Image quality assessment comparison between local and whole color rendering on large display

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Abstract

The large panel display has been manufactured and highly developed based on the cutting-edge technology. Also the advanced technology released bigger displays with higher resolution like 4K UHD and curved display in these days. The picture of the large panel display has great chances for expressing factors of presence and three dimensional effects to viewers. It leads the study for hardware system in high resolution and large panel displays to improve the viewer's optimum image quality. The study on the hardware of the panel display performs in many ways and applies on the large panel products. Beyond these studies, we need to focus on the emotional image quality and realistic image quality. We focused on with the viewer's emotion toward the images rather than on the threshold of the technical image quality. We conducted image quality experiments with images that can be shown on large panel displays and appear with great impact and presence. Researching the perceived image quality assessment about the local color rendering on the large panel display can show us that the viewer's reactions to color compensation and make another way to achieve optimum image quality. Therefore, we rendered the color of local areas of interest instead of the whole picture to improve the sense of immersion due to the picture of the large panel display big enough to fill the whole viewing angle. When the objects in scenes show, viewers focus on it and the area of interest is made up spontaneously. With the color reproduction in the area of interest catching the viewer's eyes, it can change the image quality of the entire image on the display and affect the viewer's emotional image quality. We conducted and analyzed image quality assessment experiment of the local color rendered image to implement image quality with maximized presence and impact. The perceived image quality experiment with local color rendering images show us that the partial color rendering on area of interest affects the viewer's emotional image quality and makes the entire picture more realistic. We found that the images with local color rendering process increase the reality of the entire scene by magnify the color distinction between area of interest and background.

Previous Researches

The perceived image quality experiment on the image quality's three dimensional effects and attractiveness of color from a display receives much influence from awareness perceptions. Objective awareness perceptions which can be colorfulness, brightness, light intensity, contiguity and etc., can be artificially altered and these influences from the alteration of perceptions have been discussed in many researches.

When two objects that have the same size are put together at the same distance, a person's awareness of this distance can differ by the object's brightness. Robinson(1954) [1] has argued that even if the objects have the exact same size, the brighter object will be recognized to be bigger than the less brighter object. By this effect, objects that have a brighter brightness will seem to be at a closer distance. [2] This effect also receives influences from the differences of the object & its background's brightness contrast as well. If the background's brightness is darker than the object, the brighter object from the two will look to be closer and if the background is brighter than the objects, the darker object from the two will seem to be closer. [3][4] From these research results, we can acknowledge that a person's sense of space receives significant influences from the background and the object's brightness. Through an experiment, Egusa [5] has argued that when the brightness differences between the background and the object increases, their perceived depth will also get bigger as well. Therefore, we believe that if brightness controlling color corrections can increase the display's overall presence, the three dimensional effects will also be enhanced.

From the researches of Dresp-Langley & Reeves(2014), they argued that color saturation makes definite contribution to the three dimensional effects of two dimensional images. From a subjective experiment with viewers and using an achromatic background, strongly-saturated surface colors associated with a positive luminance contrast was described to have a closer feeling of the object than the background. On the other hand, weakly saturated surface colors associated with a negative luminance contrast, it was described the object seemed to be more far away than its achromatic background. They concluded that saturation had a decisive role on the display's feature-based selection that is needed to focus while it gave direct influences to the object's perceived depth or had it interact with the brightness of the background. [6]

Farnè M. used same size squares that arranged in a line on a same background while had gradually higher contrast and tested the perceived depth of these squares. The result of the test was that squares that had relatively greater contrast were proved to look as if they were closer than the other squares. [7] Rempel and 2 others have proved through an experiment that influences of perceived depth can be emphasized by having the contrasts increased. This effect is applicable notwithstanding the size of the objects and has argued that perceived closeness increases for the bright area from a dark background when area contrast is increased. [8]

