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Image-obfuscation as a means for privacy-conscious visual data acquisition from building systems

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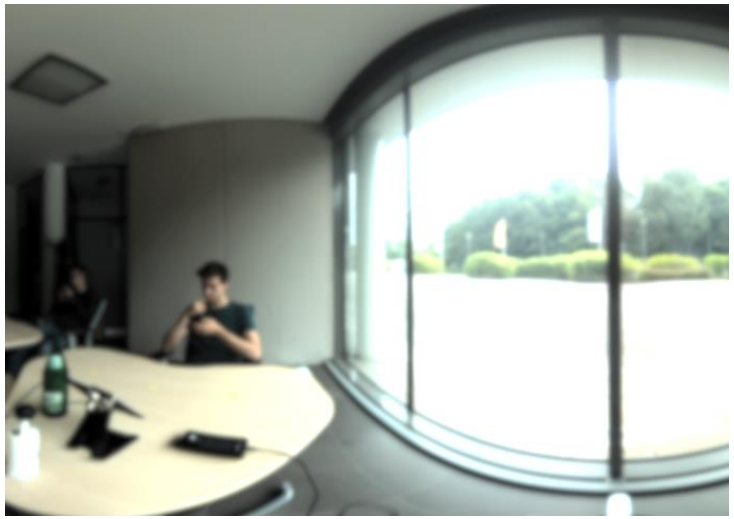
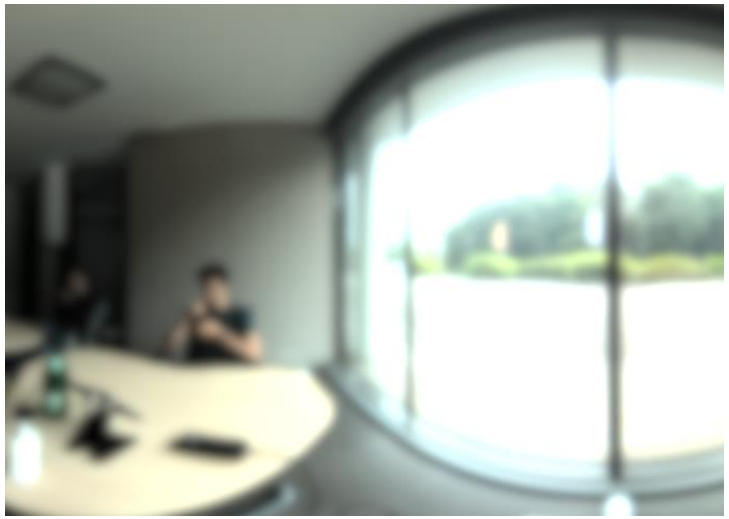
“Image-obfuscation… privacy-conscious…data..acquisition…”

“Image-obfuscation as a means for privacy-conscious visual data acquisition from building systems ”

verb [T] • FORMAL UK /ˈɒb.fʌs.keɪt/ US /ˈɑːb.fə.skeɪt/

obfuscate **to make something less clear and harder to understand, especially intentionally**





Agenda

Background | Motivation | Theory

- Living Laboratory
- Camera-based building data acquisition
- Privacy implications

Pilot Study

- Setup
- Detecting glare with HDR images
- Distortion of images
- Results

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Background: http://www.livinglab-smartofficespace.com/

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Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

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Wärme und thermische Behaglichkeit

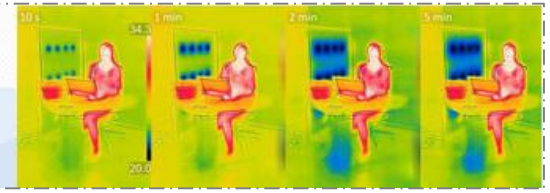
CoMoS - Comfort Monitoring Station

Wärme und thermische Behaglichkeit

Personalized Environment

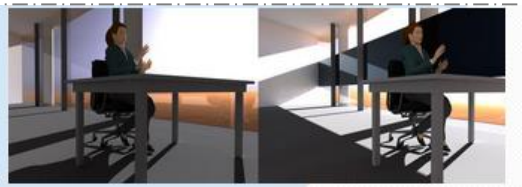
Wärme und thermische Behaglichkeit

Thekla - ThermoElektrische Kühlwand mit Aktiver Speicherung



Licht und visuelle Behaglichkeit

Lichtmanagement mit elektrochromer Verglasung



Overarching goal:

Actuate building control systems in real-time based on visible and thermal radiation

Rationale:

Save energy through better Lighting Control and HVAC control

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Using images to monitor real-time radiation values

