The Robust Design of Subjective Quality Evaluation for the Universal Printer Benchmark

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Abstract

This study addresses the importance of the subjective quality evaluation and describes the lists of considerations for print quality evaluation. It demonstrates a practical test method of the subjective quality evaluation regarding test stimuli and psychophysical assessment. For the purpose of printer benchmark, subjective quality evaluation may contribute to two objectives. It provides to detect image quality attributes such as blurriness and raggedness for character and line attributes. Also, it gives the preference measurement which provides information about the overall image quality in a customer-relevant form. Considering two aspects, we represent quantitative ranking of printer performance in terms of image quality. For the universal printer benchmark point of view, it is quite necessary to analyze the printed image quality for developing printing systems, and extract the performance level comparing other competing models. Then, the quantitative ranking is acquired based on both the measurements from quality attribute metrics and the expectation of the preference level.

1.0 Introduction

The ultimate goal of image quality evaluation is to improve an image quality during developing image quality metrics of an imaging system. Image quality evaluation is classified into subjective and objective evaluations. The subjective evaluation is usually cumbersome, but is desirable when image quality is evaluated by the person who uses the image. Objective evaluations such as traditional full reference image quality assessment (IQA) methods "peak signal to noise ratio (PSNR)" and "mean squared error (MSE)"are also used. However, there has been an issue of the objective evaluation, because it does not correspond to the human judgment[2]. For this reason, the correlation study has been performed widely between the physical characteristics of a system and a subjective evaluation. As an element of objective evaluation, it may be classified into image quality metric and image quality attribute. Image quality metric is the physical descriptor. It detects, and examines specific aspects of image quality such as line density. There are standardization activities on image quality metric. The optical density, geometric condition, the spectral characterizations are specified in ISO 5. From ISO 13655, the color measurement conditions are specified. As an image quality attributes, large area attributes such as graininess and mottle, character and line attributes such as blurriness, raggedness, and fill are specified in ISO 13660 [1]. Despite of the effort of standardization and systemized of objective evaluation, there is the limitation of the objective measurement of image quality. That is one numerical value from single attribute, which cannot represent the overall image quality, when the multivariate attributes are printed on one page. Therefore, the subjective evaluation should contribute to the quality evaluation.

The other purpose of the subjective evaluation is for predicting customer preference on image quality. Image preference can be difficult to quantify because it is subjective. Such elements for evaluation such as test stimuli, instruction, observer, psychological method, and viewing conditions are to be well planned for quantifying it. In this paper, we first describe the lists of the considerations for subjective quality evaluation. Second, the test protocol will be suggested which is related with the both objective and subjective measurement. Finally, we compare the reference printer X with other printers for one particular attribute extracted from the test protocols.

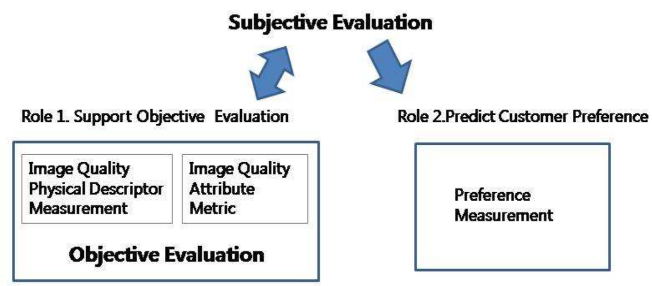

Figure 1. Diagram for the Role of Subjective Evaluation

2.0 Lists of Consideration

2.1 Test Stimuli

Test stimuli are images presented to the observer for subjective evaluation[4]. The preparation of test stimuli can be the first step for the design of psychophysical experiment. Depending on the purpose, the characteristics of stimuli can be varied. The “test target” or analytical images is used for objective evaluation. Standardization relevant to image quality evaluation is established by international standardization organizations. Large area attribute and character and line attribute for monochrome prints are specified in ISO 13660. CMYK/SCID (Standard Color Image Data) was established as ISO 12640 in 1997. XYZ(sRGB) /SCID expressed in the device-independent form was established as JIS X 9204 in 2000. CMYK/SCID and XYZ(sRGB) /SCID are the standard image for subjective evaluation, For the image preference, the content of test stimuli has actual customer-like images such as pictorials, graphics, newsletter, etc. Major issue in using image preference is that color rendering, because small variations in color have a profound effect on the image preference[3].

2.2 Psychophysical Experimental Method

There are a number of psychometric methods such as paired comparison, rank ordering, categorical judgment and magnitude estimation. Triplet comparison method and quality ruler method are recommended by ISO 20462-2 and 20462-3. Quality ruler method is suitable for the developing of image quality attribute measurement, because observers' responses can be converted to JNDs in real time. Because each method has weakness and strength, it is important to choose a proper method for the purpose of evaluation[4]. In this paper, the rank ordering method is used to compare the image preference.

2.3 Observers

Observers should have normal color vision and sufficiently accurate visual acuity. For image preference, typically large number of observers should be participated with a consideration of the characteristics of their age and gender[3]. Relatively small number of observer may be allowed for evaluating image quality attributes.

2.4 Sample Preparations

There are other significant physical variables to print quality such as paper quality or the combinations of hardware, software, utilities and operating systems[9]. Physical attributes for the paper quality include roughness, flatness and gloss and they are varied from different manufacturers. Digital printing technology, e.g. electro photographic, inkjet and thermal, is also diverse and its impact on the print quality is of great importance. In order to compare reference printer X with competing sets, variables such as paper type and technology type should be controlled in advance.

