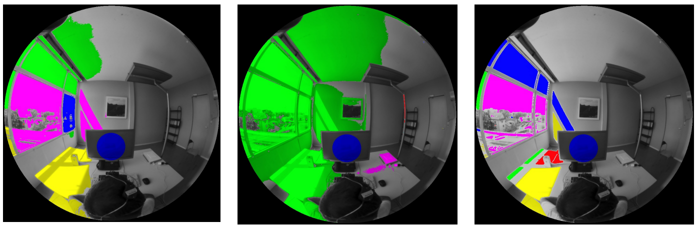
A Sensitivity Analysis On Glare Detection Parameters



Mandana Sarey Khanie[1], Yiyuan Jia[12], Jan Wienold[1], Marilyne Andersen[1]

[1]Interdisciplinary Laboratory of Performance-Integrated Design [LIPID]
School of Architecture, Civil and Environmental Engineering, EPFL, Switzerland
[2]High Performance Building Lab
College of Architecture, Georgia Institute of Technology, USA

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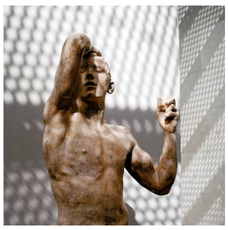
GLARE

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''

"Lighting Handbook of the Illuminating Engineering Society of North America" (IESNA, 2000) (p. G -15)



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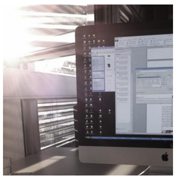
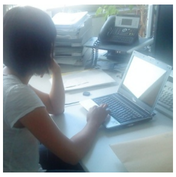
DIFFERENT TYPES OF GLARE

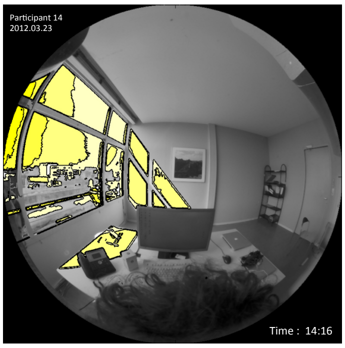
DISABILITY GLARE



VEILING GLARE

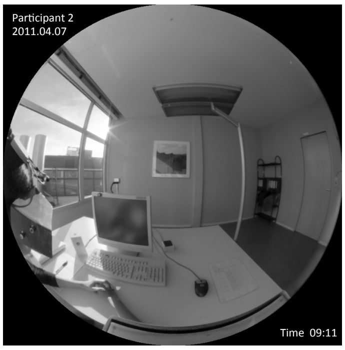


DISCOMFORT GLARE



DISCOMFORT GLARE

$$G \approx \frac{L_s^{exp1} \times \omega_s^{exp2}}{L_a^{exp3} \times P^{exp4}}$$

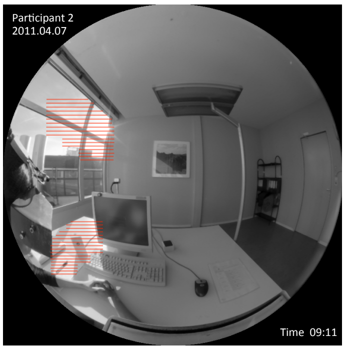


A wide angle High Dynamic Range Image

DISCOMFORT GLARE

$$G \approx \frac{L_s^{exp1} \times \omega_s^{exp2}}{L_a^{exp3} \times P^{exp4}}$$

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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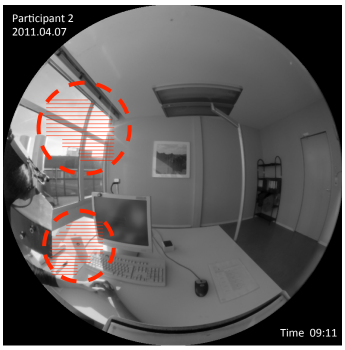

