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Screen Content Images Quality Assessment (Subjective and Objective Test)

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Abstract: Quality assessment is important for digital visual signal in the field of image and video processing. Screen content images are used in multi-device communication applications. Process evaluation, implementation, and optimization quality assessment becomes important. Screen content images (SCIs) shows different statistical properties in textual and pictorial regions, and the human visual system (HVS) also behaves differently while viewing the textual and pictorial regions in terms of the extent of visual field. Quality assessment of distorted screen content images subjectively and objectively with the help of screen image quality assessment database (SIQAD). The subjective quality scores shows, which part of the image (text or picture) have greater quality to that of overall visual quality. The single stimulus methodology is used to obtain three kinds of subjective scores i.e. the entire, textual, and pictorial regions, respectively. Analyzing the subjective data, we recommend a weighting strategy for correlation among these three subjective scores. An objective metric is used to measure the visual quality of distorted screen content images by considering visual difference of text and picture regions. The proposed quality assessment method gives better predicts to the perceptual quality of screen images, also leads to an effective way to optimization screen content coding schemes.

Keywords: Screen content image, image segmentation, quality assessment, subjective and objective quality assessment.

I. INTRODUCTION

SCREEN Content Images (SCIs) which is mixture of computer generated texts, picture and graphics content. With the quick development of internet technology such as screen sharing, information sharing between computer and mobile phones, remote computing system, cloud computing and gaming, product advertisement, etc. Quality of the images is more important into the multi-client communication system. Visual content on the screen is typically provide in the form of screen content images, SCIs determines interactivity performance and determines experience of the remote system. Screen content images are used test quality on-line, in-service monitoring visual/multimedia and system benchmarking. SCIs need to be compress efficiently for rapid sharing. Number of compression techniques has been used to compress SCIs. HEVC screen content coding encoder is used for the optimization of the screen content images.

Computer generated screen images are featured by sharp edges and thin/thick lines with few colors, whether natural images usually have smoother edges, thicker lines and more colors. While capturing the screen content images by mobile phones they get blurred, changes in contrast, having poor color depth that depends on the configuration of the system. Blockings and quantization noises are usually appeared on encoded screen content images. For the evaluation of visual quality of processed SCIs PSNR can be adopted, which is not consistent with human visual perception. The available IQA methods for natural image quality assessment can be applicable are still an open question. For the quality assessment of SCIs both subjective and objective metrics is significant to evaluate. An immensely colossal-scale Screen Image Quality Assessment Database (SIQAD) is constructed for the subjective test, in which three subjective quality scores are obtained respectively for the entire, textual and pictorial regions of each test image. According to the analysis of subjective data, we propose an incipient scheme, SCI Perceptual Quality Assessment (SPQA), to objectively evaluate the visual quality of distorted SCIs. The SPQA consists of an objective metric and a weighting strategy. The objective metric is designed to evaluate the visual quality of textual and pictorial regions separately.

II. RELATED PREVIOUS WORK

During the last decades Natural Image Quality Assessment (NIQA) has been studied immensely. Subjective testing strategies have been used to construct several image quality assessment databases, based on which various Full Reference (FR) IQA methods, such as FSIM, SSIM and VIF have been described to objectively evaluate the quality of distorted natural images. Except from this, many Reduced Reference (RR) IQA and No Reference (NR) IQA metrics are reported. Because of increase in requirements of digitization of typewritten and historical documents, DIQA attracted special attention in research community. The efficacy of the DIQA methods is conclusively evaluated by the Optical Character Recognition (OCR) precision calculated by the OCR software rather than human visual judgement. The topic Screen Content Image Quality Assessment (SCIQA) remains competitively not been explored.

Based on thorough analysis of subjective data a specific metric is proposed to objectively evaluate the visual

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quality of SCIs. There are many distortion types seems on screen images are applied to generate distorted images. Gaussian Noise (GN) is associated in image acquisition and added in most existing image quality databases. Motion Blur (MB) and Gaussian Blur (GB) also commonly exist in practical applications. Contrast Change (CC) is also an important factor affecting particularly of the HVS. Different settings of brightness and contrast of screens will result in different visual experiences of viewers. Three commonly used compression algorithms are used to encode the reference SCIs: JPEG, JPEG2000 and Layer Segmentation Coding (LSC). The textual layer is encoded by using the Basic Colors and Index Map (BCIM) method whether the pictorial layer is encoded by the JPEG algorithm [7].