Color rendering for awareness perceptions in movies are well generalized to increase the appearance and three dimensional effects. Bleach-bypass, which is one of the film developing techniques decreases chroma and exposure to express images that have higher contrast which has the image's three dimensional effects far better than natural colored images. By brightness contrast, it creates the viewer's viewing sense more sensitive in brightness than color so they can focus more on the actor's actions, expressions and their acts and to emphasize an object in a darker background during a movie, the object's chroma is increased while the black value is controlled to make the background darker. Through these adjustments, the chroma contrast & brightness contrast effects are maximized to increase the object's visibility and attractiveness of color in a darker background. Lighting that has focused particular areas shows to be more immersed than where lighting is generally bright and for scenes where bright & dark spaces are significantly classified, the spaces with brighter parts bring out a little more attention, having immerse effects fulfilled. Therefore, to increase the presence and attractiveness of images, the focused object or area that should grasp the attention will need to be separated from the background and, moreover, when the color of the area is rendered about the awareness perspective, the presence and three dimensional effect are enhanced. [9][10] By this, we control the awareness perspectives as chroma, brightness and brightness contrasts to create great impacts and presence of the image and adjusted in complex way chroma, brightness & brightness contrasts to proceed with perceived image quality assessment experiments with the viewers.

Color rendering on large display

Color correction is an indispensable work to make the recorded images real when playing on the monitor. Through the camera, we filmed actual images under the various influences of the light of colors. There are huge differences between the recorded images and the real images and we calibrate the recorded images. Color correction is the processing adjusting the colors to more similar to what we remember and this process is completed through the color rendering process. Color rendering is processed arithmetically with the pre-configured algorithm and when the image’s data becomes bigger, more calculations of arithmetic will be needed and processing time will become longer while giving out big loads to the system. In other words, high resolution displays like UHD’s color rendering process load require a multiple of work compared to the load needed in the HD leveled resolution displays. Thus, if local color rendering is applied so a particular space is emphasized such as the sense of appearance and three dimensional senses than rendering the whole image color, it will decrease the image processing time and its data calculating processes as well during the color correction phase.

Perceived image quality assessment experiment

The image quality evaluation factors related with reality in high resolution images on large-sized displays can be the awareness and technological perceptions. As for technology perceptions, it is a perception whereas the images can be controlled by the display’s hardware and is defined with the presence, the sharpness, and the stereoscopy. Awareness perception is one of the objective senses that come from complex ways from the modifications of technological perceptions such as brightness, chroma, and lighting contrasts. The realistic image quality is felt by the subjective visual evaluations of the viewers and not only does this have much influence from the display’s resolution and size but from the types of the image contents as well. [11] Therefore, the perceived image quality assessment experiment about the realistic image quality must consider the variables about the categorization of the image contents.

Color Rendering Images for experiments

We have arranged a perceived image quality assessment experiment to find out the influence about the difference between the local color rendering and the whole color rendering on the realistic image quality. For this experiment, we chose experimental image samples considered the characteristics of all images displayed in media. We generalized TV contents and considered the diversity of contents, major camera angles and other characteristics and we collected the images based on the sense of reality, dynamics, tension, movement and etc.

Figure 1.Images for experiments.

To compare the perceived experiment results for differences in recognizing the image’s quality, we determined local area of interest (AOI) and separated it with their background. Local area of interest (AOI) is the major object that is focused on in each image and has representative of the whole image. Some of images such as RYU, KYA, cave and IM, we divided small portion from AOI for highlighting it. Through this process, we made two experimental images color-rendered on the brightness, contrast and saturation of separated AOI and whole image so that we can make a comparison.

As results from preceded researches regarding brightness, contrast and saturation in color rendering, saturation’s stereoscopic effect is enhanced when the AOI’s chroma is higher than that of the background [6] and thus, we color-rendered so that the chroma of AOI gets higher than the background’s chroma stage by stage. As for brightness, research results showed that three dimensional effects were more sensed in high brightness [2] and therefore, AOI’s brightness was controlled to become brighter stage by stage. As contrast brings more focusing, absorption and three dimensional effects when the brightness of AOI is brighter than the brightness of the background, [8] the brightness of the AOI gtt brighter than the brightness of the background on a stage-by-stage basis. Especially in very dark images, the more maximization between the differences of light intensity of the AOI & its background, the attention to the AOI becomes higher and with this result, the AOI’s brightness was adjusted to become brighter than its background. The color rendering values of each attributes were drawn up by a preliminary experiment. The preliminary experiments were held by a group of women in 20s and 30s who have professional work experiences in color fields and are sensitive to colors from the quality of images. Through this test, the image’s color rendering values were configured from the images that showed higher scores. These values were used as the color rendering factors for this experiment.