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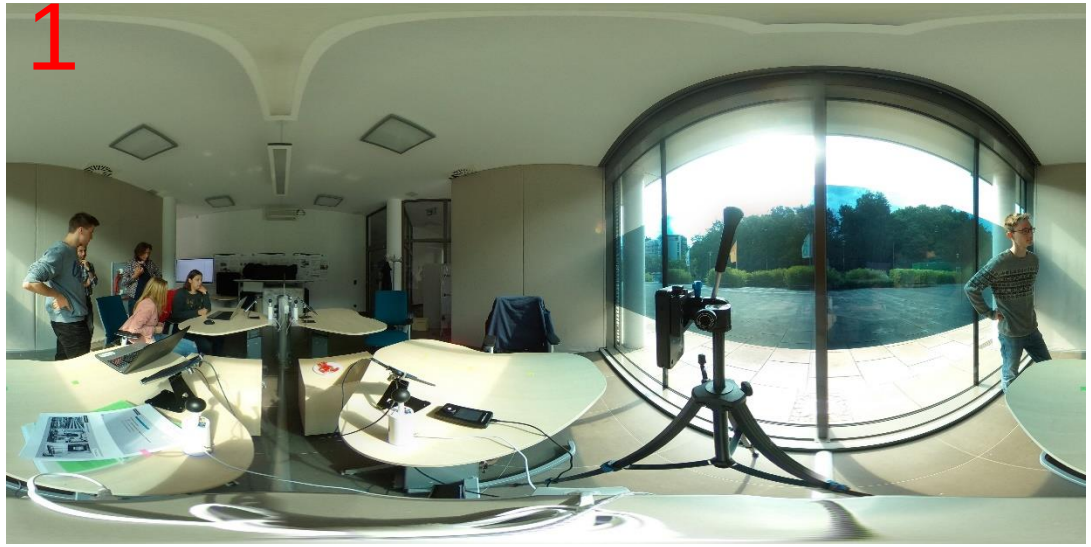