A wide angle High Dynamic Range Image

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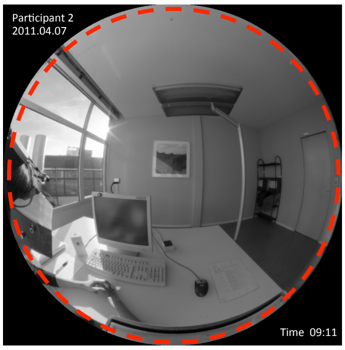

A wide angle High Dynamic Range Image

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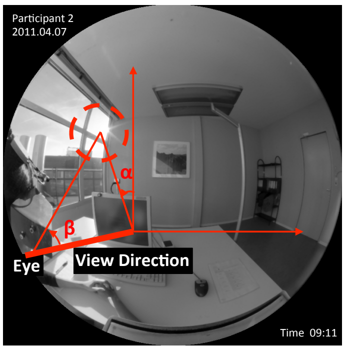

A wide angle High Dynamic Range Image

Lukiesh, Guth 1949
Iwata, et al. 1991
Kim, et al. 2009

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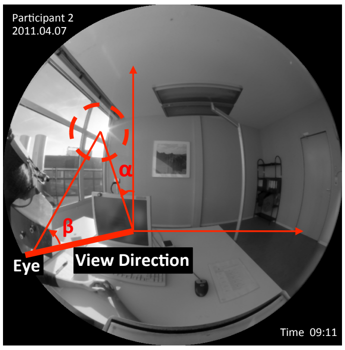

A wide angle High Dynamic Range Image

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GLARE INDICES

CIE Glare Index

$$CGI = 8\log_{10} 2\frac{\left[1 + \frac{E_d}{500}\right]}{E_d + E_i}\sum_{i=1}^{n}\frac{L_s^2\omega_s}{P_i^2}$$

Unified Glare Rating

$$UGR = 8\log_{10}\frac{0.25}{L_b}\sum_{i=1}^{n}\frac{L_s^2\omega_s}{P_i^2}$$

Visual Comfort Probability

$$VCP = 279 - 110\left[log_{10}\left[\sum_{i=1}^{n}\left(\frac{0.5L_s(20.4\omega_s + 1.52\omega_s^{0.2} - 0.075)}{P_i E_{avg}^{0.44}}\right)\right]^{n^{-0.0914}}\right]$$

Daylight Glare Index

$$DGI = 10\ \log_{10} 0.48\sum_{i=1}^{n}\frac{L_s^{1.6}\Omega_s^{0.8}}{L_b + 0.07\omega_s^{0.5}P_i}$$

Daylight Glare Probability

$$DGP = 5.87\times E_v + 9.18\times 10^{-2}\times log\left(1 + \sum_i \frac{L_{s,i}^2\times\omega_{s,i}}{E_v^{1.87}\times P_{i,i}^2}\right) + 0.16$$

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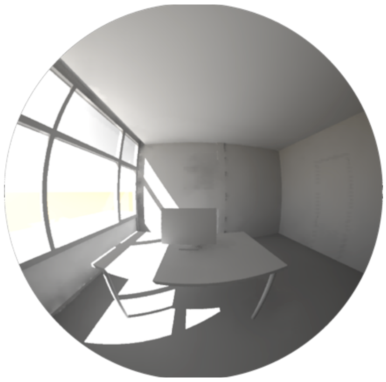
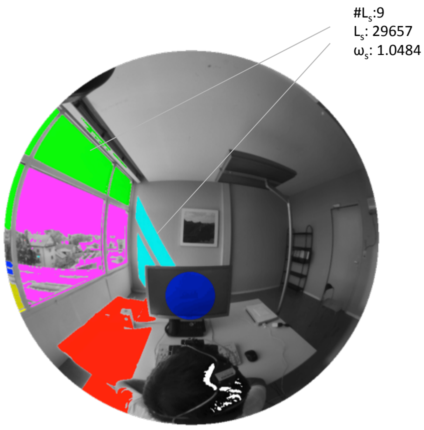
GLARE ANALYSIS & PREDICTION PARAMETERS