III. SUBJECTIVE QUALITY ASSESSMENT OF SCIS

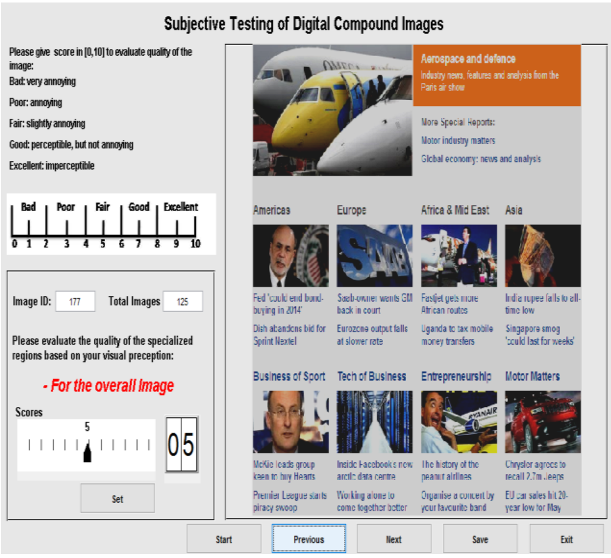

Fig 1 GUI in the subjective test

A. Methodology: (Subjective Test)
Subjective testing methodologies of image quality assessment have been suggested by ITU (International Telecommunications Union), which includes Single Stimulus (SS), Double Stimulus (DS) and Pared Comparison. Fig.1 shows GUI for the subjective test of the distorted screen images quality assessment. In this, the human subject is asked to give score from 0 to 10 (0 is the poor and 10 is excellent) on the image quality predicated on his/her vision competency. The single stimulus methodology utilizes viewing experience of subjects is proximately to that there is no access to reference images. In this test, which part of the image textual part or pictorial part provides more to the overall visual quality? Hence, the human subject have to give scores to test each image on the database with three scores, corresponds to textual, pictorial, and entire regions, respectively. In this testing methodology we generate a random permutation of 1000 images, which are divided into different batches. Each batch contains 125 images. To finish all the judgement of one batch each subject requires approximately one hour. We have to use more than two subject to give scores the each batches for getting better result.

B. Analysis of Subjective Scores: DMOS Value
All distortion types at different distortion levels, these images are re-evaluated by subjects. A linear mapping function is also learned to convert Z scores to Difference Mean Opinion Score (DMOS) values. We normalize the DMOS values to a commonly used scale (i.e., 0-100). We repeat this procedure to the three groups of subjective scores for entire, textual and pictorial regions, respectively. The consistency can be quantified by the confidence interval derived from the number and standard deviation of scores for each image. With a probability of 95% confidence level, the difference between the computed DMOS value and the "true" quality value is smaller than the 95% confidence interval. Fig.2, which gives the reliability of the subjective scores for approximating the visual quality of distorted images [6].

