Visual and Non-visual Quantities of Self-luminous Signboards in Residential Areas in China

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Abstract
This study explores quantitative influences of commercial lightbox signboards from both visual and non-visual perspectives by integrating measurements and simulations. First, 41 self-luminous signboards are individually measured and simulated. The relative root mean squared errors by using Radiance or Lark are 3.8% and 4.3%, respectively, which demonstrate the applicability and reliability of this integrated method. Over 70% of the measured signboards are greater than the maximum permitted average luminance threshold recommended by the national code. While achieving the same photopic luminance, the order of circadian luminance values from low to high for commonly used colours is: red, yellow, green, white, and blue. Secondly, a pedestrian shopping street is used as an example for context simulation. Although great luminance values concentrate on signboards, lights inside stores also contribute to scene-based lighting distributions. By integrating both field measurement and simulation, lighting pollutions caused by commercial signboards can be better understood and controlled from both visual and non-visual perspectives.

Highlights
- Quantify the impacts of commercial self-luminous signboards in terms of visual and non-visual aspects.
- Simulate signboards by using both three-channel Radiance and nine-channel Lark tools.
- White and blue colours result in greater impacts on non-visual aspect while red and yellow results in greater impacts on visual aspect.
- Over 70% of the measured signboards have great potential in lighting pollution within residential areas.
- A pedestrian shopping street is used as an example for context simulation.

Introduction
Given the rapid development of urbanization in China, lighting pollutions are becoming more and more severe (Chen, Wei, Dai, & Huang, 2019). Previous studies have demonstrated the negative influences of lighting pollutions upon astronomical observation (Falchi et al., 2016), growth cycles of plants (Owens et al., 2020), and citizen’s health (Argentiero, Cerqueti, & Maggi, 2021; Lamphar et al., 2022; Xie et al., 2022). Long-term exposure to lighting pollutions increases the chances of residents who suffered from various diseases, like children suffering from autism spectrum disorder (Xie et al., 2022), citizens suffering from breast cancer (Lamphar et al., 2022), and even citizens being infected with the Covid-19 virus (Argentiero et al., 2021). Over-bright city lighting environments at night have negative impacts on human beings, animals, and plants.

One source of lighting pollutions close to residential areas are self-luminous commercial signboards, which are densely installed on the façade of residential buildings. These buildings mix both commercial uses on the first floors along the street and residential accommodation above, which is a commonly designed hybrid building type across Chinese cities. Figure 1 shows examples of the hybrid buildings in four cities. Given the close relationships between these shops and residents, complaints concerning over-bright signboards at night were reported online or through citizen hotlines. Some researchers have already noticed the negative impacts of signboards. Ngarambe et al. found that 30% of commercial boards and 70% of decoration lights in Seoul had lighting pollution (Ngarambe & Kim, 2018). Wei et al. found that 47% of signboard measurements in Shanghai and 86% of signboard measurements in Hong Kong presented great circadian stimulus over 0.05 (Chen et al., 2019). In other words, evaluations and control ordinances concerning signboards in residential areas are necessary for creating healthy lighting environments free from pollution for residents.

![Figure 1: First-floor shops in residential buildings along the streets in Nanjing, Wuhan, Zhengzhou, and Qingdao](https://doi.org/10.26868/25222708.2023.1627)
discussed herein. For all three standards, the maximum vertical illuminance on the relevant window surfaces of nearby dwellings are 10 lx for pre-curfew and 2 lx for post-curfew for Zone 3 (E3), residential suburbs. Table 1 summaries the maximum permitted average luminance of self-luminous signs for E3. Meanwhile, only Chinese MHURD suggests the luminance thresholds based on area ranges of self-luminous signs. Both CIE and IESNA recommend 800 cd/m², which is much greater than the thresholds recommended by Chinese MHURD.

