Step 3: Quality Assessment

Image quality measures the perceived image degradation imaging systems might introduce some amounts of distortion or artifacts within the signal. Essentially image quality is measured in two ways in which subjective and objective methodology.

Step 4: Full reference quality metrics

In full reference, the known IQA reference image and predicted visual quality by comparing the distorted signal against the reference image Mean Square error (MSE) and peak signal to noise ratio (PSNR) are mostly used.

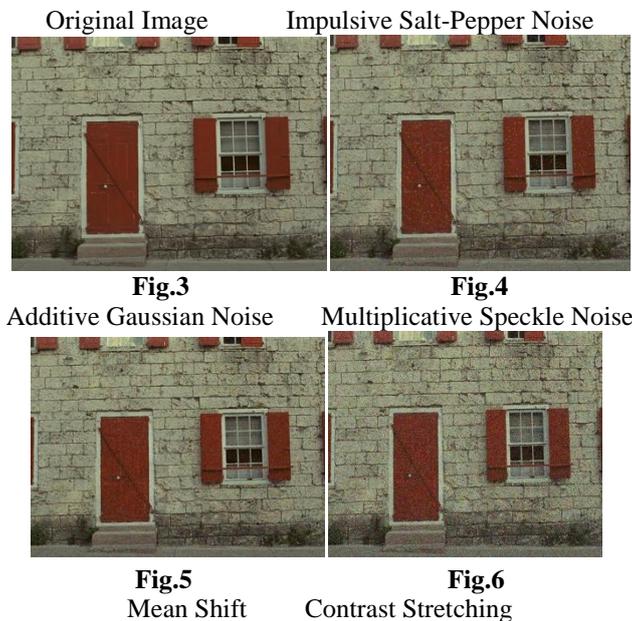
Step 5: Quality Measures

After applying some distortion to the original image we got the distorted image included and the image quality is applied to these distorted image and the results are compared. Measuring image quality for the image gave the results included. The IQA method for distortion measures provides glorious results. By selecting appropriate metrics worth for SSIM, PSNR and MSE as high as will be achieved.

VIII. Experimental Results

As can be observed, the MSE, PSNR and the SSIM is quite interesting, but does not actually indicate if one measure is more or less sensitive to any image degradation than the other. Thus, we have no information on how the values of the MSE, PSNR and the SSIM are influenced by any degradation applied to images. It appears that the SSIM is slightly more sensitive than the PSNR, MSE in discriminating the quality parameter of the image distortion, while the PSNR is slightly better than the SSIM in discriminating noise. Finally, we note that the SSIM and the PSNR, MSE are more sensitive to noise degradation than all the other degradations tested in this paper. It appears various image quality metrics introduced by noise are the most identified metrics for both the MSE, PSNR and the SSIM compared to the distortions introduced by Salt and Pepper, Additive Gaussian noise, Multiplicative speckle noise, Mean shift algorithm, Contrast Stretching, Blurred image, Jpeg compressed image. All image quality metrics are used for objective methods algorithms is to assess the image quality. After applying some distortion (contrast enhancement) to the original image we got the distorted image included and the image quality is applied to these distorted image and the results are compared.[8] Measuring image quality for the image gave the results included .

IMAGE WITH DIFFERENT TYPES OF Distortions



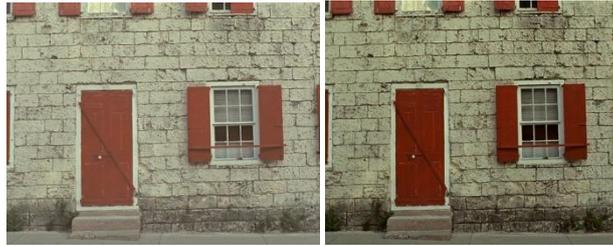


Fig.7
Blurring

Fig.8
JPEG Compression

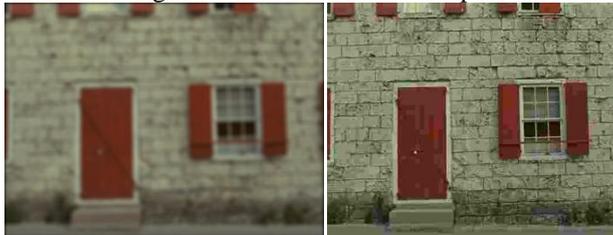


Fig.9

Fig.10

Firstly, In image quality Index process the original image is applied, IQA metrics is obtained for distorted image. Mean square error (MSE), Peak signal to noise ratio (PSNR) and Structural similarity index metric (SSIM), are obtained as image quality assessment. Experimental for image the size is 512x384 pixels. [9] The different type of distortion values for image quality metrics for numerous results are summarized within the table. The IQA method for distortion measures provides glorious results. [10] By selecting appropriate metrics worth for SSIM, PSNR and MSE as high as will be achieved.

Type of distortion	SSIM values	MSE values	PSNR values
Salt and Pepper	0.9571	256.30	24.0432
Additive Gaussian noise	0.6908	503.17	21.1136
Multiplicative speckle noise	0.9077	2048.3	15.0167
Mean shift algorithm	0.9736	899.99	18.5884
Contrast Stretching	0.9842	64.942	30.0055
Blurred image	0.5848	506.69	21.0833
Jpeg compressed image	0.8894	263.35	23.9254

Table 1: Image Quality Measurements

IX. Conclusion

Image Quality Assessment plays a vital role in Image processing. Lot of work is done in this section also in order to reduce the time, complexity and cost to assess the quality of image. Relation between various technique helps in getting the result form previous technique to new technique with the help of some mathematic. The aim to show comparison between the various techniques is just to benchmark the better algorithm for the image quality metric. A comparison between these two popular assessment techniques i.e. Pixel difference-based measurement metrics and HVS based metric shows that, of course calculating the image quality metric with the help of MSE or PSNR is very simple as compared to SSIM. But the results which satisfy the need of human eye are provided by Structural Similarity (SSIM).

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