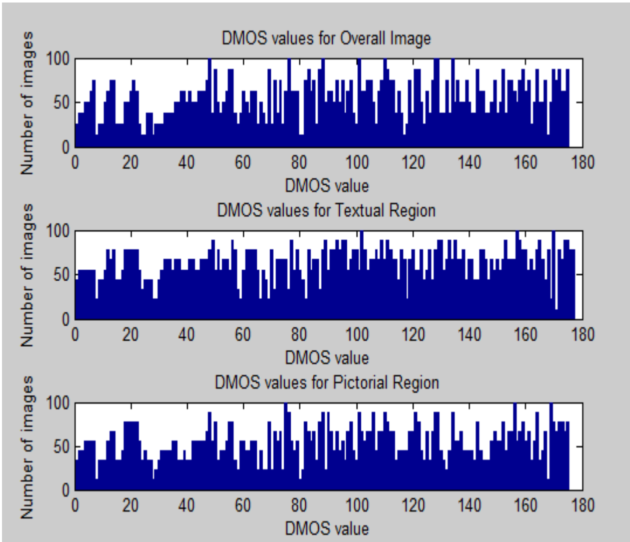

Fig2 Histogram of DMOS values of images in the SIQAD

C. Analysis of Different Regions: (QT, QP and QE)
We get three subjective scores for each test image from subjective testing of images: QT, QP and QE, corresponding to the quality of the textual, pictorial and entire regions, respectively. The subjective scores given having one problem would like to express which part contributes more to the overall visual quality of SCIs, textual or pictorial part? Because of that we analyze the overall correlation of these three quality scores in terms of Root Mean Squared Error (RMSE), Pearson Linear Correlation Coefficient (PLCC), and Spearman rank-order correlation coefficient (SROCC).

We can know that which component/part magnetizes more attention when viewing distorted SCIs through in-depth investigation of their correlation, an efficacious way for integrating textual and pictorial components can be deduced. The correlations for each distortion types Correlations for each distortion type are calculated to estimate human visual perception to different distortion types. The correlation results are reported in Table I.

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TABLE-I CORRELATION ANALYSIS OF THE OBTAINED QUALITY SCORES FOR THE ENTIRE IMAGES, TEXTUAL AND PICTORIAL REGIONS

	QE and QT			QE and QP		
Distortions	PLCC	SROCC	RMSE	PLCC	SROCC	RMSE
GN	0.6088	0.6236	1.4639	0.8549	0.9129	0.9258
GB	0.9312	0.9167	1.4639	0.9429	0.9718	0.6547
MB	0.8844	0.8767	2.3905	0.8054	0.8767	2.0354
CC	0.8756	0.7926	2.1381	0.7601	0.5661	1.9272
JPEG	0.7961	0.6670	2.7255	0.8555	0.8300	1.0690
JPEG2000	0.4714	0.4677	1.6475	0.5629	0.4734	1.5119
LSC	1.0000	1.0000	1.0000	0.7593	0.7071	0.5774
Overall	0.8264	0.7692	1.8921	0.7951	0.7259	1.3416

IV. OBJECTIVE QUALITY ASSESSMENT OF SCIS

The block diagram of the proposed SPQA scheme is shown in Fig.3. Reference SCI X and its distorted version Y are firstly segmented into textual and pictorial layers using image segmentation method. The above proposed objective metric is used to evaluate the quality of the textual and pictorial layers separately. Weighting strategy which derived from the correlation analysis of subjective scores to integrate the two quality scores Q_t and Q_p to the final visual quality score Q of the distorted SCI [7].

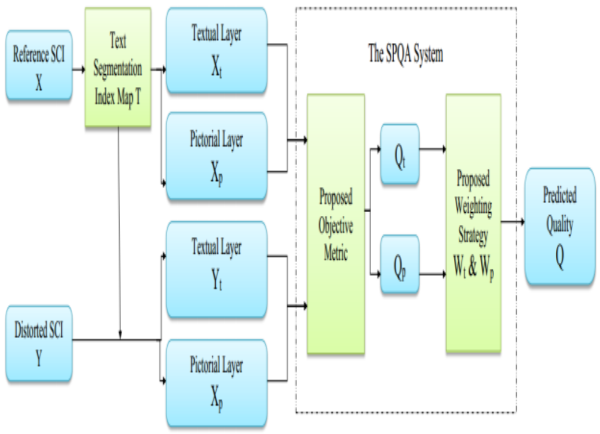

Fig. 3. Block diagram of the proposed SPQA scheme. The SPQA scheme contains two algorithms highlighted in the figure.