1. Input: HDR Image or Radiance picture (fish eye view)

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

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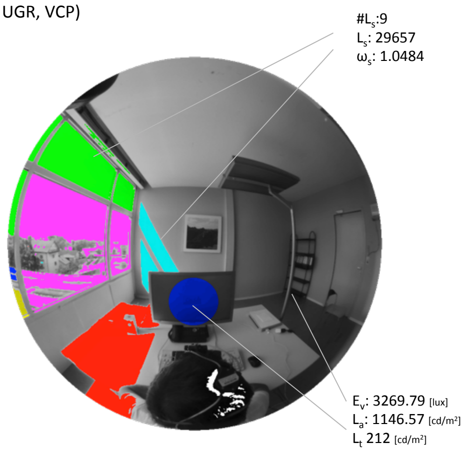
GLARE ANALYSIS & PREDICTION PARAMETERS

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)

GLARE ANALYSIS & PREDICTION PARAMETERS

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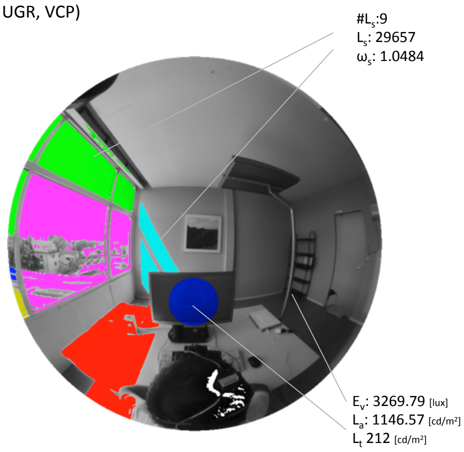

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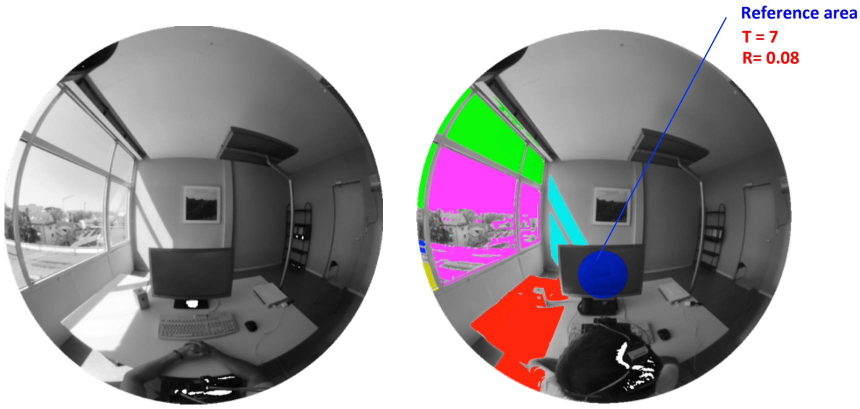
GLARE ANALYSIS & PREDICTION PARAMETERS

Threshold: In the detection algorithm, the glare pixels are determined such that the luminance value of this pixel is x-times greater compare 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

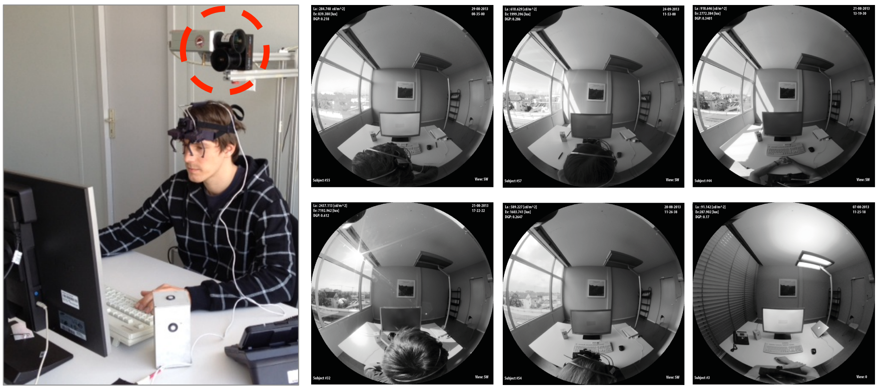


GLARE ANALYSIS & PREDICTION PARAMETERS

- 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

METHODOLOGY & EXPERIMENTAL SET UP



1. Recording Photometric Parameters
2. User ratings

128 subjects were tested

METHODOLOGY & EXPERIMENTAL SET UP

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METHODOLOGY & EXPERIMENTAL SET UP

