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Performance Analysis of No Reference Image Quality Based on Human Perception

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ABSTRACT

In this work, a No-Reference objective image quality assessment based on NRDPF-IQA metric and classification based metric are tested using LIVE database, which consisting of Gaussian white noise, Gaussian blur, Rayleigh fast fading channel, JPEG compressed images, JPEG2000 images. We plot the Spearman's Rank Order Correlation Coefficient [SROCC] between each of these features and human DMOS from the LIVE-IQA database using our proposed method to ascertain how well the features correlate with human judgement quality. The analysis of the testing and training is done by SVM model. The proposed method shows better results compared with the earlier methods. Finally, the results are generated by using MATLAB.

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1. INTRODUCTION

Interest in the measurement of visual quality can be dated back to times when interest in quality assessment was primarily based on display applications. But as time progressed and so did the prevalance of imaging in multifarious applications, 'Quality' got defined in different ways depending on application for which it was defined [2, 4, 15]. Image acquistion engineers dealing with applications like laser range scanning focused on imaging system aspects when they gauged quality; printer engineers focused on tone, color assessment and fundamental printing attributes, such as area and line quality. In contrast, medical imaging researchers related it with the clarity with which they could detect malfunctions or diseases in body from captured images, for example tumours and cancers from X-Ray images [5, 8]. However, for the scope of our current work, we are interested mainly on digital multimedia applications targeted for entertainment applications. Advancement in multimedia technologies have brought a host of devices to capture, compress, send and display different kinds of audiovisual stimulations. Great efforts have been devoted by developers working in 2D image and video transmission industry to guarantee end user a satisfactory quality of experience, being most salient for design and deployment of any multimedia service [2, 7, 14]. Perceptual optimization of multimedia services looks promising in current era of bandwidth famine coupled with increased multimedia traffic so as to provide similar quality of service to consumer. In other words, objective function while finding optimum configuration of multimedia framework can incorporate Quality of Experience as an additional term. A service network codes the produced audiovisual content to transmit it over communication channels to the consumer [15]. Various distortions due to compression, channel noise, packet loss etc are introduced in the signal from this chain of operations from content development till transmission. These distortions in visual stimuli, when perceptible, mar the viewing experience and hence reduction in perceived visual quality. The reduced quality of distorted stimuli can be judged by conducting large-scale human *subjective* studies where human observers are asked to quantify quality of stimulus shown on a fixed scale [14, 15]. However, this kind of human assessment is time, effort and cost expensive; engendering the need to design algorithms capable of duplicating and hence eliminating human involvement altogether. These designed objective quality indices can then be utilized for multifarious applications including but not limited to optimum pre-filtering and bit assignment algorithm design at encoder side; optimal reconstruction, error concealment and post-filtering at decoder side and benchmarking of image and video processing systems.

2. RESEARCH METHOD

The approach for the NRDPF- IQA (No Reference Distortion Patch Feature Image Quality Analysis) that we have developed can be summarized as follows. Given a (possibly distorted) image, first compute locally normalized luminance via local mean subtraction and divisive normalization. The following are the equations to to applied to a given intensity image [15].

$$H: \nabla_x I(i,j) = I(i,j+1) - I(i,j) \quad (1)$$

$$V: \nabla_y I(i,j) = I(i+1,j) - I(i,j) \quad (2)$$

$$MD: \nabla_{xy} I(i,j) = I(i+1,j+1) - I(i,j) \quad (3)$$

$$SD: \nabla_{yx} I(i,j) = I(i+1,j-1) - I(i,j) \quad (4)$$

$$HV: \nabla_x \nabla_y I(i,j) = I(i-1,j) + I(i+1,j) - I(i,j-1) - I(i,j+1) \quad (5)$$

$$CD_1: \nabla_{cx} \nabla_{cy} I(i,j)_1 = I(i,j) + I(i+1,j+1) - I(i,j+1) - I(i+1,j) \quad (6)$$

$$CD_2: \nabla_{cx} \nabla_{cy} I(i,j)_2 = I(i-1,j-1) + I(i+1,j+1) - I(i-1,j+1) - I(i+1,j-1) \quad (7)$$

