

Comparative analysis of image quality assessment using HVS Based Model

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Abstract

Image quality assessment means estimating the quality of an image and it is used for many image processing applications. Image quality can be measured in two ways, subjective and objective method. In this paper, I am focusing on the FR objective image quality metric, where the quality of the distorted test images are obtained based on the comparison with the reference image which is assumed to be perfect in quality. In this we evaluate the MSSIM IQA metric for colour image at different noise density level .

Keywords: Image quality assessment, PSNR, SNR.

Introduction

Image quality assessment is vital for developers of digital imaging systems. They would like to know how changes in system parameters affect image quality. They would also like to know how to obtain an imaging system that achieves a particular level of image quality at the lowest possible cost. [1] A common engineering approach to imaging system quality assessment is to analyze physical system parameters like the noise power spectra and the

modulation transfer function of the system. These parameters provide useful information, but they do not take into consideration the processing performed by the human visual system. The evaluation of quality may be divided into two classes, subjective and objective methods.

Full Reference Image Quality Assessment Method:

In this method QA algorithm have access to a 'perfect version' of the image or video against which it can compare a

'distorted version'. The 'perfect version' generally comes from a high-quality acquisition device, before it is distorted by, say, compression artifacts and transmission errors. However, the reference image or video generally requires much more resources than the distorted version, and hence FR QA is generally only used as a tool for designing image and video processing algorithms for in-lab testing, and cannot be deployed as an application.[2] To evaluate the quality of a distorted image, FR metrics, which have access to both whole original and reconstructed information, provide the most precise evaluation results compared with NR and RR.

Mathematical Metric:

PSNR

Objective image quality assessment methods were mainly based on simple mathematical measures such as the Euclidian distance between the pixels of the original image taken as the reference and its distorted version. The Peak Signal to Noise Ratio is one of the most widely used metrics until now due to its analytical and computational simplicity. This makes the PSNR practical for the optimization

of image coding, filtering and quality enhancement systems [3]. But simple quantitative measures like PSNR or mean square error do not always reflect the image distortions as perceived by the HVS: for instance, two images with a large MSE distance can be considered nearly identical by the human observer. Peak Signal to Noise Ratio is a classical index defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is given by:

$$PSNR = 10 \log_{10} 255^2 / MSE$$

Where 255 is the maximum gray level of a 8bits/pixel monotonic image. Some correlation based measures that calculate the similarity between the reference and test images are there such as structural content, normalized cross-correlation, quality, etc. The major advantages of these metrics are its simplicity and mathematical tractability, but they are not correlating well with perceived quality measurement because the Human Vision System characteristics are not considered in their models. PSNR is more consistent in the presence of noise compared to the SNR.

MSE

It stands for the mean squared difference between the original image and distorted image. The mathematical definition for MSE is:

$$MSE = (1/M \times N) \sum_{i=1}^M \sum_{j=1}^N (a_{ij} - b_{ij})^2$$

In Equation (1.2), a_{ij} means the pixel value at position (i, j) in the original image and b_{ij} means the pixel value at the same position in the corresponding distorted image. The calculated PSNR usually adopts dB value for quality judgment. The larger PSNR is, the higher the image quality is which means there is only little difference between the original-image and the distorted-image. On the contrary, a small dB value of PSNR means there is great distortion between the original-image and the distorted-image.

SSIM

The structural similarity index is a method for measuring the similarity between two images [4]. The SSIM index is a full reference metric, in other words, the measuring of image quality based on an initial uncompressed or distortion-

free image as reference. SSIM is designed to improve on traditional methods like PSNR and MSE. The choice of the SSIM index as the distortion metric is mainly due to its strength as a perceptual distortion metric, intuitiveness, amenability to analysis, and ease of implementation.

Let $X = \{x_i \mid i=1, 2, 3, \dots, N\}$ and $Y = \{y_i \mid i=1, 2, 3, \dots, N\}$ be two discrete non-negative signals that have been aligned with each other e.g., two image patches extracted from the same spatial location from two images being compared, respectively. Approximately, μ_x and σ_x can be viewed as estimates of the luminance and contrast of x , and σ_{xy} measures the tendency of x and y to vary together, thus an indication of Structural similarity. The mean intensity is estimated as

$$\mu_x = \sum_{i=1}^N x_i / N$$

$$\mu_y = \sum_{i=1}^N y_i / N$$

The block diagram of SSIM :|

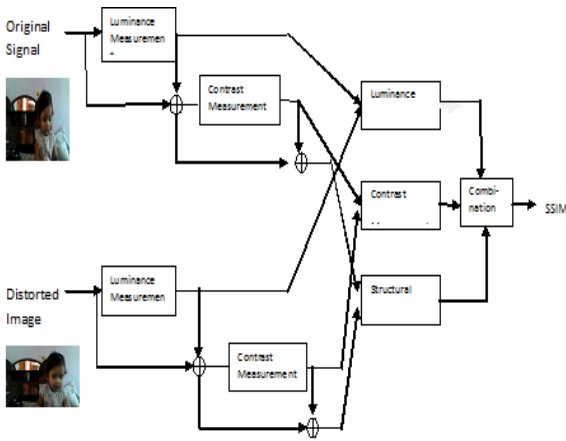


Fig. 1.4 Block Diagram OF SSIM [7]

