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QUALITY ASSESSMENTOF SCREEN CONTENT IMAGES

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Abstract-- Research on Screen Content Images (SCIs) has become important as they are used frequently in multi-device communication applications. Perceptual quality is assessed for distorted SCIs subjectively and objectively. A screen image quality assessment database (SIQAD) consisting of 20 source and 980 distorted SCIs is constructed. A subjective quality scores is used for estimating which part (text or picture) contributes more to the overall visual quality. The single stimulus methodology with 11 point numerical scale is used in subjective method. Objective metric is used to measure the visual quality of distorted SCIs which follows subjective analysis. In objective quality analysis a weighting strategy method is used to correlate quality of the two regions (text and pictorial) of SCI and provide quality for the entire image.

Keywords-Screen content image, SIQAD, subjective quality assessment, objective quality assessment.

I. INTRODUCTION

SCREEN Content Images (SCIs) [1]includes both texts and pictures together and even graphics. It have been increasingly involved in multi-client communication systems, such as virtual screen sharing [2], information sharing between computer and smart phones [3], cloud computing and gaming, remote education, etc. In these systems, visual content like web pages, emails, slide files and computer screens are typical in the form of SCIs, and then transmitted between different digital devices (computers, tablets or smart phones). For fast sharing in-between different devices, it is important to acquire, compress, store or transmit SCIs efficiently. Many solutions have been proposed to process SCIs, which including segmentation and compression of SCIs [4]. MPEG/VCEG called for proposals to efficiently compress screen content image/videos as an extension of the HEVC standard, and many other proposals have been reported to address this need.

Distortions may involve in SCI when it is processed. Some distortions are blurring, contrast change and compression artifacts. For example, when capturing SCIs by smart phones, due to hand-shake blurring appears on images or out-of-focus of camera. Different settings of brightness or contrast of screens would result in the change of contrast change in captured SCIs. Compression artifacts (e.g., quantization noises and blocking and) commonly appear on encoded SCIs. Peak Signal-to-Noise Ratio (PSNR) is adopted to evaluate the visual quality of processed SCIs. However, it is known that PSNR is not consistent with human visual perception [5]. Quality of Experience (QoE) is used to evaluate users' viewing experience on webpages, which is called Web QoE. But, the current web QoE mainly focuses on Quality of Service (QoS) metrics, e.g., loss ratio, rendering and round-trip time, than taking differences of human perception for pictures and texts into account. Here, the predicted QoS values would be constant if overall loss ratio is determined. However, different loss ratios to textual and pictorial parts lead to quite different QoE. Therefore, perceptual quality measure of SCIs is much effective for various applications. Although many IQA methods have been proposed for quality assessment of natural images [6] perceptual quality measure of SCIs ,investigate both subjective and objective metrics for the quality evaluation of SCIs.

For the subjective test a large-scale Screen Image Quality Assessment Database (SIQAD) is built. In subjective test, three subjective quality scores are obtained for the entire, textual and pictorial regions of each test image. The discrete 11 scale Single Stimulus (SS) method is adopted fort the subjective test. According to the analysis of subjective data, a new scheme is proposed, 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 separately the visual quality of textual and pictorial regions. The weighting strategy is designed to combine the predicted quality scores of pictorial and textual regions to obtain the overall quality scores of tested SCIs. Then compared with 11 state-of-the-art IQA metrics, the proposed SPQA scheme achieves much higher consistency with human visual perception when judging the quality of distorted SCIs.

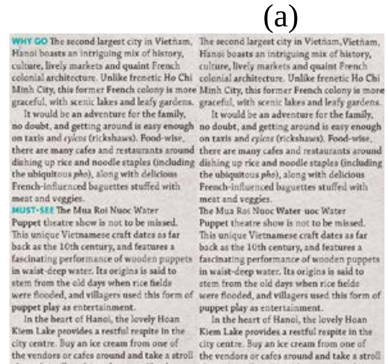
II RELATED WORK

Natural Image Quality Assessment(NIQA) has been studied for the last few decades [7]. By adopting subjective testing strategies,several image quality assessment databases [8]–[9] have been constructed, various *Full Reference* (FR) IQA methods [10], [11]–[12], such as SSIM, VIF, FSIM, MAD, GSIM and GMSD, have been proposed to objectively assess the quality of distorted natural images. Besides, *ReducedReference* (RR) IQA [13] and *No Reference* (NR) IQA metrics [14] are also reported.

