The Effects of Perceptual Based Image Gloss and Color on the Evaluation of Image Preference

Seunga Kang Ha, Youn Jin Kim; Digital Media & Communications Research Center, Samsung Electronics Company; Yousun Bang, and Heui-Keun Choh; IT Solutions, Samsung Electronics Company; Suwon, 443-742 Korea

Abstract

This study explores the correlation between perceptual based image gloss and color attribute and proposes a model of predicting the preference of business graphic images. The gloss perception is affected by various factors such as luminance, color, substrate, and micro gloss. For quantifying gloss, physical gloss measurement and visual gloss model has been developed with an acceptable correlation between objective measurement and subjective assessment. However, how the gloss perception correlates with color on customer-like image under a typical office viewing condition has been a remaining question. To answer this question, this study focuses on the effect of both image gloss perception and highly chromatic colors on the overall image preference. Vividness is a term representing chromaticness of colors. The color attribute of business graphic images is explained as vividness attribute by preferred-vividness and vividness metrics. Three psychophysical experiments are conducted in total: gloss perception on print samples on plain paper, preferred image gloss from various test images, overall image preference based on vividness and gloss level of the whole print. Consequently, business graphic image preference is modeled by CIELAB Chroma and lightness, and mean gloss.

Introduction

Colour and gloss appearance of print samples from different colour laser printers varies in the real world because each printer adopts different print technologies such as colorant, imaging algorithm, and fusing temperature. When an observer perceives a certain printed image, he/she may have overall image preference based on the interaction between colour and gloss appearance. The sensation of light is the foundation of human visual perception, and it can be categorized into colour, gloss, transparency etc.[7]

The influence of colour on both gloss perception and gloss measurement has been often noted by previous research. Yee Ng et.al.(2003) noted that there exists a nonlinear relationship between gloss measurement and perceptual gloss, because of the adaptation mechanism of human being. The *Gaussian psychometric model* is assumed to describe the perceptual gloss. The relationship between the measured gloss and the just-noticeable difference of visual gloss are fitted. Kuo et.al.(2002) propose the just-noticeable difference equation for visual glossiness sensation with 60 degree gloss reading.

$$\mathrm{JND}_{G60} = 0.14(G60)^{0.96} \tag{1}$$

Edu N. Dalal and Paul C. Swanton (1996) study on *preferred* gloss. They argue that the gloss and colour variables are evaluated together on sample prints, because the visual effect of gloss is not separated by saturation. Gloss readings on the saturated colors of cyan, magenta, yellow, red, blue, and green are taken and averaged to give one single reading to represent the overall gloss condition of sample prints. Gloss reading of black and less saturated colors tends to give a matte finish.

In 2007, International Standard provided a procedure for gloss uniformity testing and the analysis of the resulting data. The ISO/IEC 19799 differential gloss test chart is used for objective gloss measurement using 60-degree gloss measurement. The gloss value of 40 patches on the printed differential gloss is measured. Mean gloss (*Gm*) is calculated using the equation below. [10]

$$G_m = \frac{1}{40}\sum_{i=1}^{n} G_{60}^{i} \tag{2}$$

where G_m denotes the mean gloss level.

In this study, we focus on the correlation between image gloss and colours printed based on plain print quality, and propose a model of predicting the preference of business graphic image. To describe the color attribute of business graphic images, a term of vividness is adopted from Youn Jin Kim et.al. (2003). *Preferred*-vividness is measured by model based on *C**ab and *L** from CIELAB colour space. It shows that a reasonably higher lightness level is also required as well as a higher chroma level in order to achieve a higher preferred vividness of colour prints.

1st Experiment

Thirty-one normal vision observers who are currently exposed under office viewing condition are the subject of experiments. Age span is between 20's and 50's. The ambient illumination level is around 500 lx. Observers are allowed to tilt print samples freely during the experiment. Instruction is given to ignore any image artifact.

For the first experiment, observers are asked to score on image gloss from 0 to 6 while comparing five anchor prints. The lower score shows glossier appearance on print samples while higher score shows matte appearance.

For preparing print samples, three different substrates in A4 size are selected and they are printed by the default driver option on plain paper. The range of average paper gloss show from 5.23 to 6.21 with Nippon Denshoku Handy Glossmeter PG-1M at 60 degree geometry. Selected samples are printed by different colour laser printers of various manufacturers such as hp, Ricoh, Canon, Lexmark, and Samsung etc. The year of manufacturer is limited from 2001 to 2005. The total number of print samples is fifty two. The ISO/IEC 19799 differential gloss test chart (RGB mode) is used for both objective and subjective assessment.

For the analysis of the subjective data, the method of mean opinion score (MOS) is adopted. MOS is one method for analysing

the category judgment data sets and it has been recommended by ITU-R BT.500-11.7. It is computed as

$$\bar{u}_{jk} = \frac{1}{n}\sum_{i=1}^{n} u_{ijk} \quad (3)$$

where uijk is a subjective score of observer i for test printer j and image k.