A. Quality Evaluation of Textual and Pictorial Regions

The HVS pertains to image luminance, contrast and sharpness. They changes with various image distortions. Hence, they have been widely investigated in the FR NIQA. In SSIM, the product of three components of homogeneous attribute between the reference patch x and its distorted version y is computed to estimate the image local quality:

$$SSIM(x,y) = [l(x,y)]^{\alpha}.[c(x,y)]^{\beta}.[s(x,y)]^{\gamma} \quad (1)$$

Where l(x, y), c(x, y) and s(x, y) are luminance, contrast and structural similarity; α, β and γ are positive constants used to adjust the relative importance of these three components. α = β = γ = 1 is adopted in SSIM and most of its variations. The proposed weighting strategy is used to combine the luminance and gradient similarity as shown in equation below:

$$q = (1 - W) \times g(x, y) + W \times e(x, y) \quad (2)$$

Where q is the quality score of the distorted image y; e(x, y) and g(x, y) are luminance and gradient similarity. W = 0.1 × g(x, y) is used as weighting value to highlight the contribution of the gradient similarity to the final quality.

The luminance homogeneous attribute of textual regions is adaptively integrated to the sharpness homogeneous attribute, while only sharpness homogeneous attribute is considered for pictorial regions. For one SCI X and its distorted version Y, given its text segmentation index map T, their textual layers (X_t, Y_t) and pictorial layers (X_p, Y_p) are calculated by

$X_t = X \cdot T$, $X_p = X \cdot (1 - T)$, $Y_t = Y \cdot T$ and $Y_p = Y \cdot (1-T)$

The luminance similarity map S_l (X_t, Y_t) between the textual layers X_t and Y_t is calculated as follows:

$$S_l(x_t, y_t) = \frac{2.\mu_{xt}.\mu_{yt}.+c_1}{\mu_{xt}^2 + \mu_{yt}^2 + c_1} \quad (3)$$

Where μ_{xt} and μ_{yt} are the mean values for each pixel in the textual layers X_t and Y_t. C1 is a parameter to evade instability when denominator is proximate to zero. The filters capture the local variations of images at four directions, including horizontal and vertical directions [3]. The quality map for the pictorial part Qp_map is quantified by the sharpness homogeneous attribute between pictorial regions.

$$Qp_{map} = S_s^p(X_p, Y_p) \quad (4)$$

The quality map for the textual part Qt _map can be calculated by integrating the luminance and sharpness homogeneous attribute maps as follows:

$$Q_{t_{map}} = [Sl(X_t, Y_t)]^{\alpha}.[S_s^t(X_t, Y_t)]^{\beta} \quad (5)$$

Where α > 0 and β > 0 parameters used to adjust the effect of the two components. By setting β = 1 to simplify structural difference of both textual and pictorial regions. When the textual layers are processed α is used to adjust effect of the luminance component. When intensity change is small, the effect of the luminance similarity to the visual quality should be reduced; when the change is large, the effect of the luminance similarity should be enhanced.

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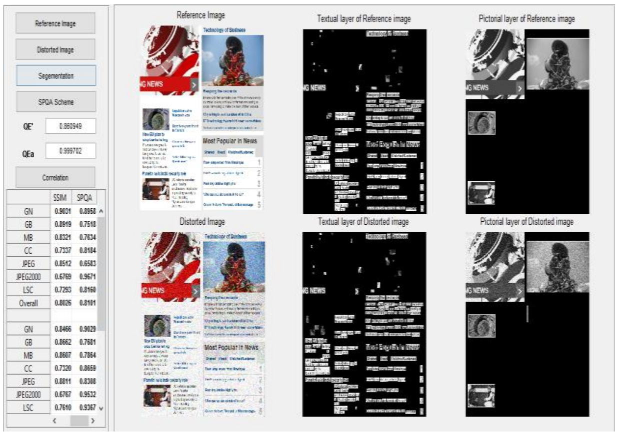

Fig. 4. Graphical User Interface for Objective tes.