Document Image Quality Assessment (DIQA) has got attention in the research community recently due to the increasing requirements of digitization of historical or other typewritten documents. Many document image databases are released, based on various DIQA methods that have been proposed.

The document images in databases mainly consist of gray-scale or binary texts, without pictures. Most of the document images suffer from degradations related to the environment, e.g., stains, paper aging, carbon copy effect and reader annotations. Almost all DIQA methods are designed in no-reference method and implemented at the character (or string) level. The effectiveness of the DIQA methods is evaluated by the Optical Character Recognition (OCR) accuracy is calculated by the OCR software rather than human visual judgement.

(a)



WHY GO The second largest city in Vietnam, Hanoi boasts an intriguing mix of history, culture, lively markets and quaint French colonial architecture. Unlike frenetic Ho Chi Minh City, this former French colony is more graceful, with scenic lakes and leafy gardens.

It would be an adventure for the family, no doubt, and getting around is easy enough on taxis and *cyclos* (rickshaws). Food-wise, there are many cafes and restaurants around dishing up rice and noodle staples (including the ubiquitous *pho*), along with delicious French-influenced baguettes stuffed with meat and veggies.

MUST-SEE The Mua Roi Nuoc Water Puppet theatre show is not to be missed. This unique Vietnamese craft dates as far back as the 10th century, and features a fascinating performance of wooden puppets in waist-deep water. Its origins is said to stem from the old days when rice fields were flooded, and villagers used this form of puppet play as entertainment.

In the heart of Hanoi, the lovely Hoan Kiem Lake provides a restful respite in the city centre. Buy an ice cream from one of the vendors or cafes around and take a stroll along the willow-fringed waters. Nearby,

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(b)

(c)

Fig. 1 (a) Natural images, (b) textual images and (c) screen content images.

III. SIQAD: SCI QUALITY ASSESSMENT DATABASE

To evaluate quality of SCIs, a large-scale screen image database (i.e., SIQAD) with seven distortion types is created, each with seven degradation levels. Totally, 20 reference and 980 distorted SCIs are included in the SIQAD. Subjective evaluation of these SCIs is conducted to obtain the subjective quality scores.

A. CONSTRUCTION OF THE SIQAD

From webpages, slides,PDF files and digital magazines through screen snapshot, twenty SCIs are collected. The reference SCIs include the dimension scale is from about 600 to 900 pixels for natively displaying on computer screens during the subjective test. The reference SCIs are selected with various styles including different percentages, positions and ways of textual/pictorial region combination. The percentage of textual regions in the reference SCIs is 35% to 60%.

Distortions which usually appear on SCIs are *Gaussian Noise* (GN), *Gaussian Blur* (GB), *Contrast Change* (CC) and Motion *Blur* (MB). For each distortion type, seven degradation levels are set to generate images from low to high degradation levels in SIQAD, which create a broad range of image impairment.

B. SUBJECTIVE QUALITY ASSESSMENT OF SCIS

Subjective testing methodologies of image quality evaluation includes Single Stimulus (SS), double-stimulus and paired comparison. In this study, the SS with an 11 point discrete scale is used. Given an image is displayed on the screen, the human subject is asked to give a score (from 0 to 10: 0 is the worst, and 10 is the best) on the image quality based on their visual perception. This methodology is chosen because the viewing experience of subjects is close to that in practice, where there is no access to the reference images. All subjects are required to sit at a distance about 2−2.5 times of the screen height. The subjects are all university under-graduate or graduate students with no experience in image processing and quality assessment. They are all with normal or corrected version, aging from 19 to 38 years old.