2nd Experiment

For the aspect of the evaluation of print image quality, it is necessary to know what level of image gloss is visually accepted and preferred. Four different types of images are used shown as Figure2: text, business graphic, photo, and metallic images. They consist of different type of customer-like images.

Figure 1. Customer-like Test Target Images

Five categorical scales are used for the score on preferred gloss. 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.

Each test image has seventeen samples printed by different color laser printers on plain papers. Each observer takes a turn to look at each test images, and rank the level of gloss preference according to the five categorical scales.

3rd Experiment

While observing the result of preferred image gloss on business graphic image from second experiment, we found that one particular sample has relatively high score of gloss preference although it has relatively low mean gloss (*Gm*) value. When comparing this print sample with others, it appears to be much more saturated. Third question we raise is about the effect of color and image gloss on overall image preference. Among test images, the business graphic image is selected, because it depicts highly saturated colours. Test target for business graphic image mainly include cyan, magenta, yellow, red, green and blue colours shown in Figure2. Five categorical scales on the level of image preference are also used.

Results

Gloss Perception

The measured 60-degree gloss readings on fifty two print samples range from 3.3 to 12.3 gloss unit. Figure 2 shows the relation between mean gloss (*Gm*) and visual assessment. 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 rank higher score when samples appear to be glossier. Linear regression is used for the analysis. The value of R^2 is 0.84. As can be seen, it shows strong negative correlation. This result suggests that human visual gloss sensation regarding overall image gloss has a simple linear relation to the gloss measurement when samples are printed by the default driver option on plain paper.

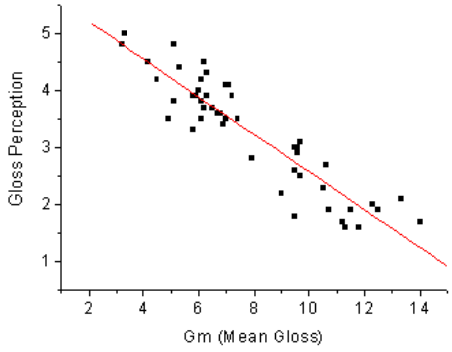

Figure 2. Mean Gloss (Gm) vs. Gloss Perception

The range of JND scale is between 0.4 and 1.8. As shown in Figure 3, it corresponds well. Based on the result, we can derive that observer can differentiate gloss level on print samples of plain paper. Therefore, the visual gloss scale regarding overall gloss sensation can be predicted with the equation of JND in this range of samples

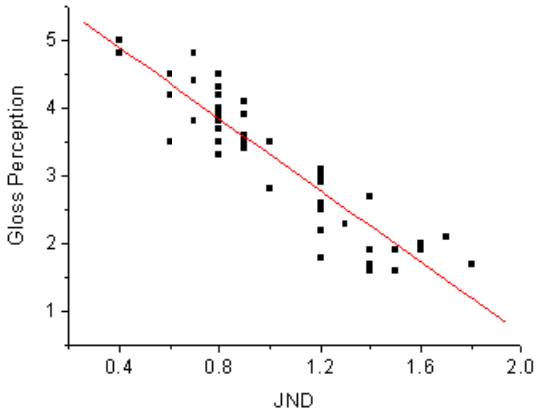

Figure 3. JND vs. Gloss Perception

Preferred Image Gloss

The human visual preference against gloss also satisfies the above log-linear model with different factors in various aspects[6].

In our experiment, overall gloss preference on photo, business graphic image, text, and metallic image is investigated. Also, the difference of preferred image gloss depending on image type, analysis of variance is compared. According to result of ANOVA, there is no significant statistical difference regarding gloss preference among test images. Although the relationship is not statistically significant in conventional level, we observe that text

and metallic image has relatively low correlation while photo and business graphic image shows relatively strong correlation between mean gloss (*Gm*) and gloss preference.

Image Type	Correlation Coefficient
Photo	-0.92
Business Graphic	-0.93
Text	-0.85
Metallic image	-0.88

Table 1. Correlation between Mean Gloss (G60) and Gloss preference (MOS)

Proposed Model for Image Preference

Observers are asked to give their preference based on vividness and gloss level of the whole print. The *preferred*-vividness is explained as the quality of color attributes for business graphic images prints by Youn Jin Kim et.al (2003). As a result, the postulation regarding *preferred*-vividness and image gloss for overall image preference can be formulated as following:

$$\psi = \frac{1}{n}(\omega_C \sum_i^n C^*_{ab\,i} + \omega_L \sum_i^n L^*_i + \omega_{Gm} \sum_i^n Gm) \quad (4)$$

where C^*_{ab} and L^* denote chromaticity and achromatic intensity while *Gm* denotes the overall level of glossiness of the prints. For C^*_{ab} and L^*, n is the number of primary color e.g. n=6 for CMYRGB. For *Gm*, n indicates the number of color patches in Differential gloss test chart e.g. n=40. The overall image preference, , is determined as a function of mean *C**ab, *L** across the primary color of CMYRGB and *Gm*. ω_c, ω_L and ω_{Gm} represent weighting factors of *C**ab, *L**, and *Gm** respectively. Based on optimizing weighting factors by multivariate regression, they are determined to be 0.26 ($=\omega_c$), 0.20($=\omega_L$), and 0.49 ($=\omega_{Gm}$).The associated p-value is much smaller than 0.05 which shows a good agreement between estimated subjective data and fitted model. Figure 4 demonstrates the experimental result and fitted linear model for business graphic image. The value of R^2 is 0.97.

