COLORCORRECTION FOR LED PANEL UNDER DIFFERENT ILLUMINANT ENVIRONMENT BASED ON CIECAM02

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ABSTRACT

A series of psychophysical assessment data for investigating the color appearance in LED panel influenced by the level of ambient illuminant were accumulated. The perceptual attributes of test color patches, displayed in LED panel under bright, average and dark environments respectively, were evaluated. The experimental results indicate that the lightness and brightness are larger when viewing in dark and the lightness and brightness are smaller when viewing in bright sunny day. The visual data were used to compare with the corresponding data predicted by CIECAM02, and a modified CIECAM02 color appearance model with condition parameters correction is developed. A paired comparison experiment is carried out to verify the perceptual attributes predicted by the proposed CIECAM02 have good performance in various levels of illuminant.

INTRODUCTION

LED display panels with high luminous are widely used as billboard in outdoor public area and viewed in day and night. However, it always glares the pass-by pedestrians and makes them uncomfortable because the color appearance of LEDs is significantly influenced by the luminous of the surroundings. It is necessary to investigate how the color appearance changes with the surrounding luminance level and develop a color appearance model for LED panels to accurately adjust the light of RGBLEDs resulting in the same color appearance in various luminance environments. The effect of surround luminous levels on the color appearance in various media has been studied by many researchers.JM Kim et. al.[1] focused on the appearance in small size of mobile display. It found the color gamut of a mobile display is decreased and perceived darker, less saturated by increasing the luminance of environment. Choi et al. [2] conducted a psychophysical experiments using 42-inch Plasma Display to investigate the changes in color appearance in various surround ambient conditions.

The color appearance model CIECAM02, providing equations and methodologies to predict the color appearance in different viewing conditions, has been successfully applied in many fields [3]. The color appearance prediction in various viewing condition, including different luminance levels, ranging from dark, dim and average, can be obtained by CIECAM02. However, the color appearance prediction in bright illumination is not included in CIECAM02. Previous studies indicated that CIECAM02 performed poorly to predict the color appearance in bright ambient [4][5][6]. Park, Y.et. al.[7] investigated the color appearance in mobile under varied soundings. Based on the experiment results, a refined version of CIE-CAM02, called Refined CIECAM02, was developed for mobile displays to be viewed under different surround conditions. The viewing parameters of *Nc*, *F*, and *c* from surround ratio, which is used to define surround conditions in the CIECAM02, are able to calculate accurately.

In this study, the color appearance in full-color LED panel under different luminance level environments, including dark, average and bright is accumulated to test the performance of CIECAM02, and surrounding parameters in CIECAM02 are adjusted to have good predictions for various levels of luminous ambient. Finally, paired comparison experiments are conducted, in which observers compare the color appearances of uncorrected and corrected colors predicted by model in one viewing condition with viewing in the other luminous level. The experimental results showTestCAM02 has good performance in LED panel, especially for the predictions under bright surround condition.

EXPERIMENTAL

A perceptual attributes assessment, including lightness, colorfulness, brightness and hue, was conducted under dark, average and bright environments, in which the values of surround ratio S_R were 0, 0.35 and 3.3, respectively. A color patch, produced by high luminous full-color RGBLED chips with visual angle 6^o, is presented in the front of observers and is assessed in color attributes. The absolute luminance and CIExy coordinates of primaries R, G, B and white of used LEDs are shown in Table 1.Total eighteen test colors, uniformly spreading in CIELAB a*b* plane, are shown in Figure 1, where the neutral contains three different levels in lightness. The experimental setup is shown diagrammatically in Figure 2.

Table 1: The color coordinates xyY of primaries RGB and white in full-color LED

	x	y	Y (cd/m^2)
R	0.691	0.304	489
G	0.160	0.719	1103
B	0.136	0.056	174
W	0.3125	0.3277	1646

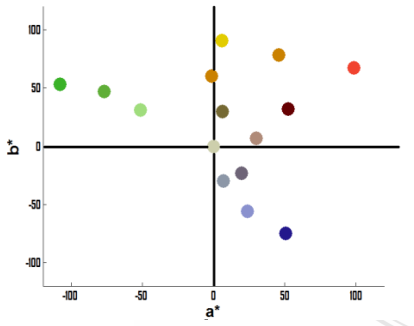

Figure1.Location of the LED test colors CIELAB a*b* plane

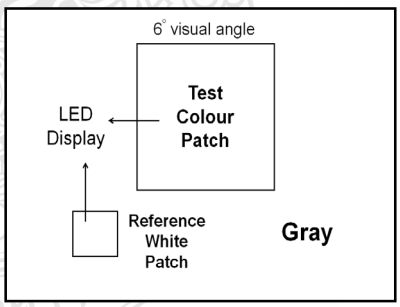

Figure2.The layout of the psychophysical experiment diagram

RESULTS AND DISCUSSIONS

The visual data of color appearance in RGBLED panel under dark, average and bright were obtained. The corresponding color perceptual attributes were calculated using CIECAM02, in which the luminous levels of dark and average are considered and the surround parameter c, F, N_c are defined. The surround parameters for bright was not considered in CIECAM02 and in this