The standard deviation is given by

$$\sigma_x = \left[\sum_{i=1}^N (x_i - u_x)^2 / (N - 1) \right]^{1/2}$$

$$+ \sigma_y = \left[\sum_{i=1}^N (y_i - u_y)^2 / (N - 1) \right]^{1/2}$$

The covariance is estimated as

$$\sigma_{xy} = \sum_{i=1}^N (x_i - u_x)(y_i - u_y)^2 / (N - 1)$$

μ_x be the mean of X

σ_x be the variance of X

σ_{xy} be covariance of X and Y

Universal image quality index:

By “universal,” 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 “universally,” regardless of their questionable performance. The disadvantage with the UIQI is that there is no implementation of HVS characteristics. This disadvantage can easily be seen by removing all the information in the distorted image, i.e., setting the pixel values to zero, the image quality index becomes zero. Furthermore, the UIQI gives poorer results if the colours in the image are inverted. By analyzing the distorted images visually an image with non information would have a poorer image quality compared to an image where the colour are inverted [5].

$$L=X=\{x_i \mid i=1,2,\dots,N\} \text{ and } Y=\{y_i \mid i=1,2,\dots,N\}$$

Be the original and test image signal respectively.

If \bar{x} is the mean of x, σ_x^2 the variance of x, σ_{xy} is covariance of x.y then UQI is given by:-

$$UQI= 4 \frac{\sigma_{xy}}{\sigma_x \sigma_y}$$

$$\overline{(x+y)^2} = \overline{x^2 + y^2 + 2xy} = \overline{x^2} + \overline{y^2} + 2\overline{xy}$$

$$\overline{x} = 1/N \sum_{i=1}^N x_i \text{ and } \overline{y} = 1/N \sum_{i=1}^N y_i$$

also standard derivation given as:-

$$\sigma_x = \sqrt{1/N - 1 [\sum_{i=1}^N (x_i - \mu_x)^2]}$$

$$\sigma_y = \sqrt{1/N - 1 [\sum_{i=1}^N (y_i - \mu_y)^2]}$$

covariance is given as

$$\sigma_{xy} = 1/N - 1 \sum_{i=1}^N (x_i - \mu_x)(y_i - \mu_y)$$

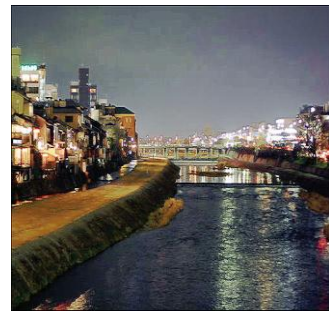
The dynamic range of UQI is [0,1]. The best value of 1 is achieved if and only if $y_i = x_i$ for all $i=1,2,\dots,N$.

$$UQI = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \frac{2 \overline{xy}}{\overline{x^2} + \overline{y^2}} \frac{2 \sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2}$$

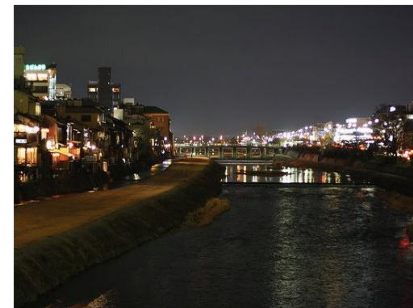
This quality index models any distortion as a combination of three different factors loss of correlation as represented by the first term where second component represents luminance distortion and the last component is contrast distortion. Thus, UQI can be written as a product of three components.

Results

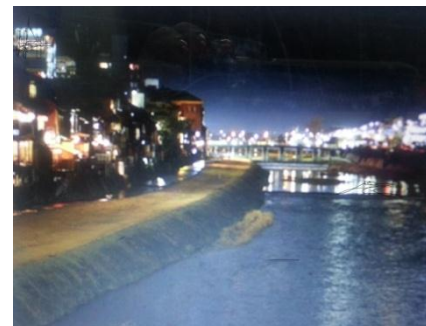
In this we compare the performance of MSSIM with the statistical methods that are PSNR, SNR for the following image at different noise density levels.



(noise density 0.1)



(noise density 0.2)



(noise density 0.3)

Noise	SNR	PSNR	MSSIM	ELAPSED TIME

0.1	3.4429	11.765122	0.38912	0.02603
0.2	8.7486	17.0708	0.57359	0.02594
0.3	3.5120	11.83429	0.38939	0.02609

CONCLUSION

In the field of image processing, image quality assessment is a fundamental and challenging problem with many interests in a variety of applications, such as dynamic monitoring and adjusting image quality, optimizing algorithms and parameter settings of image processing systems, and benchmarking image processing system and algorithms. This dissertation is concerned with the assessment of the quality of the images and to guide the researchers in selection of a method that best correlate with the subjective perception values. Earlier techniques were based on mathematical metrics like PSNR, MSE but they do not correlate well with subjective perception values. Moreover they are difficult to estimate and become unstable if the image has significant amount of distortion. MSSIM is a human visual system based metric which uses the luminance, structural and contrast information present in the given image as like in HVS model. These validation results show the robustness,

feasibility of the MSSIM and it can perform better than PSNR and SNR.

FUTURE SCOPE

Although this HVS based metric has good consistency with subjective perception values, there are still some issues to be investigated in the future. For example, we can investigate the new image representation method to reduce the number of feature parameters needed for IQA metrics. Also we can introduce the methods which can estimate the quality of the image without any reference.

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