Table 1: Maximum permitted average values of self-luminous signs for E3

<table>
<thead>
<tr>
<th>Self-luminous area (m²)</th>
<th>Chinese MHURD Values</th>
<th>CIE Values</th>
<th>IESNA Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0, 0.5]</td>
<td>400 cd/m²</td>
<td>800 cd/m²</td>
<td>800 cd/m²</td>
</tr>
<tr>
<td>(0.5, 2)</td>
<td>300 cd/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2, 10]</td>
<td>250 cd/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10, ∞)</td>
<td>150 cd/m²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Due to various types of signboards in terms of illuminating methods, designs, and material compositions, it is straightforward to conduct field measurements (Mander, Alam, Lovreglio, & Ooi, 2023) rather than simulation studies (Ho & Lin, 2015). While simulating signboards, assumptions concerning luminaire types and material properties were made (Ho & Lin, 2015). Although Ho and Lin obtained 16% of average differences between the measured and simulated vertical illuminance, simulation differences could be reduced by inputting measured rather than assumed data. A method of integrating measurement and simulation for improving simulation efficiency and accuracy is required. Furthermore, previous studies and standards concentrate on visual impacts of signboards. However, insufficient studies have concentrated on the non-visual impact of lighting stimulus, which influences citizen’s internal circadian. Studies have identified the important factors on circadian entrainment: timing, intensity, duration, and wavelength of light, along with the proceeding record of exposure (Duffy & Wright Jr, 2005). Given that signboards vary in both intensity and colour, the consideration of wavelength composition for signboards requires further exploration.

An efficient way of simulating signboards’ visual and non-visual quantities could provide better understandings of signboard designs. However, there are several difficulties to overcome: 1) signboards have complex shapes of Chinese characters and logos for simulation; 2) currently, to the authors’ knowledge, there is no standard data or files, such as an illuminating engineering society (IES) file that provides measurements of lighting quantities for simulation, for a signboard’s visual or non-visual simulation; 3) compositions of signboards, including structure, luminaires, and translucent materials, add complexity to signboard simulations. Therefore, this study aims at proposing and validating a simplified method of simulating commonly used signboards in terms of both visual and non-visual quantities.

Method

This study was conducted in two steps: isolation simulation and context simulation, as shown by Figure 2. The former involves measurement and simulation of individual signboards. A simplified method of simulating individual self-luminous signboards was proposed, the results of which were compared to the measurements; The latter involves measurement and simulation of signboards in the context of Hongmiao Street for further validation.

Measurement

There are mainly five types of illuminating systems for signboards: neon-based (profile or billboard), light emitting diode (LED)-based (profile or billboard), internal lightbox, external floodlight, and mixed lighting systems (Tong, 2017). Given that internal lightbox is the most widely used illuminating system based on our observation, this research concentrates on simulation method of internal lightbox.

Concerning data collection of individual signboards, we used a spectral radiance colorimeter (SRC-2) fixed on a tripod for measuring lighting quantities of a aiming point, which allows the isolation of a signboard’s self-luminous character or background. To avoid daylight influences, we collected lighting quantities between 8pm and 10 pm between February and May. Measured lighting quantities included luminance values, lighting spectrum and correlated colour temperature. We measured three to seven points on each signboard. For example, this “好运来餐厅” signboard (Figure 3) has both self-luminous red characters and yellow background. Hence, three or four points of each colour were measured, and the distributions of measured points are illustrated by black circles in Figure 3. If a signboard only has self-luminous characters, three or four points on these characters were measured. Two types of internal lightbox signboards were observed: projection signboards and surface signboards. The former refers to the design with protruded characters upon signboards, along with either self-luminous or opaque backgrounds; The latter refers to the design of one flat

Figure 2: Research flow
translucent surface including both characters and backgrounds. Figure 4 shows two examples of each type.

**Figure 3: Distributions of measured points**

**Figure 4: Examples of projection signboards (left) and surface signboards (right)**

Xuanwu District in Nanjing was selected due to its high density of residential buildings with active first-floor shops along the stress. Valid data of 41 stores were obtained for simulation. The criteria of selecting signboard data included: 1) a store consistently open with internal lightbox signboard; 2) a lightbox signboard with evenly distributed light, which was examined first by observations onsite and secondly by comparisons of multiple measured luminance. If differences of measured luminance were greater than 10%, the internally lighting distributions of this lightbox was not even for study. Figure 5 shows the location of 41 stores measured in Xuanwu District. A circle’s colour demonstrates this signboard’s character colour, and the outline’s colour demonstrates the signboard’s background colour. If a signboard’s background is opaque material, its outline is black. For example, a white circle with red outline demonstrates that this store uses white characters and red backgrounds for its signboard design.

