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PAPER TITLE
Study on Reproduction of Spatial Brightness on a High-Luminance Large LED Display -Effects of image color and texture on subjective evaluation-

KEYWORDS
Brightness, Large display, Simulation-tool, Tone-mapping

ABSTRACT
Recently, simulation tools have become more familiar as the use of BIM has taken root in architectural design. Furthermore, as display performance improves, it is becoming possible to display luminance chromaticity equivalent to that of real space, as displays with high-resolution and wide-color range become more widely available. Visual experiences equivalent to real space utilizing displays are expected to reduce discrepancies before and after construction, leading to more efficient design. In this study, the spatial brightness evaluation in measured images (based on luminance chromaticity distribution by image photometry system)and simulated images (based on luminance-chromaticity distribution calculated by Radiance as a light environment simulation tool) was compared in order to verify the reproducibility of spatial brightness using a large display. Simulated images were created using three material setting methods used in general design practice: achromatic, coloured and textured. In all of these settings, the spatial brightness evaluation of the space in relation to the mean luminance on display matched the measured image. In light of previous research showing that spatial brightness equivalent to observing a real space can be obtained under luminance and chromaticity conditions that can be presented on a display, it is suggested that if luminance is reproduced by accurate illumination calculation, it is possible to obtain the spatial brightness perception from simulated images that is equivalent to that of real space.

Study on Reproduction of Spatial Brightness on a High-Luminance Large LED Display -Effects of image color and texture on subjective evaluation-

1. Introduction

Spatial brightness : determine the quality of lighting environments.

Predicting lighting environments using displays

>> would be beneficial for architectural and lighting design.

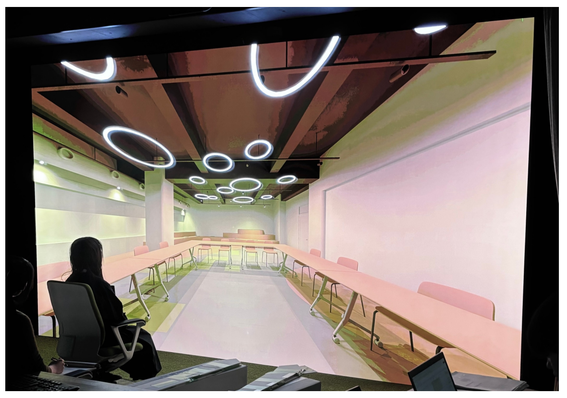
Purpose

To clarify the reproducibility of visual effects such as brightness for large displays

Previous study (in a simple office room)[1]

The spatial brightness on the display ≒ That in the real space

Under electric lighting conditions, it was perceived as somewhat **darker.**



- High-luminance large LED display -

2. Method for reproducing luminance and chromaticity distribution on a display

How to create images for display

Getting XYZ data ▶▶▶ Filtering ▶▶▶ Tone-Mapping ▶▶▶ Display

✓Pixels with luminance exceeding 1,200cd/m² were **blown out**.
✓Pixels which were less than 1,200cd/m² were tone-mapped by **linear scaling** with the luminance and chromaticity of the real space

- Information of display -

Screen size	W: 4,864 mm, H: 2,736 mm
Pixel count of the display	3,840 × 2,160
Bit depth	24 bit (RGB)
Gamma value	2.2
Maximum luminance	1,200 cd/m²

3. Experimental methods

Experimental spaces : 3 spaces

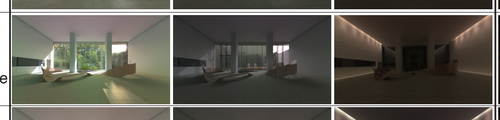
Images for display : 4 variations

Experimental procedure :

1) The participants adapted at the evaluation seat (10 min.).
2) Observed spatial brightness (30 sec.).
3) Evaluated the spatial brightness by adjusting uniform luminance of hemispheric space

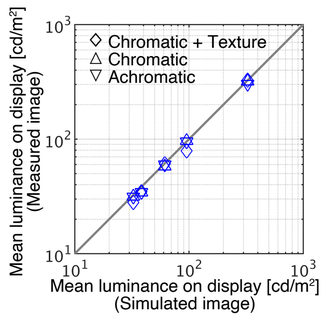
Participants : 18 participants (early 20s).
✓The conditions with the highest and lowest mean luminance were presented first as practice conditions.
✓The conditions were presented in random order.
✓During the evaluation, the luminance and chromaticity distribution in the space were measured*2 from the evaluation seat.

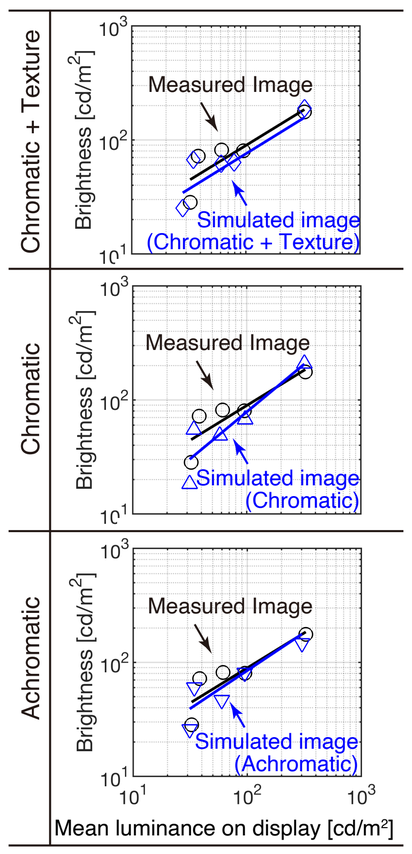
- Information of display -

	Space A			Space B	Space C
Daylit	Sunny	Cloudy	×	Sunny	×
Electric lighting	×	×	○	○	○
Measured image					
Simulated image Chromatic+Texture					
Chromatic					
Achromatic					

4. Analysis results

The stratified analysis showed that the spatial luminance ratings were in statistical agreement with the measured images, even for achromatic images reproducing only the luminance distribution and for chromatic images reproducing the chromaticity as well (Figure 4). In a previous study, it was confirmed that the respective brightness ratings for measured images and real space were equivalent when luminance was lower than the maximum luminance (1200 cd/m²) that could be displayed.





- Relationship between mean display luminance and brightness -

- The error of mean luminance on display -

5. Conclusions

In light of previous research (Nomoto 2024) showing that spatial brightness equivalent to observing a real space can be obtained under luminance and chromaticity conditions that can be presented on a display, it is suggested that if luminance is reproduced by accurate illumination calculation, it is possible to obtain the spatial brightness perception from simulated images that is equivalent to that of real space. The results of the achromatic simulation images suggest that the perception of the space can be equivalent to that of a real space in the early stages of design, where no detailed representations such as colouring or textures have been made.