study they were set as the same as the values for average to evaluate the performance of CIECAM02. The predictions obtained from CIECAM02 model were plotted against the corresponding visual data under dark, average and bright individually. The datum points should be located on the line of 45° if the predicted values agree with the experimental values. The results indicate the values of lightness in LED predicted by CIECAM02 under dark and average conditions are lower than the visual assessments. The colorfulness has better predicted performance for dark and average and a little over-estimation for bright. For the brightness, CIECAM02 gave bad predictions for all the conditions, especial the over-evaluated values under bright surround. According the results, the surround parameters c, F, N_c used in CIECAM02 were adjusted in this study to the corresponding predictions are close to the visual assessments based on RMS (Root Mean Square) method. The modified surround parameters values for dark, average and bright are shown in Table 2. The attributes in brightness Q also is modified to divide a constant 2.93 as shown in Equation 1.

Table 2: The modified surround parameters c, F, Nc

	Dark	Average	Bright
c	0.28	0.4	0.56
F	0.8	1	1
Nc	0.72	0.76	0.55

$$Q = \frac{\left[\left(\frac{4}{c}\right)\left(\frac{J}{100}\right)^{0.5}(A_w+4)F_L{}^{0.25}\right]}{2.93} \quad (1)$$

The perceptual attribute in lightness and brightness predicted by the CIECAM02 model with modified surround parameters, called TestCAM02, were plotted against experimental visual results to test the performance of model. It indicates datum points spread along the lines of 45° and the predictions are almost agreed with visual assessments. The lightness and brightness estimation fromTestCAM02 have a good performance.

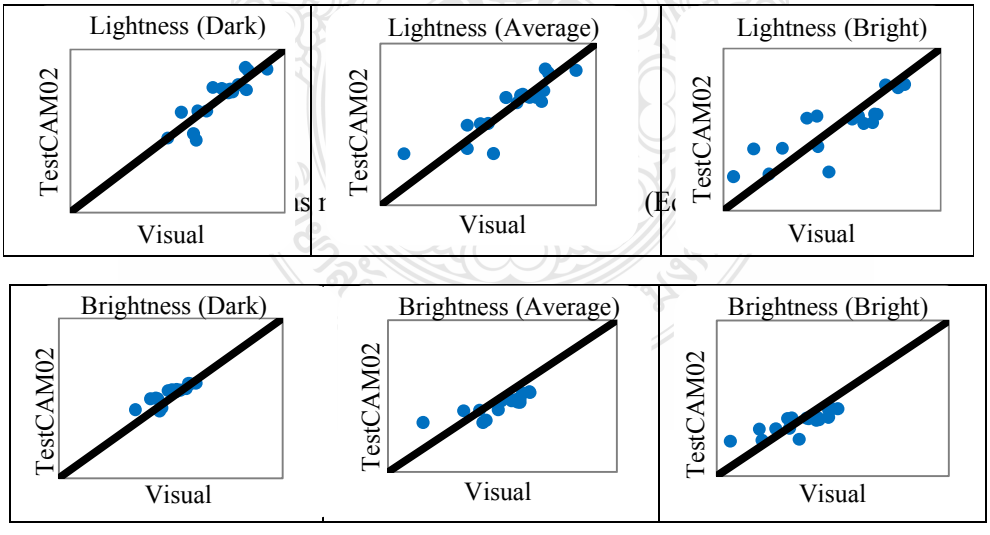

Figure 3. Diagrams of the TestCAM02 predictions plotted against experimental data

Paired comparison experiments were carried out to verify the efficiency of proposed model TestCAM02. The main advantage of color appearance model application is to correct color

stimuli displayed in LED panel to have the same color appearance in different luminous level ambient. The corrected color images were produced through the processes of the inverse CIECAM02, and TestCAM02 in dark and bright. The corrected and uncorrected images viewing in the corresponding luminous levels were compared with the original image in average environment by observers. The observers are forced to choose which one had more similar color appearance with the original in average surround. The z score were calculated to rank the performance of CIECAM02, TestCAM02 and the result is shown in Table 3.

Table 3: The z score from the paired comparison experimental results

	uncorrected	CIECAM02	TestCAM02
Original		132	170
CIECAM02	176		196
TestCAM02	138	112	
Sum	314	244	366
Z-score	0.0494	-0.5288	0.4793
Rank	2	3	1

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