In addition to the 41 store signboards, Hongmiao Street was selected for the context simulation. The reasons for selecting Hongmiao Street are threefold: 1) it is a pedestrian shopping street that excludes the disturbance from vehicle; 2) there are only a few small trees that partially block several signboards; 3) it is a bustling internet celebrity street with numerous restaurants with various designs of signboards in terms of illuminating intensity and colours. Figure 6 shows the images of first-floor stores along the Hongmiao Street. The modeled street is 73m long and 10.8m wide. The height of the first-floor shops is 3.5m, and seven-floor residential buildings is 21.5m in total.
In addition to the measurement of 35 self-luminance sources from 20 self-luminous signboards along Hongmiao Street, we took high-dynamic range (HDR) images by using a Canon EOS 5D Mark IV and a Sigma 8mm f/4 EX DG fisheye lens along the Hongmiao Street. HDR images were taken following Inanici and Jakubiec’s methods (Inanici, 2006; Jakubiec, Inanici, van Den Wymelenberg, & Mahić, 2016; Jakubiec, Van Den Wymelenberg, Inanici, & Mahić, 2016). Figure 6 shows the nine scenes along Hongmiao street. Only the open stores with their signboards light up were recorded. Of the nine arrows in Figure 6, the circles demonstrate the camera position, and the arrows demonstrate the image-taking direction. Only vertical illuminance in front of the lens was measured twice, before and after taking the HDR images. Post data processing of luminance values followed Inanici and Jakubiec’s methods. Moreover, circadian luminance values were converted from HDR images following Jung’s methods (Jung & Inanici, 2019), which utilizes a tristimulus colour calibration procedure of calibrating camera RGB channel values. Finally, the geometry information and positions of taking HDR images were also recorded for simulation.

**Simulation procedure**

A lightbox is composed by steel structure, translucent surface, and internal luminaires. One direct way of simulating a lightbox is to model it according to its components. Instead of defining lighting properties of each component of a lightbox, researchers and designers are more concerned about the external lighting behavior of a signboard. In other words, regardless of lighting reflectance and transmission occurrence inside of each signboard, this study only focuses on the radiance leaving off each signboard’s surface. Hence, we use Radiance glow material, a material type that is used for self-luminous surfaces, to reproduce signboard’s colour and intensity.

We used two methods of creating glow materials: three-channel simulation and nine-channel simulation, both of which use Radiance as the simulation engine but different data inputs. Concerning the three-channel simulation, X, Y, and Z tristimulus reflectance values were calculated from the chromaticity coordinates x, y and z. Then, Radiance RGB values were converted from X, Y, and Z following Equation 1 by using xyz_rgb.cal.

\[
\begin{bmatrix}
R \\
G \\
B
\end{bmatrix}
= 
\begin{bmatrix}
2.5653 & -1.1668 & -0.3984 \\
-1.0221 & 1.9783 & 0.04382 \\
0.0747 & -0.2519 & 1.1772
\end{bmatrix}
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix}
\]

(1)

Radiance glow material was generated following this format (Ward & Shakespeare, 1998):

```cpp
void glow modifier
0
0
d R G B max_radius
```

where R, G and B refer to red, green and blue radiance converted from X, Y and Z, and max_radius refers to the maximum radius for shadow testing. The wavelength intervals for the three-channel method are divided as [380 nm, 498 nm] for blue, [498 nm, 586 nm] for green and [586 nm, 780 nm] for red. The photopic coefficients for blue, green, and red are 0.2651, 0.670, and 0.065, respectively.

Concerning the nine-channel simulation, Lark Spectral Lighting (referred to as Lark), a Grasshopper plugin for analyzing circadian light, was used for simulation. Lark subdivides RGB channels into three to obtain nine channel simulation (Inanici, Brennan, & Clark, 2015). Lark provides both photopic and circadian results. Table 2 lists the nine wavelength intervals, as well as the associated photopic and circadian response functions (Lucas et al., 2014) applied in Lark. Measured luminance value and the associated spectrum power density of a self-luminous signboard were input for generating Lark glow materials. The procedure and calculation equations was based on Balakrishnan and Jakubiec’s research of generating glow sky for Lark (Balakrishnan & Jakubiec, 2019).