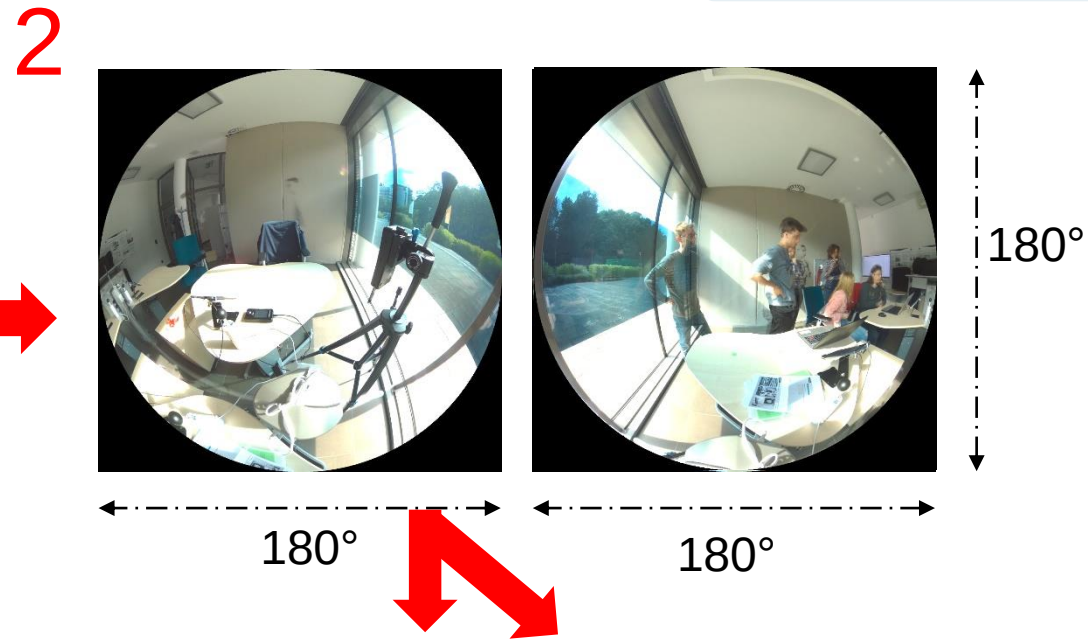

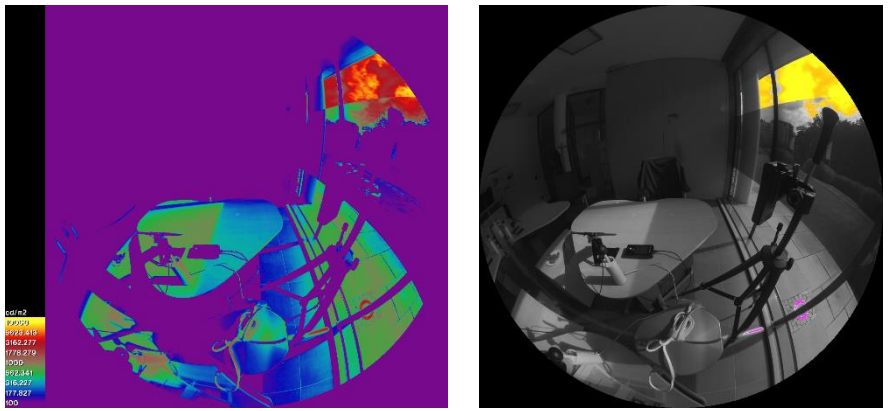

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1 Tone-mapped equirectangular HDR image

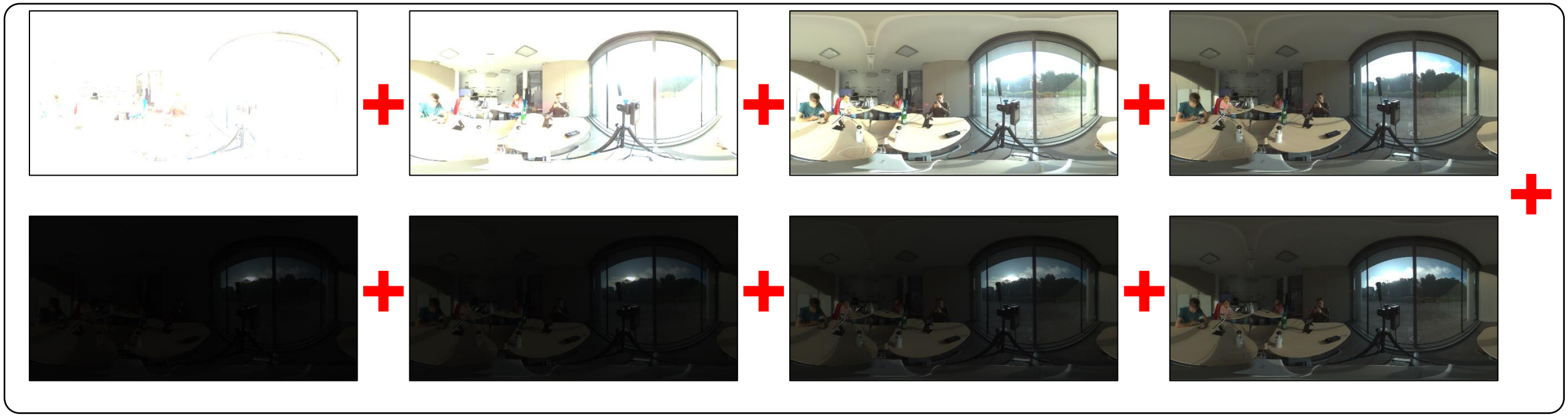
2 Tone-mapped fish-eye HDR images

3 Falsecolor HDR image

4 Glare-analyzed HDR image

High Dynamic Range (HDR) Imaging

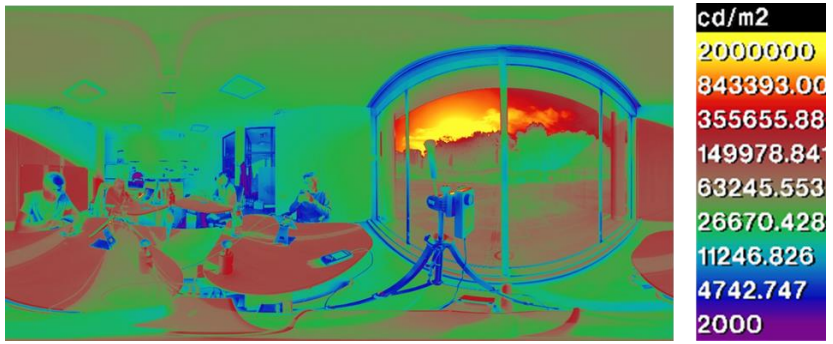
Decreasing exposure (by reducing camera shutter speed)



Decreasing exposure (by reducing camera shutter speed)