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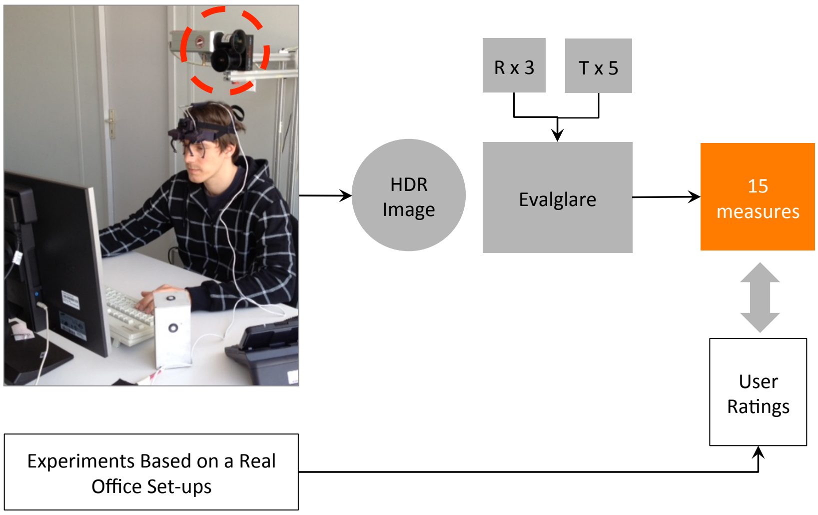
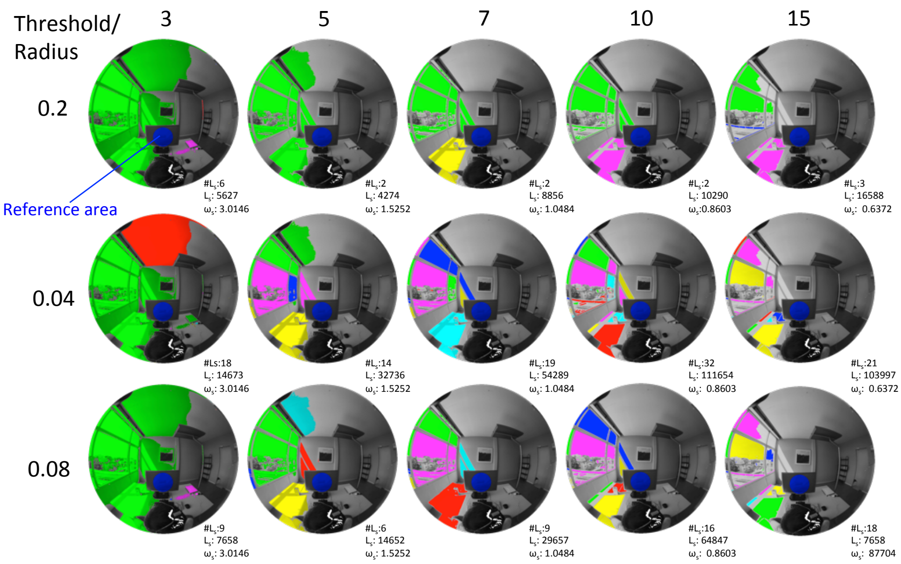
METHODOLOGY & EXPERIMENTAL SET UP