$$J(i,j) = \log\,[I(i,j) + K] \quad (8)$$

$$D_1: \nabla_x J(i,j) = J(i,j+1) - J(i,j) \quad (9)$$

$$D_2: \nabla_y J(i,j) = J(i+1,j) - J(i,j) \quad (10)$$

$$D_3: \nabla_{xy} J(i,j) = J(i+1,j+1) - J(i,j) \quad (11)$$

$$D_4: \nabla_{yx} J(i,j) = J(i+1,j-1) - J(i,j) \quad (12)$$

$$D_5: \nabla_x \nabla_y = J(i-1,j) + J(i+1,j) - J(i,j-1) - J(i,j+1) \quad (13)$$

$$D_6: \nabla_{cx} \nabla_{cy} J(i,j)_1 = J(i,j) + J(i+1,j+1) - J(i,j+1) - J(i+1,j) \quad (14)$$

$$D_7: \nabla_{cx} \nabla_{cy} J(i,j)_2 = J(i-1,j-1) + J(i+1,j+1) - J(i-1,j+1) - J(i+1,j-1) \quad (15)$$

The equations from (1) to (15) represent the features of the distortion patches. It also observed that the normalized luminance values strongly tend towards a unit normal Gaussian characteristic for images. Compute the MATLAB program for the equations from (1) to (15).

$$\hat{\boldsymbol{I}}(\boldsymbol{i},\boldsymbol{j}) = \frac{I(i,j) - \mu(i,j)}{\sigma(i,j) + C} \quad (16)$$

$$\mu(i,j) = \sum_{k=-K}^{K} \sum_{l=-L}^{L} \omega_{k,l}\; I_{k,l} I(i,j) \quad (17)$$

$$\boldsymbol{\sigma(i,j)} = \sqrt{\sum_{k=-K}^{K}\sum_{l=-L}^{L}\omega_{k,l}\,(I_{k,l}I(i,j) - \mu(i,j))^2} \quad (18)$$

$$\boldsymbol{f(x;\alpha,\sigma^2)} = \frac{\boldsymbol{\alpha}}{\boldsymbol{2\beta\Gamma\left(\frac{1}{\alpha}\right)}}\boldsymbol{exp}(-(\frac{\boldsymbol{|x|}}{\boldsymbol{\beta}})^{\alpha}) \quad (19)$$

$$\boldsymbol{\beta} = \boldsymbol{\alpha}\sqrt{\frac{\boldsymbol{\Gamma(1/\alpha)}}{\boldsymbol{\Gamma(3/\alpha)}}} \quad (20)$$

$$\Gamma(a) = \int_0^{\infty} t^{a-1}\, e^{-t} dt \;\; a > 0 \quad (21)$$

$$H(i,j) = \boldsymbol{\hat{I}(i,j)\hat{I}(i,j+1)} \quad (22)$$

$$V(i,j) = \boldsymbol{\hat{I}(i,j)\hat{I}(i+1,j)} \quad (23)$$

$$D1(i,j) = \boldsymbol{\hat{I}(i,j)\hat{I}(i+1,j+1)} \quad (24)$$

$$D2(i,j) = \boldsymbol{\hat{I}(i,j)\hat{I}(i+1,j-1)} \text{ for i } \in \{1,2,\ldots,M\} \text{ and j } \in \{1,2,\ldots,N\} \quad (25)$$

The NRDPF-IQA algorithm is designed for this image quality assessment purpose. The MATLAB code is developed for entire equations from (16) to (25).

3. RESULTS AND ANALYSIS

While we are using a probabilistic framework for distortion classification where we use the probability of an image being distorted with a particular distortion, but just as a proof of how good the featues used in the framework act as distortion identifiers and also which distortions are misclassified with which ones, we are reporting the confusion matrix for first stage classification. We would like to point out that each entry in the confusion matrix is the mean of confusions across 1000 trials. We can see from database that fast fading and JPEG2000 are confused with each other. Also, JPEG2000 and JPEG are also confused sometimes. WN and Blur are comparatively more robust in detection and not confused usually with other distortions.