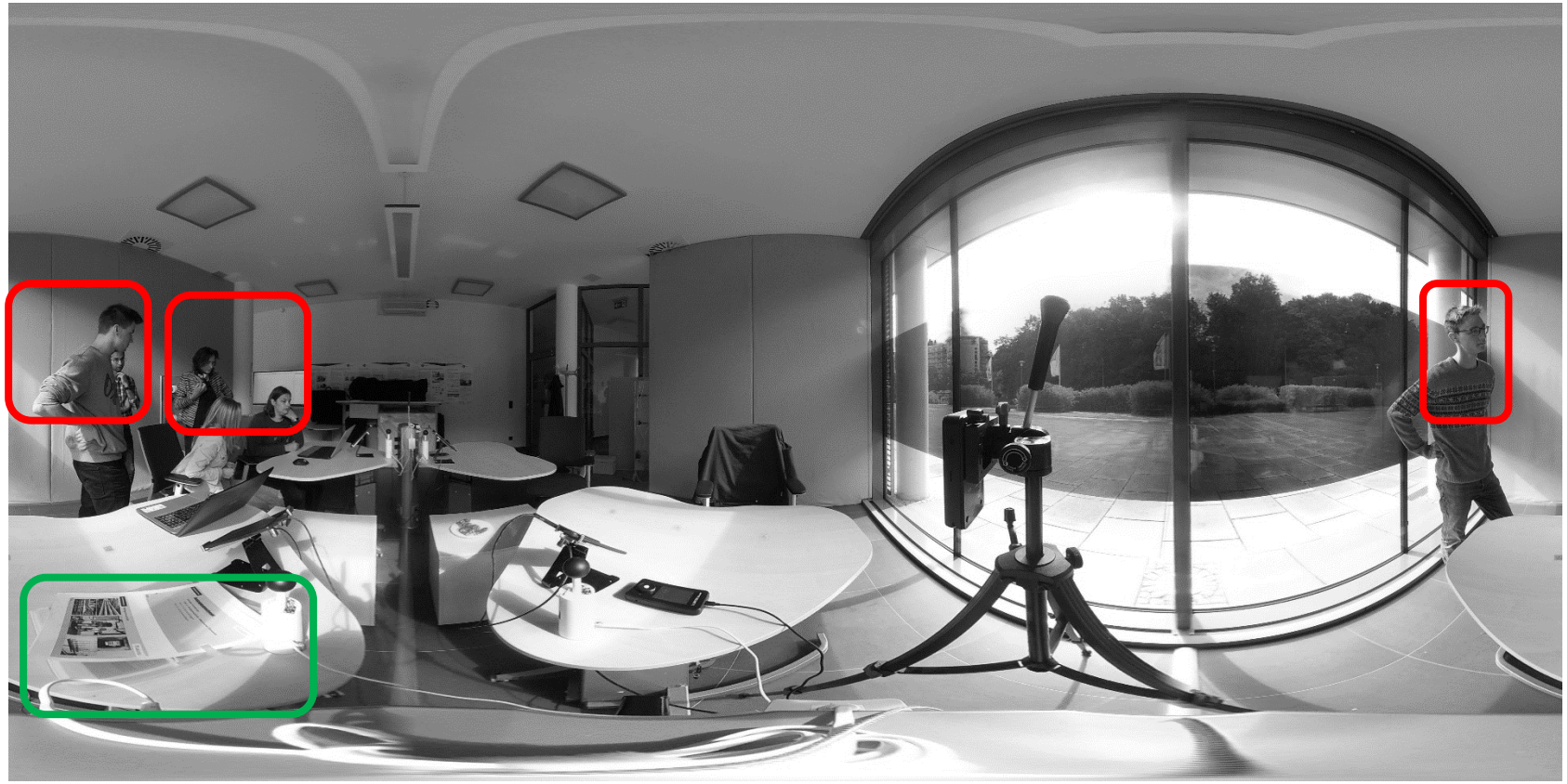
=

Resultant HDR (Tonemapped)