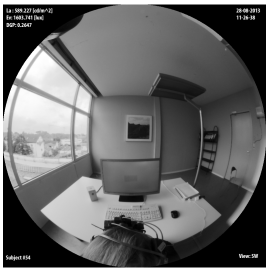


DIFFERENT THRESHOLD AND RADIUS PARAMETERS



METHODOLOGY & EXPERIMENTAL SET UP

LC1, Artificial lighting



LC2, Overcast sky

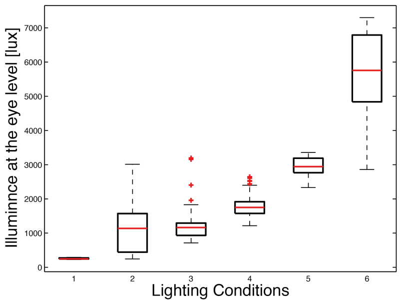
LC3, Clear sky, no direct sun inside

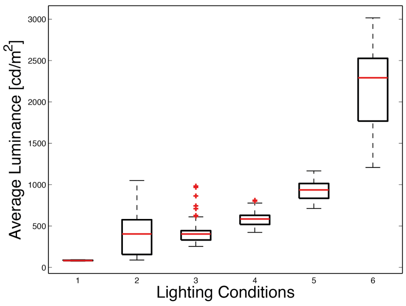
LC4, Clear sky, direct sun inside

LC5, Clear sky, direct sun inside

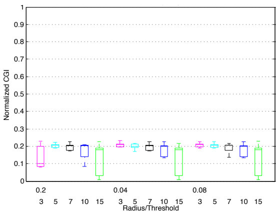
LC4, Clear sky, sun in FOV

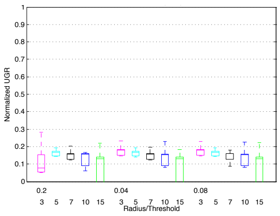
METHODOLOGY & EXPERIMENTAL SET UP

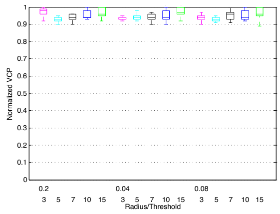


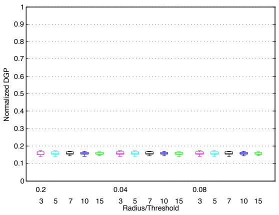


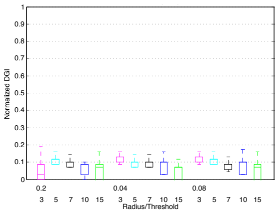
LIGHTING CONDITION 1 – NORMALIZED INDICES DISTRIBUTION
artificial lighting

CGI


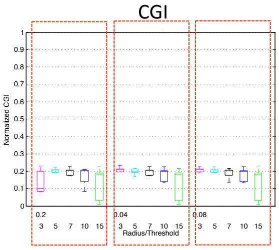
UGR


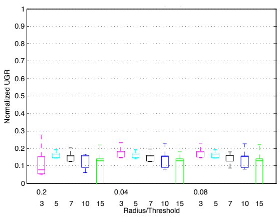
VCP


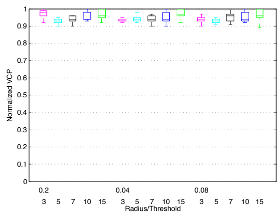
DGP


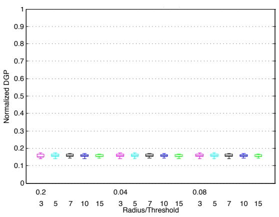
DGI


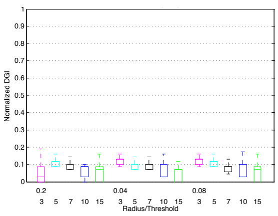
LIGHTING CONDITION 1 – NORMALIZED INDICES DISTRIBUTION
artificial lighting