**Table 2: Coefficients of photopic and circadian response functions utilized in Lark**

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Photopic</th>
<th>Lucas et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>380-422</td>
<td>0.0004</td>
</tr>
<tr>
<td>B2</td>
<td>422-460</td>
<td>0.0095</td>
</tr>
<tr>
<td>B3</td>
<td>460-498</td>
<td>0.0522</td>
</tr>
<tr>
<td>G1</td>
<td>498-524</td>
<td>0.1288</td>
</tr>
<tr>
<td>G2</td>
<td>524-550</td>
<td>0.2231</td>
</tr>
<tr>
<td>G3</td>
<td>550-586</td>
<td>0.3174</td>
</tr>
<tr>
<td>R1</td>
<td>586-650</td>
<td>0.2521</td>
</tr>
<tr>
<td>R2</td>
<td>650-714</td>
<td>0.0162</td>
</tr>
<tr>
<td>R3</td>
<td>714-780</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

Rhinoceros (referred as Rhino) has a text command that provides multiple fonts for Chinese characters (Associates, 2019). Therefore, we generated Chinese characters of signboards in Rhino and exported them into Grasshopper. Figures 7 and 6 show the Rhino models of signboards and Hongmiao, respectively. Then, Honeybee-Radiance (Roudsari & Pak, 2013) was used for three-channel simulations.

**Figure 7: Rhino model of signboards**

Finally, the relative root mean squared errors (RMSErel) was calculated by Equation 2 to validate this proposed simulation method. RMSErel provides an absolute average deviation percent of simulated luminance values in relation to measured ones, which has been widely used by
previous lighting research (Jones & Reinhart, 2017; Kong & Jakubiec, 2021; Kong, Uitzeng, & Humann, 2018).

\[
RMSE_{rel} = \frac{1}{L_{mea-mean}} \sqrt{\frac{\sum_{i=1}^{n} (L_{mea,i} - L_{sim,i})^2}{n}}
\]

where \(L_{mea,i}\) represents the \(i\)th measured luminance value, \(L_{sim,i}\) represents the corresponding simulated luminance value by using either three-channel or nine-channel method, \(L_{mea-mean}\) represents the mean luminance values of all measurements, and \(n\) represents the total groups of data.

**Results & Discussions**

**Measurements of isolated signboards**

Table 3 presents statistical information of measured data. Of the 41 signboards, 28 are projection signboards and 15 are surface signboards. Five self-luminous colours are mainly used in these signboard: red, white, yellow, green and blue. Signboards using different colours for characters and backgrounds are grouped separately.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Place</th>
<th>No.</th>
<th>Mean Luminance (cd/m²)</th>
<th>Luminance range (cd/m²)</th>
<th>Mean CCT (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Character</td>
<td>19</td>
<td>1143.8</td>
<td>195.5-2853.3</td>
<td>10490</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>4</td>
<td>702.7</td>
<td>449.2-826.6</td>
<td>7608</td>
</tr>
<tr>
<td>Red</td>
<td>Character</td>
<td>11</td>
<td>131.2</td>
<td>5.4-341.544</td>
<td>2083</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>7</td>
<td>122.6</td>
<td>8.9-320.3</td>
<td>1513</td>
</tr>
<tr>
<td>Yellow</td>
<td>Character</td>
<td>9</td>
<td>711</td>
<td>139.9-1478.6</td>
<td>3897</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>3</td>
<td>599.2</td>
<td>539.7-641</td>
<td>4124</td>
</tr>
<tr>
<td>Green</td>
<td>Character</td>
<td>4</td>
<td>313.3</td>
<td>47.9-696</td>
<td>6922</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>1</td>
<td>105.3</td>
<td>105</td>
<td>8181</td>
</tr>
<tr>
<td>Blue</td>
<td>Background</td>
<td>1</td>
<td>354.9</td>
<td>355</td>
<td>10000</td>
</tr>
</tbody>
</table>