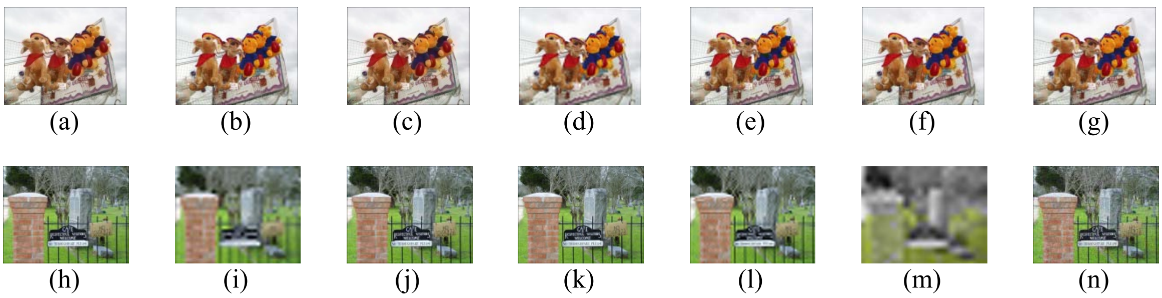

Figure 1. Images from (a) to (g) and (h) to (n) are consider for the testing by SVM

As we computed have correlations for each algorithm over 1000 traintest trials, we find mean SROCC value and the standard error associated with these correlation values. We plot the same across the dataset along with error bars one standard deviation wide for each of the evaluated algorithms.

Table 1. Median spearman rank ordered correlation coefficient (srocc) across 1000 train-test combinations on the live iqa database for different window sizes bold indicate proposed algorithm

K,L	JPEG2000	JPEG	WN	Blur	FF	ALL
4	0.9820	0.9803	0.9798	0.9605	0.9401	0.9489
5	0.9663	0.9715	0.9762	0.9597	0.9315	0.9461
6	0.9641	0.9642	0.9686	0.9497	0.9248	0.9419
7	0.9548	0.9618	0.9618	0.9427	0.9231	0.9345
8	0.9531	0.9512	0.9514	0.9329	0.9126	0.9258
9	0.9418	0.9465	0.9501	0.9301	0.9103	0.9186

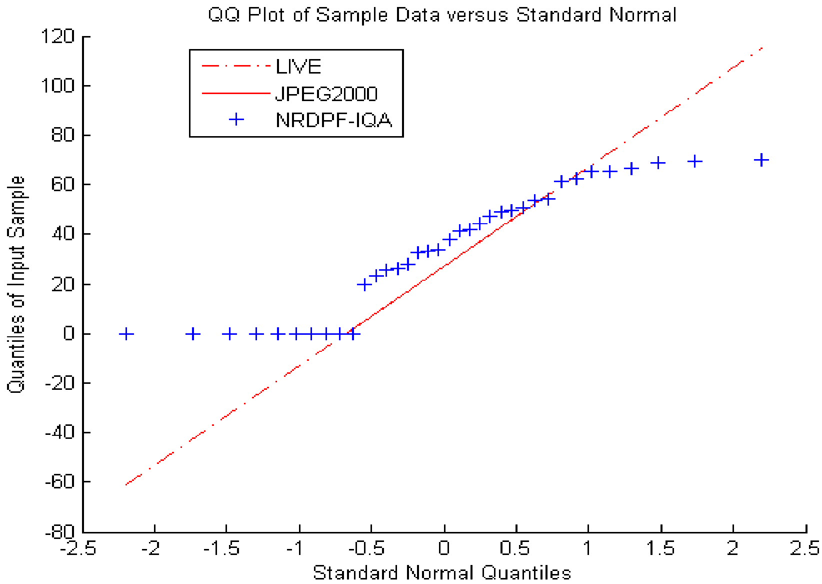

Figure 2. QQ plot of sample data versus Standard Normal IQA

4. CONCLUSION

We proposed a No reference image based quality assessment model NRDPF-IQA which performs quality assessment of an image with out any information from distortion image. No distortion specific features such as ringing blur or blocking has been modeled in the algorithm in specific. The algorithm only quantifies the blind in the image due to presence of distortions. The designed framework is spatial domain, human perception based, simpler and faster which makes it superior to other no reference algorithms. The index is been shown to perform well across different distortions verifying its distortion agnostic nature. An exhaustive analysis of performance is done using LIVE IQA database on five kinds of distortions through spearman rank ordered correlation coefficent. The frame work is found to perform statistically better than other proposed no reference algorithms.

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