Table 1: Local area of interest segment for color rendering

	AOI_1	AOI_2	BG
RYU			
KYA			
Cave			
Bow			
FLW			
IM			
AVG			
DP			
Meat			

Table 2: An example of color rendering for whole image and local AOI

Whole				
	BRIGHTNESS	+20		+30
	CONTRAST	+20		+40
	SATURATION	+20		+30
Local				
	BRIGHTNESS	AOI_1	+20	+20
		AOI_2	+30	
		BG	-10	+10
	CONTRAST	AOI_1	+20	+20
		AOI_2	+40	
	SATURATION	AOI_1	+20	+20
		AOI_2	+30	

Circumstance of Experiments

We conducted the experiment under a similar environment of where we watch normal television shows. The distance between the TV and subjects were 2.5 times of the TV's height while a 65 inch UHD TV was used for this experiment. To confirm the subjects' optimized and preferred quality images by their age and gender, we recruited from the ages in the 20s, 30s, & 40~50s with 62, 58, 40 subjects respectively. Thus, a total of 160 subjects participated in this experiment with a gender ratio at approximately 1:1.5.

Process of Experiments

This experiment was based on the pair-comparison to find out the impact of local color rendering. Subjects watched two pairs of images; one pair was original image and local rendered image that used the basis of color rendering values from the preliminary experiments, and the other pair was original image and the rendered image of the whole screen compare their image quality and to score them respectively as well. The medium gray color image is inserted between the images so that afterimage effects are gone from the subjects during the experiment. After the original test image footage is shown and assumed as the score of this image quality is 4, subjects scored the color rendered image shown afterwards from 1 to 7 so we can go through comparative evaluations. Here, a score of 1 would mean the image quality's preference is the lowest while a score of 7 will be the highest. This process was repeated 2 times so that an original image can have comparative evaluations both on its local color rendering and whole color rendering factors. The local color rendering and whole color rendering images had no sequences and were displayed in a random perspective so that the subjects' learning effects were minimized. The experiment lasted for 30 to 40 minutes and there was also a resting time during the experiment to minimize the subjects' visual exhaustion.

Results

The results of the perceived image quality assessment experiment with the use of local color rendering on the images have shown results as below in figure 2.

