DOI: http://dx.doi.org/10.26483/ijarcs.v13i3.6819

ISSN No. 0976-5697

Volume 13, No. 3, May-June 2022

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

NO REFERENCE IMAGE QUALITY ALGORITHM BASED ON HUMAN-EYE SENSITIVE CONCEPTION FOR CONTRAST-DISTORTION EVALUATION

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Abstract: No reference image quality assessment IQA algorithms are widely used for finding distortions in images without comparing them to references. Image' areas with no details may indicate a brightness saturation change, as well as the presence of noise in the background, which are more visible types of distortions. Thus, the design of such IQA should take into account the human visual conception. This paper proposes a no-reference image quality evaluation algorithm that takes into account the finest edge detection process and entropy deployment in regard to human visual sensitive HVS to quantify brightness saturation variations and noise in pixels. Statistic objective metrics for correlation coefficient CC which person PCC, spearman rank order SROCC, root mean squared error RMSE are used in the objective evaluation in corresponding with the subjective evaluation. The proposed algorithm is tested and significantly has well correlation PCC > 0.87, SROCC > 0.93, RMSE < 0.34. The findings of this research could be used to improve the performance of no-reference HVS-based IQA algorithms currently in use.

Keywords: No-Reference Image Quality Algorithms; Edge Detection; Distortions; Entropy Measure; Human Visual Perception HVP.

I. INTRODUCTION

Image quality is the aim of an IQAs algorithm based on the comparison between the source image and its distorted one that is suffered from brightness change in objects illumination or in the background in general [1]. Full reference and no reference measures IQMs are two popular types of objective IQAs' over IQA' classification [2-5]. In google and internet, it is difficult to know the original version of an available image; Also, a reference image may have reduced contrast which needs some enhancement and however; the resulted image should get improved contrast and as a result, it is intended to be distinct from the original image; note Figure 1 where the two original versions of images in left side suffering from brightness saturation change as in right side. So, the power and the strength of no reference IQMs are needed [6-7]. Based on subjective IQAs, Human eyes are very sensitive to image' distortions and its influence on vision such as noising influence, blur influence, contrast change influence and so on. These distortions have the potential to damage the image's overall quality. In general, HVP-Luminance mask refers to the fact that distortion visibility is stronger with medium backdrop intensity and lower with very low or very high background intensity. HVP-Texture mask refers to the fact that a distortion appears more prominently in homogeneous regions than in textured or complex regions [9]. However, subjective IQA is rarely used due to computationally expensive.

(a) Original Dolly.tif (610*488) — The distorted one

(b) Original Butterfly.jpg (768*512) — The distorted one

Figure 1. The original images and its distortions of SUN database [8].

Here, this work concentrates on the how such proposed algorithm can be more sensitive to brightness change or (saturation) and noise in all its types. Many image processing techniques, such as image compression, digital watermarking, and image quality assessment, and image automatic histogram equalization enhancement exhibit distortions [10]. The following is a summary of the paper's structure: In this paper, we present the suggested IQA framework as well as the algorithm specifics (Section III). The effort and its outcomes are being evaluated and discussed (Section IV). The conclusion is included in (Section V), while a summary of relevant studies is found in (Section II).

II. RELATED WORKS REVIEW

The mean, variance, entropy, kurtosis, and skewness are all features of an image's global spatial statistics. Absolute mean brightness error AMBE can identify excessive brightness changes by measuring the absolute difference between the mean of the input and output image. It works without the use of HVS conceptions. Entropy is also a measure of the unpredictability of a random variable. Equation 1 is used to represent the information contained in an information source (the image entropy *E(i,j)).*

$$E(i,j) = \sum_{g=0}^{l-1} P_l(g)\, log2P_l(g) \qquad (1)$$

$$P_l(g) = \frac{N_l(g)}{n^2} \qquad (2)$$

$$N_l(g) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1} I_g(r-1+i, c-1+j) \qquad (3)$$

The probability of grayscale level *Pi (g)* is defined as the total number of pixels with grayscale level *g* divided on sub-image region (n ×n = 9) while the N_l (g) is the total number of pixels within the specific grayscale in that region. Hypothetically and without HVS conception, higher entropy means more information is available in that region of an image. As a result, an image with higher entropy is thought to be of higher or better quality [1]. Based on the survey of [6], the weakness of the existing image quality measurement algorithms in both spatial and transform domains have been identified in order to find a good multiscale geometric analysis MGA transforms for quality prediction [6]. MGA transforms are Curvelet Transform, Wave Atoms Transform, and Contourlet Transform as in [10-12]. Based on the concepts of Natural Scene Statistics (NSS), which state that there are a few regularities in natural scene statistics that may be missing from distorted image statistics; the no-reference IQAs are proposed for contrast-distortion images CDI in [9],[13-16]. However, this gap leads to focus on main spatial features in time and frequency domain as into the next section.

III. PREPOSED NR IQM ALGORITHM

The proposed NR IQM algorithm is designated based on edge-detection and entropy measure based on HVS conceptions. The following Figure 2 shows the general schema applied in the work while Figure 3 presents the proposed NR-IQM diagram.