CGI


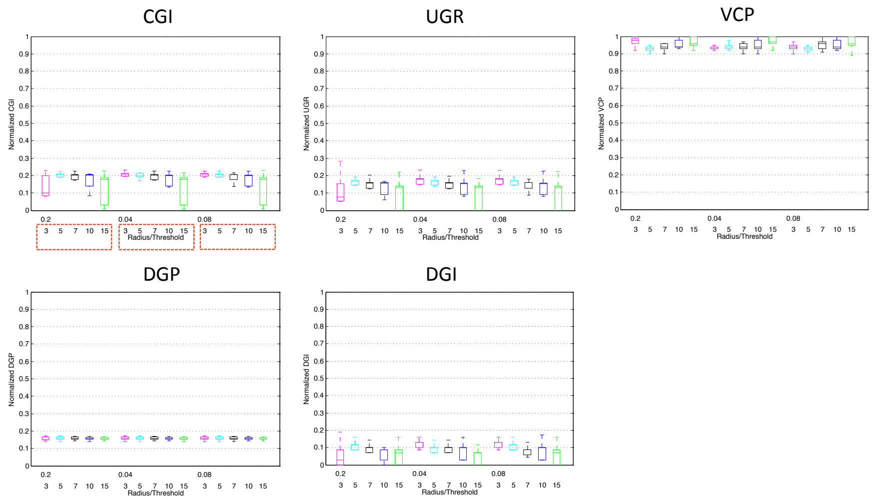
UGR


VCP


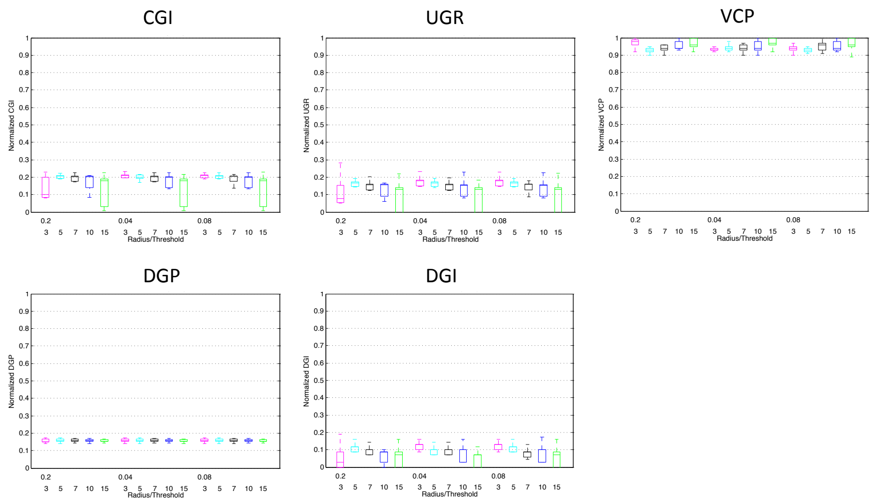
DGP


DGI


LIGHTING CONDITION 1 – NORMALIZED INDICES DISTRIBUTION
artificial lighting



LIGHTING CONDITION 1 – NORMALIZED INDICES DISTRIBUTION