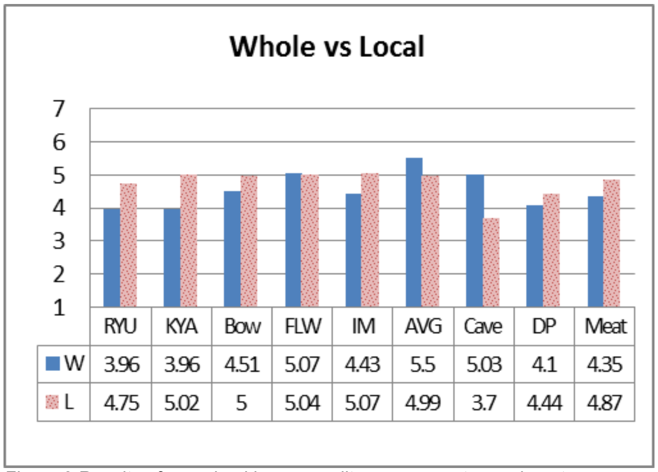
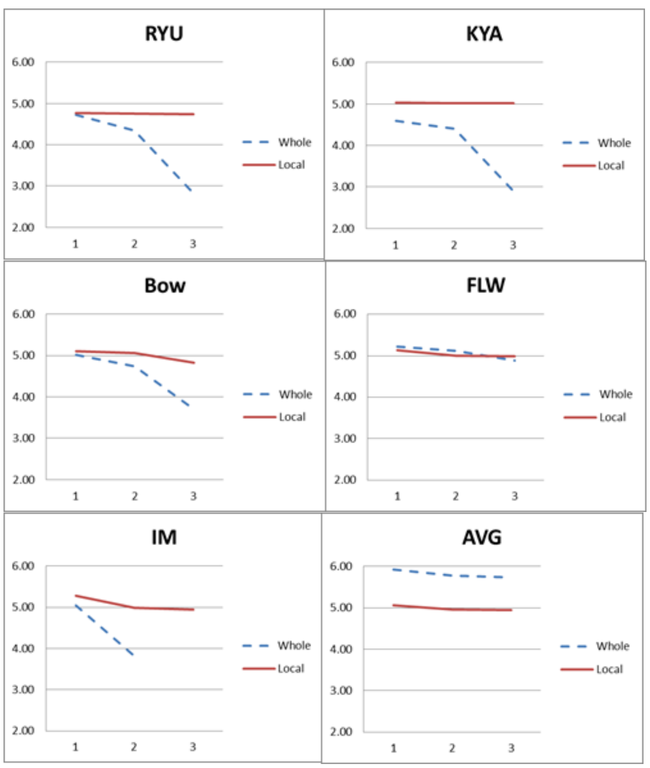


Figure 2.Results of perceived image quality assessment experiment

We averaged the image quality scores of the experiment and analyzed top 3 scored images.



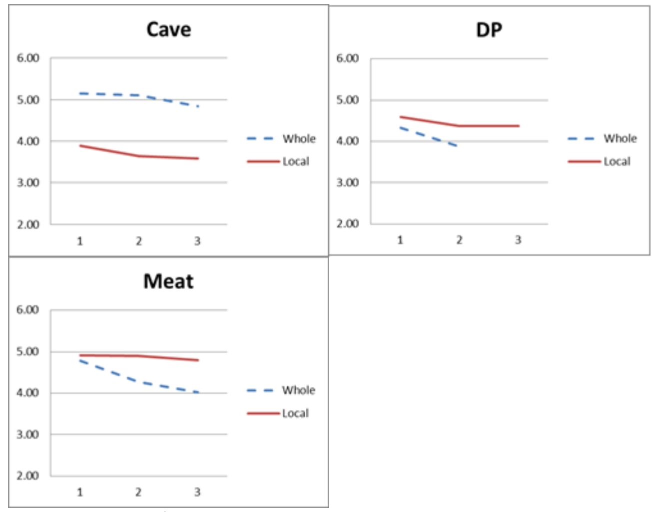


Figure 3.Results of experiment with scored best top 3.

Most of the image quality scores got higher scores than score of 4 points of the original image and 6 of images from the 9 experimental images showed higher scores in the image quality evaluations of local color rendering images than the scores for the whole color rendering images. (Figure 4)

Figure 4.Images with preferred on local color rendering.

Table 3: Best IQ score for local color rendering (7 is the best IQ score and 1 is the worst.)

Image	Color Rendering	Best IQ score
RYU	AOI_B+10 / C+10 / S+10 BG_B+10	4.77
KYA	AOI_1_B+10 / C+10 / S+10 AOI_2_B+20 / C+20 / S+20 BG_B+5	5.03
Bow	AOI_B+30 / C+20 / S+20 BG_B-10	5.1
IM	AOI_B+20 / C+20 / S+20 BG_B-10	5.28
DP	AOI_C+20 BG_B+10	4.59
Meat	AOI_C+20 BG_C+30	5.00

When analyzing the experiment results, images with AOI that takes a proportion of more than 30% of the image and images that have relatively bigger brightness contrast between the AOI & its background from the sample images used in the experiment show that local color rendering is more preferred.

The 6 most preferred image quality and their scores are shown in Table 3. The three perspectives which are brightness, chroma and saturation of AOI was increased of 10 to 20% evenly while of its background brightness was increased around 10% have the best probability of achieving a high score.