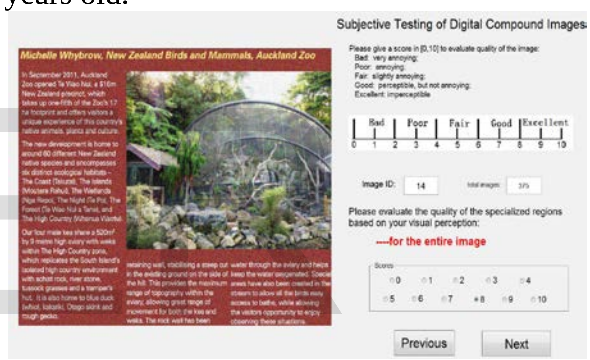

Fig. 2 Graphical user interface in the subjective test. The red tooltip will change if subjects need to judge different regions.

C. OBJECTIVE QUALITY ASSESSMENT OF SCIs

In objective measure of SCI a scheme (SPQA) is used to objectively evaluate the visual quality of distorted SCIs, considering the visual differences betweentextual and pictorial regions. The diagram of the proposed scheme is illustrated in Fig. 3. One reference SCI X andits distorted version Y are firstly segmented into textual and pictorial layers based on their text segmentation index map T . The quality of the textual and pictorial layers is then separately evaluated objectively. A novel weighting strategy, derived from the correlation analysis of subjective scores to integrate the two quality scores $Qt$and $Qp$to

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the final visual quality score Q of the distorted SCI.

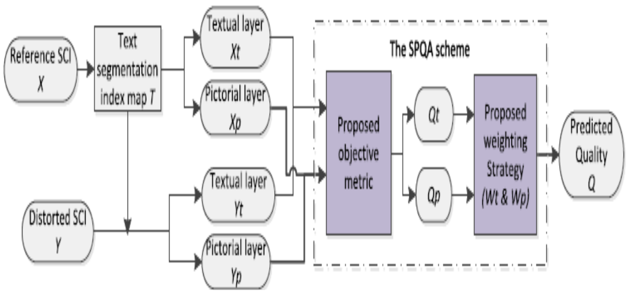


Fig.4 Diagram of the proposed SPQA scheme.

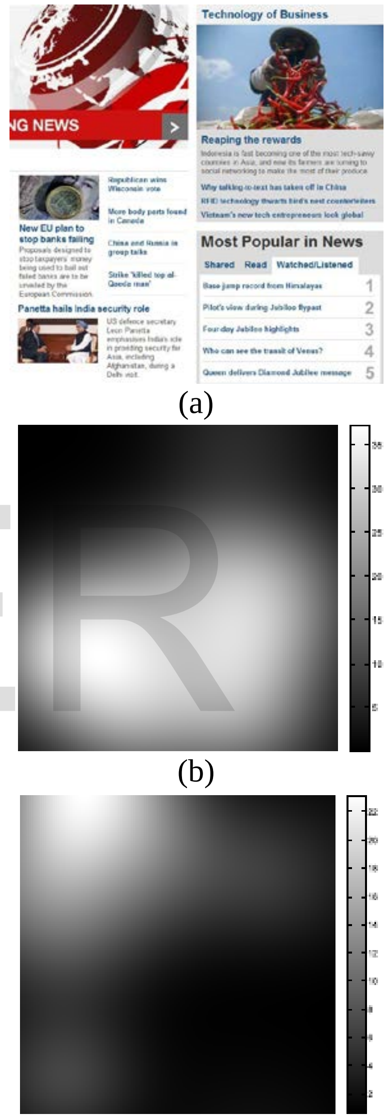
IVPROPOSED WEIGHTING STRATEGY

Many factors are there that affects human perception when viewing SCIs, including area ratio and position of texts, size of characters, content of pictures, etc. Initially investigate a statistical property of SCIs that reflects impairments of test images, rather than any specific factor. Image activity measure is adopted to calculate the weights. Image activity values reflect the variation of image content, which can be used to differentiate images [15], [16]. Based on the activity measure and the segmentation process [17], proposed 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. In particular, given one reference SCI and its text segmentation index map T in which textual pixels are marked by one and pictorial pixels by zero, and calculates the activity map A of the corresponding distorted SCI [17]. The activity maps $At = A \times T$ and $Ap = A \times (1 - T)$ of the textual and pictorial regions can be calculated. Considering the human visual acuity in the HVS,, a Gaussian mask G is used to weight the activity values. Based on the weighted activity map, two values Wt and Wp for the textual and pictorial parts are computed as Eq. (1) and (2), which are subsequently employed as weights to combine the two quality scores.