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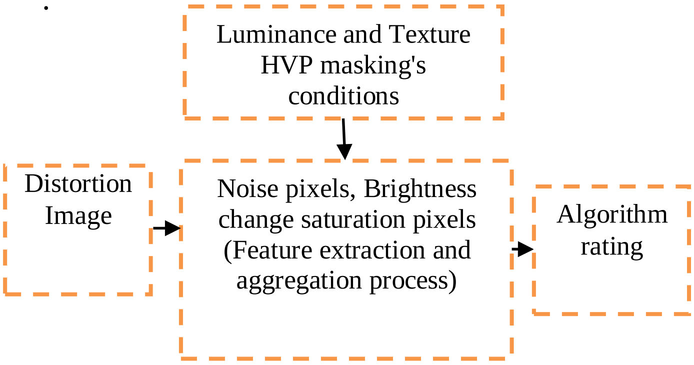

Figure 2. The schema of the proposed NR-IQ

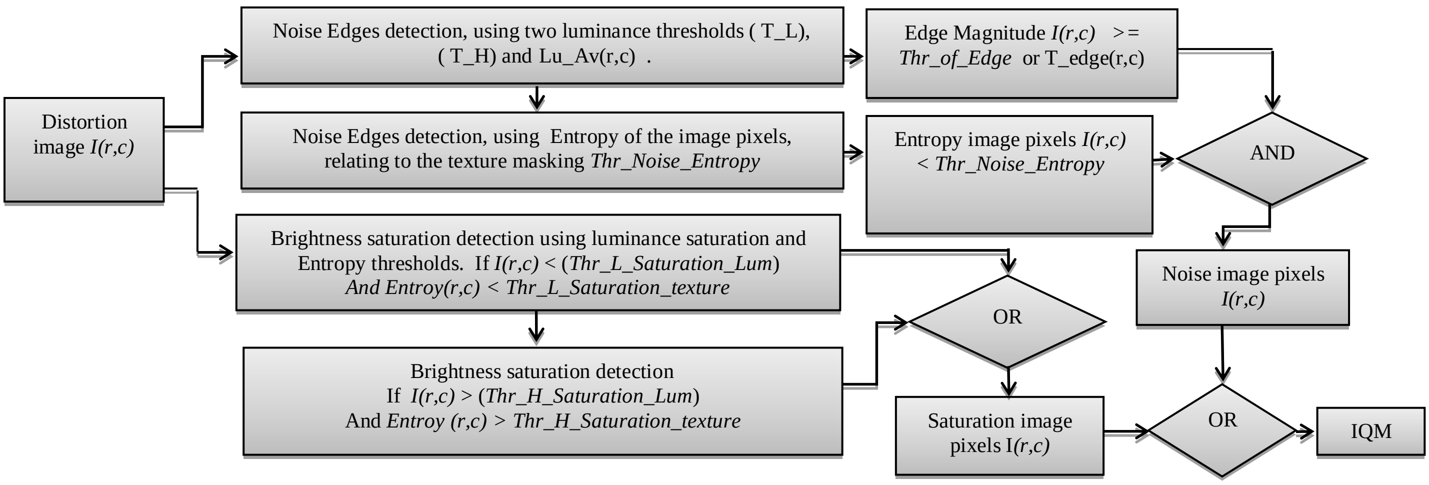

Figure 3. The diagram of the proposed NR IQM' algorithm.

The pixels of two prominent types of distortions are computed as following.

1- Noisy pixels: are detected by applying the two prewitt masks (i.e. the horizontally M_r and vertically M_c) and detect the edge magnitude direction $EM(r,c)$ on the grayscale version of distorted image *I(r, c)* as following Equation (4) and Equation (5) respectively.

$$P_{r,c} = \sum_{i=0}^{n}\sum_{j=0}^{m} I(r-1+i, c-1+j) M_{r,c}(i,j) \qquad (4)$$

$$EM(r,c) = \sqrt{P_r^2 + P_c^2} \qquad (5)$$

A particular point is considered as noise pixel if its $EM(r,c)$ is greater than or equal to $T_{edge(r,c)}$ which is computed based the luminance average $Lu_{Av(r,c)}$ HVS' masks in two thresholds (T_L=30 and T_H=245); while the standard threshold T=0.0031 is chosen empirically for normalize image $I(r, c)$ brightness intensity range in (0 to 1) as following Equation (6) and Equation (7) respectively.

$$Lu_{Av(r,c)} = \frac{1}{n^2}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1} I(r-1+i, c-1+j) \qquad (6)$$

$$T_{edge(r,c)} = \begin{cases} T^2, & if\left(T\_L \leq Lu_{Av(r,c)} \leq T\_H\right) \\ 2T^2, if\left(T_L > Lu_{Av(r,c)}\ Or\ Lu_{Av(r,c)} > T\_H\right) & \end{cases} \qquad (7)$$

The entropy *Entr(r, c)* based the HVS' texture mask means the activity of each sub-image with low entropy [1]; pixel with entropy level lower than a suggested T_N_Entr=1.25 is considered to be visible noise artifacts as following Equation (8).