artificial lighting



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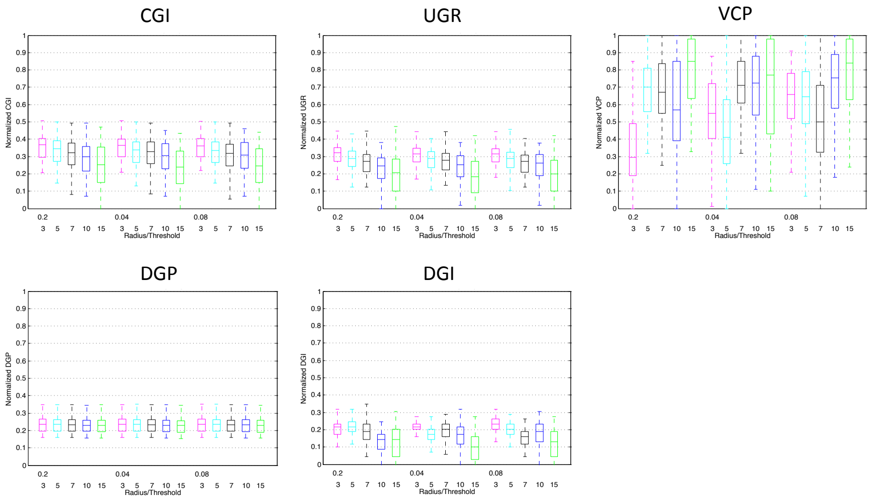
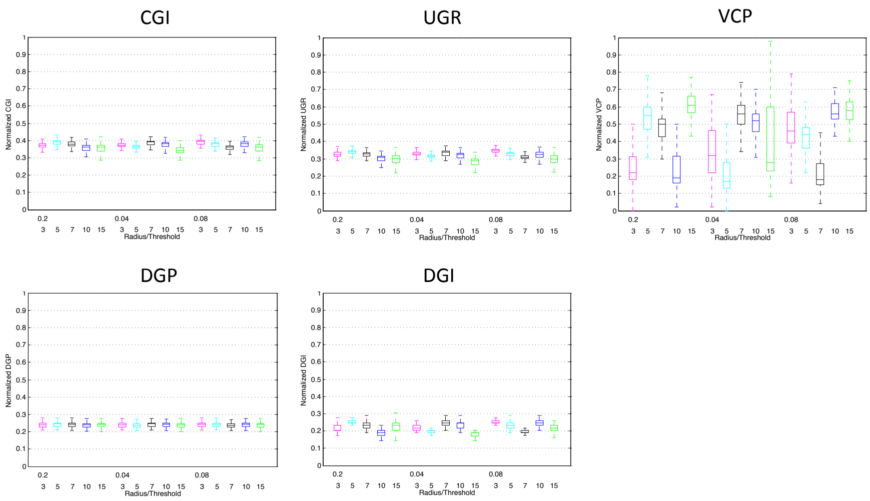
LIGHTING CONDITION 2 – NORMALIZED INDICES DISTRIBUTION