$$Wt = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(A.T.G)i,j}{\sum_{i=1}^{m}\sum_{j=1}^{n}(T)i,j} \;.... (1)$$

$$Wp = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(1-T)i,j}{\sum_{i=1}^{m}\sum_{j=1}^{n}(1-T)i,j} ....(2)$$

where$m$ and n represent the dimensions of the images. The weighting maps for textual and pictorial parts of one SCI example are shown in Fig. 5.



(a)

(b)

(c)

Fig. 5 Weighting maps for textual and pictorial regions of one SCI example. (a) Reference image: cim1. (b) Weighting map for textual regions. (c) Weighting map for pictorial regions.

Based on the calculated quality maps of textual layer

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Qt_map and pictorial layer *Qp_map*, the quality scores of the textual and pictorial regions are computed as the mean values of the corresponding regions:

$$Qt = \frac{Qt\_map\ .T}{\sum_{i=1}^{m}\sum_{j=1}^{n}(T)} \quad ….(3)$$

$$Qp = \frac{Qp\_map\ .(1-T)}{\sum_{i=1}^{m}\sum_{j=1}^{n}(1-T)} \quad ….(4)$$

Following the same notation above, *m* and *n* denote the dimension of the reference SCI. The final quality score *Q* of the distorted image *Y* is computed as follows:

Q = Wt* Qt+Wp* Qp…(5)

V. EXPERIMENTAL RESULTS

The images in the *SIQAD* are used to conduct the comparison experiments by using the proposed SPQA with the following 11 state-of-the-art metrics.

It is analyzed that the normal image measuring techniques PSNR does not provide an accurate assessment for the Screen Content Images.

Comparisons of two combination methods, the proposed weighting strategy are more consistent with human visual perception. The paired t-test is applied to the *Qe*' and *Qea*. The result (h = 1, p <0.05) indicates that the quality scores generated by the two methods are statistically different. Hence, here in terms of *Pearson Linear CorrelationCoefficient* (PLCC), *Root Mean Squared Error* (RMSE) and*Spearman rank-order correlation coefficient* (SROCC) *the comparison between* proposed weighting strategy andhuman visual perception *for an entire image is made.*

Image types	Methods					
	QE and QEa			QE and QE'		
Distortions	PLCC	SROCC	RMSE	PLCC	SROCC	RMSE
GN	0.9085	0.8968	6.2332	0.9436	0.9364	4.9392
GB	0.9047	0.9083	6.4672	0.9422	0.9429	5.0856
MB	0.8735	0.8755	6.3298	0.9277	0.9258	4.8551
CC	0.8522	0.8129	6.5830	0.8850	0.8321	5.8575
JPEG	0.7750	0.7473	5.9378	0.8436	0.8279	5.0458
JPEG2000	0.8171	0.7964	5.9914	0.8528	0.8441	5.4284

TABLE 2- COMPARISON TABLE

METHODS	VALUES
SIQAD	0.3928
MSE	0.3582
PSNR	63.10

VI CONCLUSION

A study on perceptual quality measure of distorted SCIs, from both subjective and objective perspectives is studied. A large-scale image database, SIQAD, isbuilt to explore the subjective quality evaluation of SCIs. Values of images in the database are obtained via the subjective test, and their reliability is verified. The built SIQAD is expected to be helpful in further research in SCIs. Based upon the three subjective scores for textual, pictorial and entire regions, we find that textual regions contribute more to the quality of the entire image in most distortion cases. The proposed weighting strategy works well and combining the weighting strategy, a new objective quality metric is constructed to separately assess the visual quality of textual and pictorial regions. The proposed integration scheme, named SPQA, outperforms existing 11 NIQA objective metrics on visual quality evaluation of distorted SCIs.

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