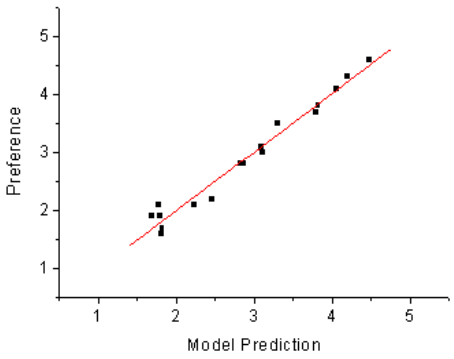

Figure 4. Relation between subjective data (MOS) and Model Prediction.

Table 2 lists and compares optimized weights between for *preferred*-vividness and overall image preference model. As can be seen, the contribution of chromaticity is consistently higher than lightness level between models. From the model of overall image preference, the contribution of mean gloss is much higher than that of lightness and chromaticity factor.

	ω_c	ω_L	ω_{Gm}
Preferred-vividness	0.57	0.43	--
Overall Image Preference	0.26	0.20	0.49

Table 2. Comparison of weights

Figure 5 illustrates the calculated preference scale of overall image quality for each sample. This model demonstrates that the visual preference increases along with increasing both *preferred*-vividness and dominant gloss within image.

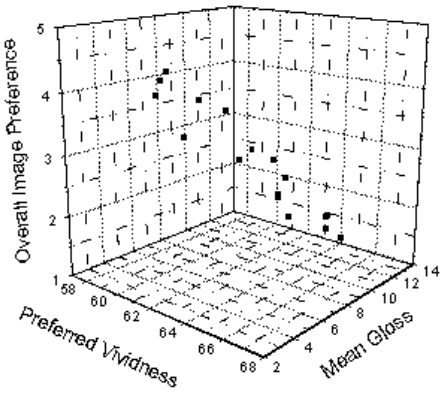

Figure 5. Mean Gloss (Gm) vs. Image preference

Conclusion

The visual assessment of perceptual image gloss on print samples is studied in this paper. The mean gloss (Gm) of samples with 60 degree gloss reading is from 3.3 to 12.3 gloss unit. Print samples have similar surface uniformity. With the result from the first experiment, we found that the gloss sensation has a simple linear relation to the gloss measurement for the evaluation of image quality on plain paper. With regard to be determining of preferred level of image gloss, observers have more gloss preference when the print samples appear to be more glossiness. To analyze effects of perceptual based image gloss and color for the evaluation of image preference, chromaticity (C*ab), lightness (L*), and mean gloss (Gm) are selected. As a result, each variable shows significant influence on the overall business image preference. The preference of business graphic images is assumed and a fitted function with weighting factors is shown in Equation 6. The performance of this model is also evaluated by comparing with corresponding subjective result ($R^2 > 0.90$).

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Author Biography

Seunga Kang Ha has been with Samsung Electronics, Korea since 2008. Before join to Samsung Electronics, she worked in EMRT as an cosultant of NexPress from 2005 to 2007, and worked as co-op from NexPress in 2005. She received her MS in Print Media from Rochester Institute of Technology with MS in Housing and Interior Design from Yonsei University, Seoul, South Korea. Her research interests include image quality evaluation and color management system

Youn Jin Kim received his BS in physics from Daejin University, Korea, in 2003, MS in imaging science from the University of Derby, UK with distinction, in 2004, and PhD in color chemistry from the University of Leeds, UK, in 2008. Since then, he has worked in the Samsung Electronics Company in Korea. His interests are color science, image quality and image enhancement such as super resolution and contrast enhancement.

Yousun Bang received her BS and MS in mathematics from Ewha Womans University, Seoul, Korea, in 1994 and 1996, respectively. She received her PhD in the School of Electrical and Computer Engineering, Purdue University, West Lafayette, Indiana, in 2005. She has been working at Samsung Electronics Company since 2004. Her research interests include color management system, image rendering, and print quality.

Heui-Keun Choh received his BS in physics and MS in solid state physics from Korea University, Seoul, Korea, in 1984 and 1986 respectively. He has been with Samsung Electronics, Korea. His research interests include modeling of color imaging devices, appearance color modeling, cross-media color reproduction for color management, digital printing, and image processing for color images.