A Sensitivity Analysis On Glare Detection Parameters

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BACKGROUND

MOTIVATION

METHODOLOGY

FINDINGS

GLARE

Glare is defined as: “the sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort or loss in visual performance and visibility”

DIFFERENT TYPES OF GLARE

DISABILITY GLARE  VEILING GLARE

DISCOMFORT GLARE

\[ G \approx \frac{L_s^{\exp 1} \times \omega_s^{\exp 2}}{L_a^{\exp 3} \times P^{\exp 4}} \]

A wide angle High Dynamic Range Image

| Sarey Khanie, M.

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05/02/15
A brighter and larger glare source in a highly contrasted room, depending on its angular location with respect to the view direction, induces a certain risk of glare.
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DISCOMFORT GLARE

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GLARE INDICES

CIE Glare Index

\[ CGI = 8 \log_{10} \left[ 1 + \left( \frac{E}{L_0} \right) \sum_{i=1}^{n} \frac{L_i^2 \omega_i}{P_i} \right] \]

Unified Glare Rating

\[ UGR = 8 \log_{10} \left( \frac{0.25 + \sum_{i=1}^{n} L_i^2 \omega_i}{P_i} \right) \]

Visual Comfort Probability

\[ VCP = 279 - 110 \log_{10} \left[ \sum_{i=1}^{n} \left( \frac{0.5L_i(0.04\omega_i + 1.52\omega_i)^2 - 0.075)}{P_i E_i} \right) \right]^{1/3} \]

Daylight Glare Index

\[ DGI = 10 \log_{10} 0.48 \sum_{i=1}^{n} \frac{L_i^1.6 \omega_i^{0.8}}{P_i L_0} \]

Daylight Glare Probability

\[ DGP = 5.87 \times E_0 + 9.18 \times 10^{-2} \times \log \left( 1 + \sum_{i=1}^{n} \frac{L_i^2 \omega_i}{P_i^2} \right) + 0.16 \]
GLARE ANALYSIS & PREDICTION PARAMETERS

1. Input: HDR Image or Radiance picture (fish eye view)
2. Detect glare sources based on Threshold & Search Radius: Location, size and brightness

HL = 29657
L = 1.0484
GLARE ANALYSIS & PREDICTION PARAMETERS

1. Input: HDR Image or Radiance picture (fish eye view)
2. Detect glare sources based on Threshold & Search Radius : Location, size and brightness
3. Compute the rest of the components for each glare index
4. Output: Calculates glare indices (CGI, DGI, DGP, UGR, VCP)

| M. Sarey Khanie

\[
\begin{align*}
R_l\, & L = 29657 \\
\omega & 1.0484
\end{align*}
\]

\[
\begin{align*}
E_j & 3269.79 \text{ lux} \\
L & 1146.57 \text{ lux}\text{m}^2 \\
L & 212 \text{ lux}\text{m}^2
\end{align*}
\]
GLARE ANALYSIS & PREDICTION PARAMETERS

Threshold: In the detection algorithm, the glare pixels are determined such that the luminance value of this pixel is $x$-times greater compared to the average luminance of a reference area. With different threshold $x$, the glare pixels are treated differently.

Radius: After the glare pixel detection, the glare sources are merged into larger area, the search distance between each glare pixel (search radius) defines the sizes of glare sources.

Is there an effect of threshold and radius on glare analysis?

How big is this effect?

Are there combinations of threshold and radius that work better for a specific lighting scenario?
METHODOLOGY & EXPERIMENTAL SET UP

1. Recording Photometric Parameters
2. User ratings
   128 subjects were tested
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2. User ratings
128 subjects were tested
METHODOLOGY & EXPERIMENTAL SET UP

Experiments Based on a Real Office Set-ups

DIFFERENT THRESHOLD AND RADIUS PARAMETERS

<table>
<thead>
<tr>
<th>Threshold/Radius</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>10</th>
<th>15</th>
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</thead>
<tbody>
<tr>
<td>Reference area</td>
<td></td>
<td></td>
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<tr>
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<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
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<tr>
<td>0.08</td>
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<td><img src="image15.png" alt="Image" /></td>
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METHODOLOGY

Experiments Based on a Real Office Set-ups
METHODOLOGY & EXPERIMENTAL SET UP

LC1, Artificial lighting
LC2, Overcast sky
LC3, Clear sky, no direct sun inside
LC4, Clear sky, direct sun inside
LC5, Clear sky, direct sun inside
LC6, Clear sky, sun in FOV

METHODOLOGY & EXPERIMENTAL SET UP

[Charts showing data on illuminance and average luminance across different lighting conditions]
BACKGROUND  
MOTIVATION  
METHODOLOGY  
FINDINGS

LIGHTING CONDITION 1 – NORMALIZED INDICES DISTRIBUTION
artificial lighting

<table>
<thead>
<tr>
<th>CGI</th>
<th>UGR</th>
<th>VCP</th>
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<tbody>
<tr>
<td>DGP</td>
<td>DGI</td>
<td></td>
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</tbody>
</table>

Normalized CGI
Normalized UGR
Normalized VCP
Normalized DGP
Normalized DGI
LIGHTING CONDITION 2 – NORMALIZED INDICES DISTRIBUTION
overcast sky

LIGHTING CONDITION 3 – NORMALIZED INDICES DISTRIBUTION
clear sky, No direct sun
CONCLUSION

• There is and effect of threshold for most glare indices
• This effect is minimum for DGP
• There is an effect of search radius for most glare indices
• This effect is none for DGP and minimum for UGR
• These effects are higher for lower luminance levels
• Is there an effect of threshold and radius on glare analysis?
• How big is this effect?
• Are there certain combinations of threshold and radius that work better for a specific lighting scenario?

GLARE ANALYSIS & PREDICTION PARAMETERS

PREDICTION PERFORMANCE (MBE) $M_{BE} = \frac{1}{n} \sum_{i=1}^{n} \frac{x_{p} - UR}{UR}$

<table>
<thead>
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<th>LC3</th>
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<table>
<thead>
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<th>LC4</th>
<th>LC5</th>
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CONCLUSION

For lighting condition 1 to 5

- The highest threshold and smaller search radius combination works best for most glare indices
- DGI is better predicted for Threshold 5 and search radius 0.2
- DGP predictions are the most robust for all daylit conditions

SENSITIVITY ANALYSIS OF THRESHOLD AND RADIUS FOR GLARE INDICES

- Threshold and Search radius are sensitive parameters for glare evaluations using Radiance based tools such as Evalglare
- By Comparing the prediction parameters with user ratings (true values), we can have better insight in how to use the tool to make more accurate prediction of a given scenario.
- To make a conclusion on how to best use this parameters more lighting scenarios and façade systems should be analyzed
Thank You!