**Simulation results of isolated signboards**

Table 4 lists the RMSE\(_{rel}\) of simulated luminance values against measured ones, as well as the RMSE\(_{rel}\) grouped by signboard types. Of the 59 groups of data (including luminance values of both characters and backgrounds), the three-channel simulation method results in a RMSE\(_{rel}\) of 3.8%, and the nine-channel simulation method results in a RMSE\(_{rel}\) of 4.3%. Although the three-channel method presents slightly lower RMSE\(_{rel}\), a difference of 0.5% is small. Therefore, both three-channel method and nine-channel method are able to simulate self-luminous signboards accurately enough to represent the conditions in the real world. Additionally, the RMSE\(_{rel}\) of projection signboards and surface signboards are separately calculated (Table 4). Given the variation of RMSE\(_{rel}\) between 3.4% and 4.4%, both simulation methods simulate comparable results, regardless of signboard types.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Place</th>
<th>RMSE(_{rel})</th>
<th>Signboard types</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td></td>
<td>3.8%</td>
<td>Projection</td>
</tr>
<tr>
<td>Red</td>
<td></td>
<td>4.4%</td>
<td>Surface</td>
</tr>
</tbody>
</table>

**Circadian results of Isolated Signboards**

Given the accuracy of nine-channel method in terms of simulating photopic luminance, the circadian luminance values are reliable for exploration. Figure 8 presents both photopic and circadian luminance distributions for six representative signboards varying in type and colour. To keep the simulation results consistently, only the results using the nine-channel method are shown here. The left column presents the visual appearance of the signboards, which vary in colours of both characters and backgrounds. Black boards in the left column indicate that the backgrounds are opaque boards. The middle and right columns present photopic luminance and circadian luminance, respectively.

The legend for each signboard’s photopic and circadian luminance values is the same, which provides straightforward comparison between these two units from the perspective of different colours. Concerning white and blue colours, due to the large portions of blue spectrum power, circadian luminance values are greater than photopic luminance values. For example, white “干洗” presents a photopic luminance of 2123.5 cd/m² and a circadian luminance of 2634.7 cd/m². White and blue signboards have greater impact upon circadian rhythm than visual aspect. Concerning red and yellow colours, the
smaller portions of blue spectrum power result in lower circadian luminance values than photopic luminance values. For example, yellow “绝味鸭脖” presents a photopic luminance of 233.8 cd/m² and a circadian luminance of 94.7 cd/m². Finally, green colour presents slightly greater circadian luminance than photopic luminance. The green background of “小刘薄利水果超市” presents a photopic and circadian luminance of 112.5 cd/m² and 117.8 cd/m², respectively.

Furthermore, Table 5 lists the descriptive data of 59 groups of data in terms of both photopic and circadian luminance distributions. The grouped data basically follow the same patterns as the representative signboards shown by Figure 7. Moreover, both red and yellow present great decreases of luminance values converting from the photopic to circadian. For example, the mean of red characters decreases from 118.4 cd/m² to 70.4 cd/m² while converting from the photopic luminance to circadian luminance, and the mean decreases from 711.3 cd/m² to 300 cd/m² for the yellow characters. When all five colours achieve similar photopic luminance, the order of their circadian luminance from low to high is: red, yellow, green, white, and blue. In other words, red and yellow are more appropriate for signboard design for controlling the impact of signboards upon residents’ circadian rhythm.

Measure and simulation results of Hongmiao Street

Of the nine scenes taken on Hongmiao Street, the measured vertical illuminance varied between 23.6 lx and 94.1 lx. Meanwhile, the vertical circadian illuminance varied between 21.4 lx and 101.8 lx. Figure 9 shows three scenes of HDR images taken onsite, along with the falsecolour images of both photopic and circadian luminance distributions. Since great photopic and circadian luminance values mainly originate from small signboards, it is difficult to observe subtle differences between photopic and circadian luminance of one HDR image. However, different vertical illuminance values demonstrate the change. For example, the extremely bright signboard of “港师傅菠萝包” for Scene 5 is white with a great portion of blue spectrum, which results in a greater circadian illuminance (101.8 lx) than photopic illuminance (91.3 lx). On the other hand, Scenes 4 and 6 are predominated by red and yellow signboards, which result in lower circadian illuminance than photopic illuminance.

