A MODIFIED STRUCTURAL SIMILARITY INDEX WITH LOW COMPUTATIONAL COMPLEXITY

Woei-Tan Loh
Faculty of Engineering
Universiti Malaysia Sarawak
Kota Samrahan, Malaysia
lohwt91@yahoo.com

David Boon Liang Bong
Faculty of Engineering
Universiti Malaysia Sarawak
Kota Samrahan, Malaysia
bbldavid@unimas.my

***Abstract*—Structural Similarity Index (SSIM) has been a benchmark method for image quality assessment (IQA). This is due to its simplicity and good performance. In this paper, we propose a modified SSIM method that reduces the computational complexity with comparable performance. Instead of computing similarities on local windows, the proposed method computes global information similarities. The proposed method omits the luminance part similarities in SSIM due to its less crucial role in assessing image quality. From the presented results, the proposed method has a much lower computational time and comparable performance compared to SSIM.**

Keywords*— *image quality, computational complexity, SSIM

I. INTRODUCTION

In the past decade, many image quality assessment (IQA) methods are proposed. Among them, Structural Similarity Index (SSIM) [1] is the most popular methods. Many researchers extend SSIM. Results of these works prove the capability and generality of SSIM. The proposed method in this paper is termed global-SSIM (GLOSS). In GLOSS, the quality index is calculated from global information. This is different from literature works [2-3]. Fast SSIM [2] optimizes computation speed using the integral image. Work by Bruni and Vitulano [3], on the other hand, utilizes a subset of image information that is computed from local windows. GLOSS will focus on all distortions of natural images that is dissimilar to other works [4-6].

II. PROPOSED METHOD

The main factor that increases the computational complexity of SSIM is the utilization of local windows. To speed up SSIM, GLOSS computes a quality index from the global aspect. This is inspired by the work by Larson and Chandler [7]. The effectiveness of global quality in accessing image quality is also proven in other works [8]. Different from these works, global quality is not computed from local quality indices, but directly computes global quality from every pixel in GLOSS.

Thus, mean, standard deviation, and covariance are computed from the whole image. For GLOSS, similarity equation from [1] is modified to:

$$GLOSS\_1(X,Y)=\frac{(2\mu_X\mu_Y+C_1)(2\sigma_{XY}+C_2)}{(\mu_X^2+\mu_Y^2+C_1)(\sigma_X^2+\sigma_Y^2+C_2)}, \tag{1}$$

where μ and σ are the mean and standard deviation of entire image X and Y. Parameter σ_{XY} is the covariance of entire image X and Y. Constants C_1 and C_2 are used to prevent instability.

In SSIM [1], weighting function w_i aims to remove blocking artifacts. The blocking effect is due to the local information computation. In GLOSS, no local information computation is involved and w_i could be omitted. According to [9], the luminance part of SSIM is less crucial in determining image quality. Hence, the luminance similarity term is omitted accordingly. GLOSS is now simplifies to:

$$GLOSS\_2(X,Y)=\frac{2\sigma_{XY}+C_2}{\sigma_X^2+\sigma_Y^2+C_2}. \tag{2}$$

In order for GLOSS to have values between zero and one, equation (2) is modified to use the absolute value of σ_{XY}. Finally, GLOSS is formulated as:

$$GLOSS(X,Y)=\frac{2|\sigma_{XY}|+C_2}{\sigma_X^2+\sigma_Y^2+C_2}. \tag{3}$$

III. EXPERIMENTAL RESULTS

Three publicly available benchmark image databases, LIVE [10], TID2013 [11], and CSIQ [12] were utilized for evaluating GLOSS. The performance of GLOSS is evaluated from two aspects. Spearman Rank Order Correlation Coefficient (SC) measures prediction monotonicity while prediction accuracy is evaluated by Pearson Linear Correlation Coefficient (PC). Before measuring PC, nonlinear regression of the predicted scores is computed by using a logistic regression function [13]. GLOSS is compared with SSIM and Fast SSIM. The method by Bruni and Vitulano [3] is not compared as its code is unavailable.

The results of performance comparison are shown in Table 1. The best results are highlighted. For LIVE image database, SSIM performs the best. Fast SSIM and GLOSS have very similar performances for all distortion types except AWN and FF. For TID2013 image database, GLOSS outperforms SSIM especially for SC. All methods have poor results for local block-wise distortions, contrast change, and change of color saturation. This may due to the less