B. Proposed Weighting Strategy in SPQA scheme

Based on area ratio and position of texts, size of characters, content of pictures, etc. many factors affecting human perception. Image activity measure (IAM) is adopted to calculate the weights of images. Image activity values reflect the variation of image content, which can be habituated to differentiate images. Based on the activity measure and segmentation algorithm proposed in [5], a novel model to compute two weights Wt and Wp that can measure the effect of textual and pictorial regions to the quality of the entire image. One reference SCI and its text segmentation index map T in which textual pixels are marked by one and pictorial pixels by zero, calculates the activity index map A of the corresponding distorted SCI [5]. The activity maps $A_t = A \times T$ and $A_p = A \times (1 - T)$ of the textual and pictorial regions can be calculated. In the HVS, a Gaussian mask G is used to weight activity values. Based on the weighted activity map, values of W_t and W_p for the textual and pictorial parts are calculated by equation (6) and (7):

$$W_t = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(A.T.G)_{i,j}}{\sum_{i=1}^{m}\sum_{j=1}^{n}(T)_{i,j}} \qquad (6)$$

And

$$W_p = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(A.(1-T).G)_{i,j}}{\sum_{i=1}^{m}\sum_{j=1}^{n}(1-T)_{i,j}} \qquad (7)$$

where m and n represent the dimensions of the images. The quality scores of the textual and pictorial regions are calculated as the mean values of the corresponding regions based on the calculated quality maps of textual layer Q_t _map and pictorial layer Q_p_map,

$$Q_t = \frac{Q^t\_map .T}{\sum_{i=1}^{m}\sum_{j=1}^{n}(T)} \qquad (8)$$

$$Q_p = \frac{Q^t\_map .(1-T)}{\sum_{i=1}^{m}\sum_{j=1}^{n}(1-T)} \qquad (9)$$

Where m and n denote the dimension of the reference SCI. And finally quality score Q of the distorted image Y is computed as:

$$Q = W_t * Q_{t+} W_p * Q_p \qquad (10)$$

V. EXPERIMENTAL RESULTS AND ANALYSIS

By applying the weighting strategy to subjective data obtain the three sets of subjective scores for entire, textual and pictorial regions in SCIs, it is plausible to verify the proposed weighting strategy on the substructure of subjective scores. A quality score QE' of an entire SCI is prognosticated on the quality scores of textual and pictorial regions, i.e., QT and QP. The QE' is computed as follows:

$$QE' = W_t * QT + W_p * QP \qquad (11)$$

The predicted quality scores QEa is the mean of quality scores of textual and pictorial regions:

$$QEa = 0.5 * QT + 0.5 * QP \qquad (12)$$

	Distortions	PSNR	SSIM	SPQA
PLCC	GN	0.8990	0.9031	0.8958
	GB	0.8515	0.8919	0.7518
	MB	0.8643	0.8321	0.7634
	CC	0.6862	0.7337	0.8184
	JPEG	0.8910	0.8512	0.6583
	JPEG2000	0.7146	0.6769	0.9671
	LSC	0.7948	0.7293	0.8160
	Overall	0.8145	0.8026	0.8101
SROCC	Distortions	PSNR	SSIM	SPQA
	GN	0.7962	0.8466	0.9029
	GB	0.8646	0.8662	0.7681
	MB	0.8545	0.8607	0.7864
	CC	0.7412	0.7320	0.8659
	JPEG	0.9114	0.8811	0.8308
	JPEG2000	0.7360	0.6767	0.9532
	LSC	0.8228	0.7610	0.9367
	Overall	0.8181	0.8035	0.8634
RMSE	Distortions	PSNR	SSIM	SPQA
	GN	0.7362	0.8665	0.9213
	GB	0.8345	0.8425	0.7184
	MB	0.8435	0.8261	0.7648
	CC	0.7243	0.7432	0.8596
	JPEG	0.9212	0.8654	0.8206
	JPEG2000	0.7253	0.6877	0.9325
	LSC	0.8432	0.7435	0.9762
	Overall	0.8142	0.8231	0.8436

IV. CONCLUSION

The quality assessment of distorted Screen Content Images, from both subjective and objective perspectives. An immensely colossal-scale image database (SIQAD) helps to explore the subjective quality evaluation of SCIs. DMOS values of images obtained via subjective test, and their reliability is verified. The three subjective scores for textual, pictorial and entire regions are predicted using proposed methodology. Thus we find that textual regions contribute more to the quality of the entire image in most of the distortion cases. With the weighting strategy, an emerging objective quality metric is constructed to discretely assess the visual quality of textual and pictorial regions.

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