3.0 Test Protocol of Image Quality Evaluation

Image quality metrics, image quality attributes and image preference are three domains of image quality[3]. Each one has different role to measure image quality. According to Edu N.Dala (1998), image quality metrics are developed for engineering, while image preference is suitable for customer-related application. It emphasizes the development of image quality attribute, because it is ideal for planning and other high-level applications. Each vendor has its own system to measure and evaluate image quality based on these three domains. Such an example of the test protocol as an aspect of the image quality metric is developed by Michael F. Moire (2009). Author adds the new column of subjective evaluation to see how they are related with each other.

Objective Evaluation			**Subjective Evaluation**	
IQ Metrics	**Type**	**Signal to Noise**	**IQ Attribute**	**Customer Image Preference**
Density	Solid Area	The larger the better	Color	Vividness
Graininess	Solid Area	The smaller the better	Artifacts	Impairment (Annoying)
Mottle	Solid Area	The smaller the better	Artifacts	Impairment (Annoying)
Color Gamut	Solid Area	The larger the better	Color	Vividness
Gloss	Solid Area	Nominal the best	Physical /Uniformity	Vividness
Line Width	Line	Nominal the best	Line quality	Line Sharpness
Line Blur	Line	The smaller the better	Line quality	Line Sharpness
Line Ragged	Line	The smaller the better	Line Quality	Line Sharpness

Figure 2. Test protocol for Three Domain of image quality

4.0 Subjective Evaluation

After building the test protocol, the result from each objective measurement is acquired as a numerical value. Now we need to find how it is correlated with subjective evaluation.

4.1 Relationships between the Objective and Subjective Evaluation

Among IQ metrics, gloss attribute is extracted to show the relation between subjective and objective measurement. The X-axis is the range of mean gloss (Gm) from print samples, and the Y-axis represents score of visual assessment on gloss and matte appearance on print samples. Observers ranked higher scores when samples appear to be glossier. In this case, the objective measurement is for the physical attribute of gloss uniformity. However, any objective measurements either image quality metric or image quality attribute can be modified for the X-axis.

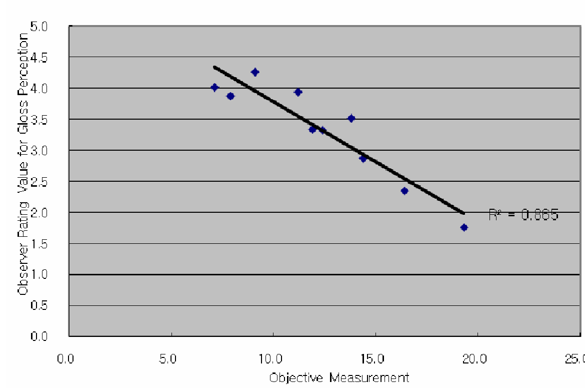

Figure 3. Gloss Perception vs. Mean Gloss (Gm) for Objective Measurement

4.2 Image Preference

Subjective evaluation has a very important role for the predicting a customers' preference, but it is not quite simple to quantify, since it is much related to memory and emotion. Image preference can contribute to measuring of the overall image quality. In this paper, vividness attribute as gloss uniformity and color rendering is evaluated.

The five-point rank ordering method scale is used for the score on preferred -*vividness*. They are listed in the following:

1. Like very much
2. Like slightly
3. Neither like nor dislike
4. Dislike slightly
5. Dislike very much.

4.3 Image Quality Ranking

Based on the objective measurement of image gloss, and the subjective measurement, the printer X as the reference printer is evaluated. In the Figure 4, the printer X shows a relatively high gloss level. Figure 5 shows the evaluation of 'vividness' attribute as an aspect of color and gloss attributes. Based on the results, it appears an insufficient quality for image preference. Thus, we can conclude that it needs to be revised for color and gloss as vividness perceptual attribute in the future.

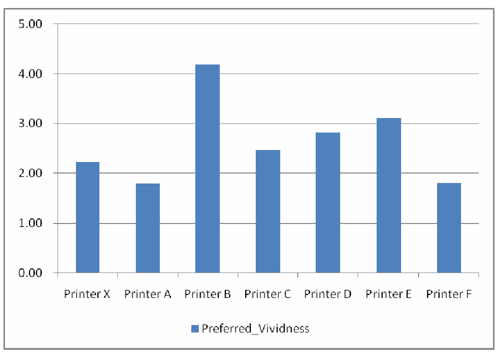

Figure 4. Universal Printer Benchmark for Gloss Uniformity

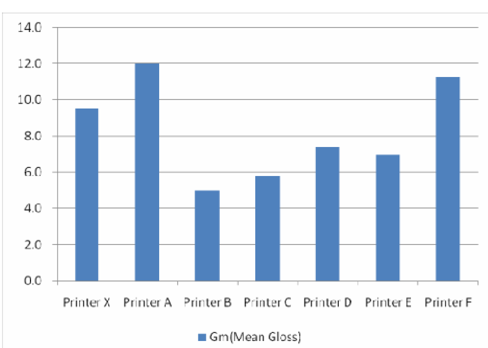

Figure 5. Universal Printer Benchmark for Preferred- Vividness

5.0 Conclusion

We have demonstrated a method of subjective evaluation especially the benchmark testing purpose as an aspect of image quality performance. This study also addresses the importance of the subjective quality evaluation and describes the lists of considerations for print quality evaluation.

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