overcast sky



LIGHTING CONDITION 3 – NORMALIZED INDICES DISTRIBUTION

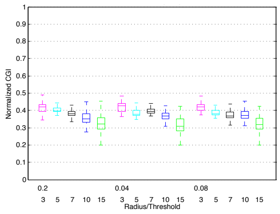
clear sky, No direct sun



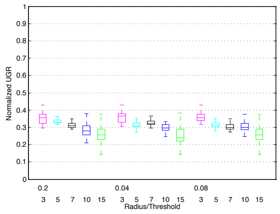
LIGHTING CONDITION 4 – NORMALIZED INDICES DISTRIBUTION

clear sky, direct sun inside

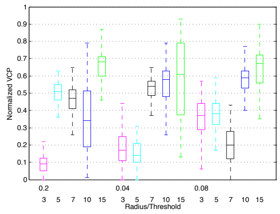
CGI



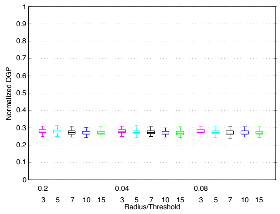
UGR



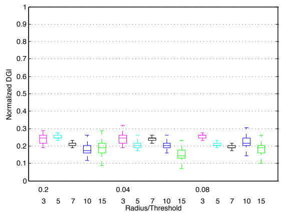
VCP



DGP



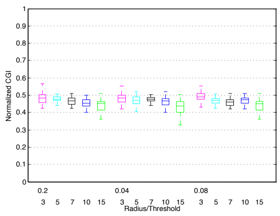
DGI



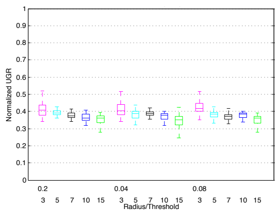
LIGHTING CONDITION 5 – NORMALIZED INDICES DISTRIBUTION

clear sky, direct sun inside

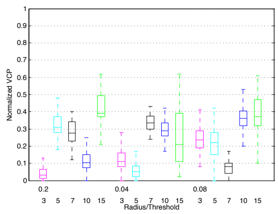
CGI



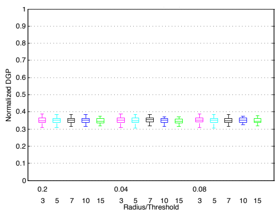
UGR



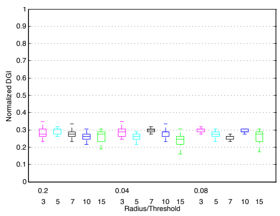
VCP



DGP



DGI



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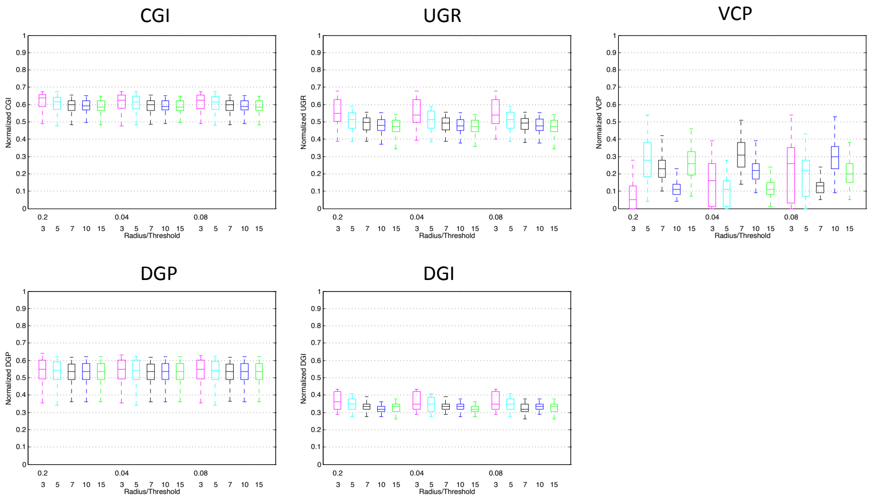
LIGHTING CONDITION 6 – NORMALIZED INDICES DISTRIBUTION

clear sky, sun in FOV



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

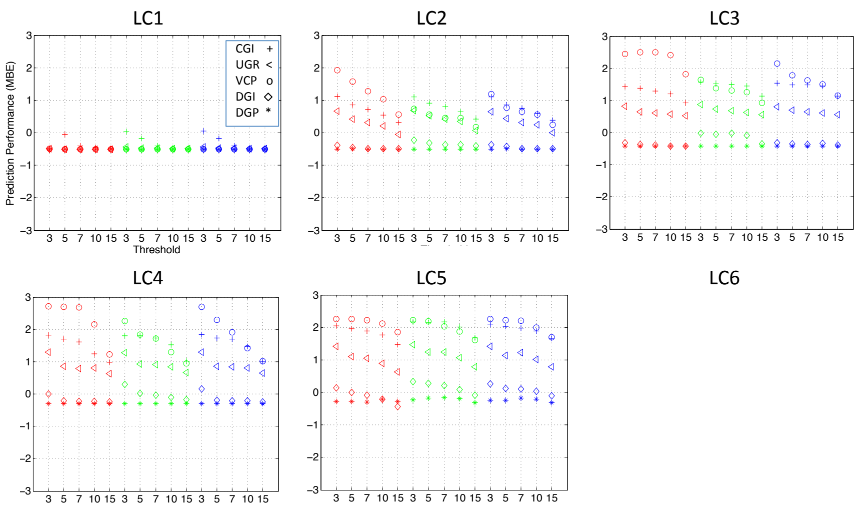
- These effects are higher for lower luminance levels

GLARE ANALYSIS & PREDICTION PARAMETERS

- 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?

PREDICTION PERFORMANCE (MBE)

$$MBE = \frac{1}{n}\sum_{i=1}^{n}\frac{x_p - UR}{UR}$$



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!

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