$$I_{noise}(r,c) = \begin{cases} 1, if\left(EM(r,c) \geq T_{edge(r,c)}\right) \\ and\ (Entr(r,c) < T\_N\_Entr) \\ 0, \qquad Elsewise \end{cases} \qquad (8)$$

2- Saturation pixels: are computed based on the entropy measure based HVS' luminance masking. Suppose saturation threshold *T_Satu_lum* which is the mean of the pixels' values less than *T_L* or greater than T_H; this is to ensure that the pixel activity in the distorted image is enough to be seen (there are enough details). Also, suppose *T_Satu_textu* based HVS' luminance mask. It is the mean of the entropy of all image pixels which having values less than *T_L* or greater than T_H. This is to ensure that the saturation is observable as following Equation (9).

$$I_{satur}(r,c) = \begin{cases} 1, & IF\ (I(r,c) < T\_L\_Satu\_lum)\ and \\ & (Entropy(r,c) < T\_L\_Satu\_textu) \\ 1, & IF\ (I(r,c) > T\_H\_Satu\_lum)\ and \\ & (Entropy(r,c) > T\_H\_Satu\_textu) \\ 0, & Else \end{cases} \qquad (9)$$

The combination of distortion results $I_{combin}(r,c)$ of entire image as following Equation (10).

$$I_{combine}(r,c) = \sum_{r=0}^{n-1}\sum_{c=0}^{m-1} I_{noise}(r,c) | I_{satu}(r,c) \qquad (10)$$

Finally, as Equation (11) shows, the rating vector of the tested image *R(x)* reflects the outcome, which is the ratio of total number of distorted pixels to total number of image pixels.

$$R(x) = \frac{\sum_{i=0}^{height-1}\sum_{j=0}^{width-1} I_{noise\&satu}(i,j)}{height \times width} \qquad (11)$$

IV. RESULTS AND DISCUSSIONS

To compare the performance of the suggested IQM, subjective and objective evaluations should be considered. Therefore, more than 40 degraded images are generated from 7 sources images [17][18] using the guidance rules proposed in [19] and the experiment of observation is done by 24 persons to collect the human mean opinion scores MOS as to the experimental subjective evaluation in [2].

The objective evaluation of the proposed IQM is done by using four popular metrics as following (PCC, RMSE, SROCC, and outlier ratio OR) [1]. They results are in range (0 to 1) and for PCC and SROCC, the 1 represent the best result of accuracy and monotonicity respectively while for RMSE and OR, the 0 represent the best result of prediction accuracy and consistency respectively. Also, two popular measures are used for comparison; AMBE, and Entropy. Matlab 2019 is used for applying these subjective and objective evaluation results. Table 1 shows the obtained results of objective metrics.

TABLE 1. THE OBJECTIVE EVALUATION RESULTS OF PCC, SROCC, RMSE, AND OR.

IQMs	PCC	RMES	SROCC	OR
AMBA	0.3058	0.5042	0.125	0.417
Entropy	0.425	0.395	0.2592	0.2759
Proposed NR IQM	**0.8754**	**0.3391**	**0.9354**	**0**

The results of the proposed NR_IQM over the performance metrics shows that it has higher excellently correlation to MOS comparing to all other IQMs in detecting the brightness saturation with noise artifacts. The Scott-plots of the NR IQM and other well-known are shown in Figure 4.

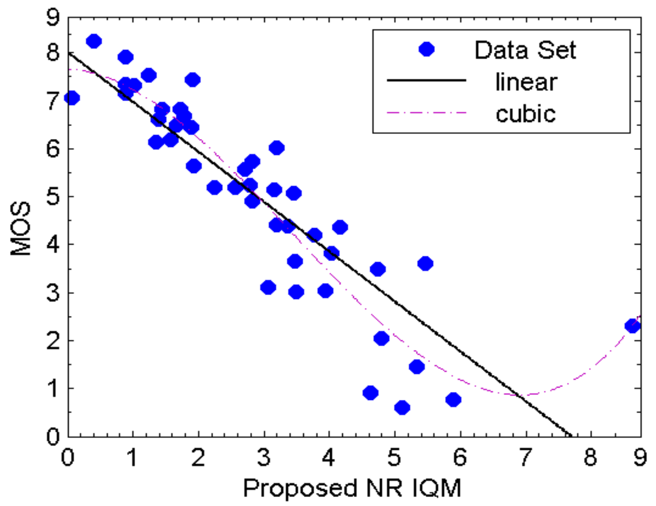

Figure 4. The linear relation between MOS and the proposed NR_IQM over 43 images of the subjective experiment evaluation.

V. CONCLUSION

In order to develop fully contrast enhancement technique and discovering the annoying distortions in images; this work presented NR IQM by considering the important aspects of HVS in terms of luminance and texture masks, as well as the optimal use of an edge detection technique and the entropy measure. The proposed NR IQM outperformed the current two generally used measures AMBE and Entropy, which had a weak correlation with MOS according to the evaluation results; the results show higher scores based on the used objective metrics. Future research should focus on applying deep learning to the proposed NR IQM in order to achieve real-time execution.

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