From the results of RYU and IM's images which regards in fragmenting the small portions in the AOI, the image quality score somewhat decreased compared to scores about the AOI without the small portion. We assumed that fragmenting the AOI can actually interrupt the image's sense of unity which has it to receive lower scores. As for meat images, there are several objects within the AOI compared to other images but since those several objects have the similar color tone and texture, it can be speculated that viewers were aware of the objects as if it was just a single object. Increasing the brightness 5 to 10% in backgrounds with high brightness and high chroma and decreasing 10% in backgrounds with low brightness and low chroma were preferred. When analyzing the characteristics by age groups, 20s, 30s and 40s groups all showed similar distribution of scores in the image quality's changes in their perceived image quality assessment experiment while there were no differences between genders as well.

Figure 5.Images with preferred on whole color rendering.

Table 4: Best IQ score for whole color rendering (7 is the best IQ score and 1 is the worst.)

Image	Color Rendering	Best IQ score
FLW	W_B+30 / C+20 /S+20	5.22
AVG	W_B+50 / S+20	5.92
Cave	W_C+120	5.15

On the other hand, when the image's overall colors are in a darker tone and when the AOI & background's brightness and chroma don't have much difference like in figure 5's experimental images, the image quality score of whole color rendering images were received higher scores than the local color rendering images. As for FLW images, whole color rendering received higher scores even though adequate differences did exist between the AOI and background's brightness and chroma. We assumed that the reason is expected to be because objects within the AOI had different colors, having them recognized as multiple objects and not a single object. In other words, if color rendering is processed on an AOI with multiple objects, the attention will be dispersed compared to the AOI's color rendering for a single object. Therefore, the impact effects for these images do decrease in local color rendering processes. Thus, the image quality score of whole color rendering and local color rendering from FLW images shows almost similar values. This tendency will have more influences by the size of the display. Since AVG images have the entire image very dark, the separation between the AOI & background is undistinguishable and showed results with no meanings. Also, when increasing more of the AOI's contrast, the image's unnaturalness was also increased, creating the image's preferences to decline. The cave image was the only image that did not receive a higher average point than 4 and lower estimated than the original image after the local color rendering process. It is analyzed that the focus of the AOI was already adequately attained over the overall achromatic colored image and it brought up the image's artificiality and have its preference declined attributes with local color rendering with modifications.

Conclusion

We performed the perceived image quality assessment experimentation for images that were locally color rendered. We asked image quality preference for the images with that was color-rendered in the area of interest and the whole. We found out that the image quality of the local color rendered image was higher than that of the whole rendered image when the image has a single area of interest. Also, as larger the chroma difference between area of interest and background is the image quality was higher. On the other hand, the images with multiple areas of interest and high chroma in the area of interest and background, the subjects scored higher image quality on the whole color rendered image than the local rendered ones. The average image quality of the local rendered images was 4.44 and for the whole rendered image was 3.96. With 10% higher brightness, contrast and saturation (especially contrast) leads to high image quality for most of the local color rendered images. This means that the local color rendering makes a clear difference between the area of interest and background, and affects its distinctness and discrimination. Therefore, we percept the local color rendered image as a high sharp image. However, there were exceptional cases that images with bright artificial illuminations were scored with high image quality when the brightness, contrast, and saturation were lower than the original image.

The evaluation factors in high resolution display for presence image quality is consisted of perception properties and technical properties. We use the hardware system to control the image quality by technical properties. The perception properties are part of the objective properties, such as brightness, chroma, and contrast. Both properties are required to and needs a complex analysis by those two combined to determine precise image quality. The perceived image quality experiment with local color rendering images show us that the partial color rendering on area of interest affects the viewer's emotional image quality and makes the entire picture more realistic. We found that the images with local color rendering process increase the reality of the entire scene by magnify the color distinction between area of interest and background. Therefore, the local color rendered images get higher image quality than the whole color rendered images because the subjects perceived the local color rendered images with the sharpness.

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