Finally, Figure 10 shows measured and simulated luminance distributions from both photopic and circadian aspects. Given the complex lighting sources of each scene, only signboards were simulated herein. Moreover, a few apartments above had interior lights on but are not included in the simulation. Given the variations and complexities of scene-based lighting distributions, it is more convenient and reliable to use measure rather than simulation method. However, when concerning exploration of individual signboards, detailed simulation method, as proposed in this study, can provide better understanding and predictions of lighting sources.

Conclusions

This preliminary study has several limitations. First, we only collected limited amount of signboard data, which results in limitations on colours, photopic luminance ranges and circadian luminance ranges. Given that projection signboards are more frequently used by stores, the amount of surface signboards need to be further increased. Other characteristics specific to projection
signboards or surface signboards still need further exploration. Second, we simplified geometries for simulating signboards require further detailed modeling. Some logos designed in complex shapes or several colours were either simplified or removed. Further detailed geometry models could provide better understanding of signboard designs. Third, current simulation does not consider night sky simulation. Variations of night sky brightness caused by cycles of the Moon phases might influence signboard measurements and simulation results (Jensen et al., 2001; Linares et al., 2020). Following studies should include night sky brightness for both measurement and simulation. Forth, at present, these signboards are separately simulated and analyzed. However, citizens experience streets as an integral whole. Combining stores’ signboards and using streets as a research unit can better reflect citizen’s lighting experience.

To sum up, this study validates the accuracy of using either three-channel or nine-channel simulation methods to simulate self-luminous lightbox signboards. Two ways of creating glow materials, one using inputs of RGB and the other using inputs of spectrum power density, provide equally accurate results. Moreover, even within residential areas (E3) in Nanjing, over 70% of the measured signboards are greater than the maximum luminance threshold requested by the national code. The proposed simulation method might be applied to designs of signboards. Considering signboards’ effects upon both visual and non-visual aspects, the colour selection from good to bad follows: yellow, red, green, white, and blue. Further studies will include both lighting quantities and subjective evaluations for proposing suitable luminance thresholds and lighting spectrum compositions for signboard designs.

Table 5: Statistical information of simulated photopic and circadian luminance values grouped by colours

<table>
<thead>
<tr>
<th>Colour</th>
<th>Place</th>
<th>No.</th>
<th>Mean photopic luminance (cd/m²)</th>
<th>Photopic luminance range (cd/m²)</th>
<th>Mean circadian luminance (cd/m²)</th>
<th>Circadian luminance range (cd/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Character</td>
<td>19</td>
<td>1161</td>
<td>198.8-2922</td>
<td>1233.3</td>
<td>204.9-3210.8</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>4</td>
<td>734.2</td>
<td>460.3-864.3</td>
<td>615</td>
<td>362.4-804.1</td>
</tr>
<tr>
<td>Red</td>
<td>Character</td>
<td>11</td>
<td>118.4</td>
<td>4.7-336.6</td>
<td>70.4</td>
<td>0.7-297.2</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>7</td>
<td>111.3</td>
<td>7.1-311.3</td>
<td>42.5</td>
<td>0.1-125.5</td>
</tr>
<tr>
<td>Yellow</td>
<td>Character</td>
<td>9</td>
<td>711.3</td>
<td>140.4-1486.4</td>
<td>300</td>
<td>32.1-1038.3</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>3</td>
<td>608</td>
<td>548-649.2</td>
<td>286.4</td>
<td>266.4-318.1</td>
</tr>
<tr>
<td>Green</td>
<td>Character</td>
<td>4</td>
<td>354.8</td>
<td>47.9-696.1</td>
<td>238.5</td>
<td>57.9-365</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>1</td>
<td>112.5</td>
<td>112.5</td>
<td>117.8</td>
<td>117.8</td>
</tr>
<tr>
<td>Blue</td>
<td>Background</td>
<td>1</td>
<td>350.9</td>
<td>350.9</td>
<td>571.6</td>
<td>571.6</td>
</tr>
</tbody>
</table>

Figure 10: Visual appearance and falsecolour images for both photopic and circadian luminance distributions of HDR images and simulated data for Hongmiao Street

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