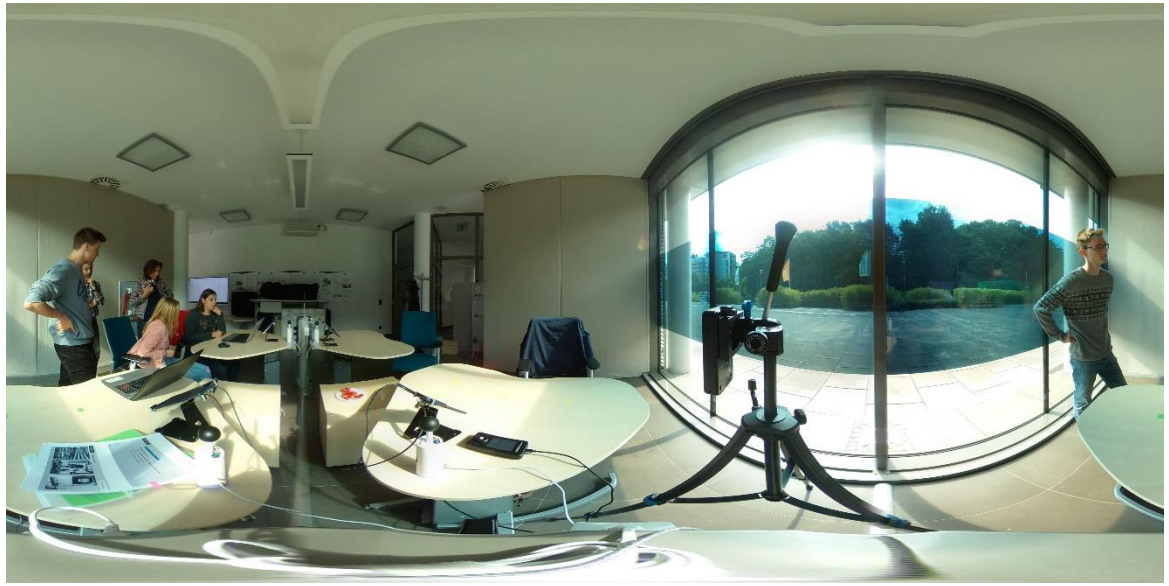
Resultant HDR (in falsecolor)

Privacy considerations in image acquisition



Avoid disclosing identities and documentation

Plausible solution: Image distortion prior to acquisition ?



Normal Image | In focus

Blurred Image | Out-of-focus

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- Obfuscation of images
- Detecting glare with HDR images
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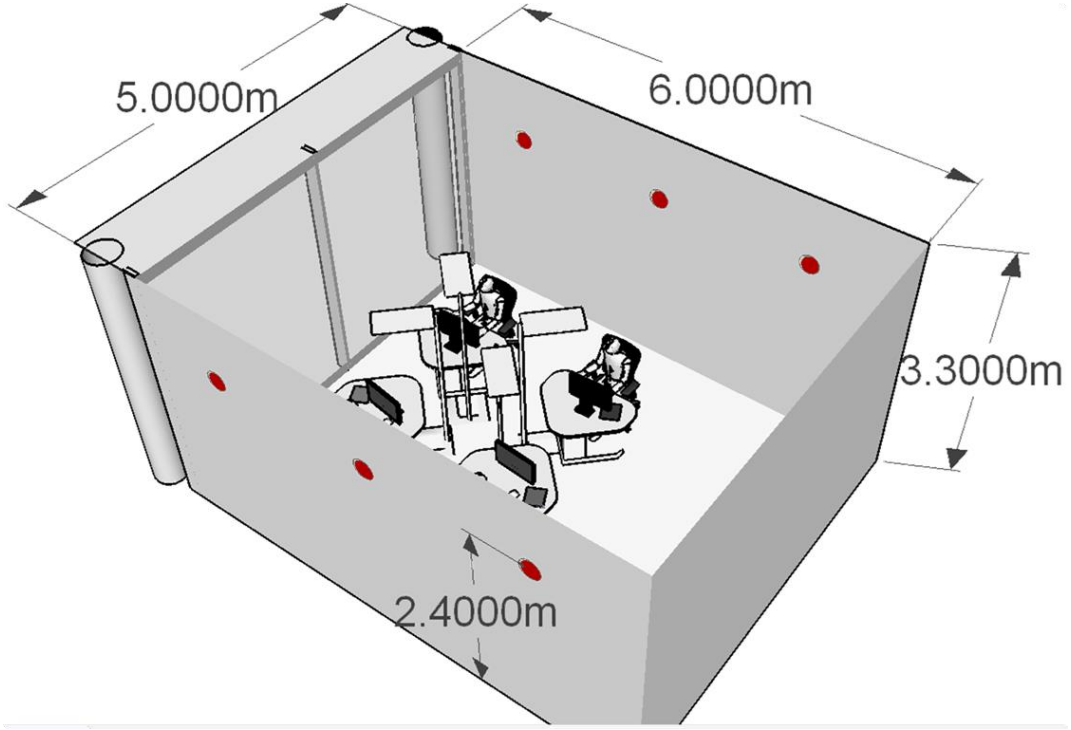
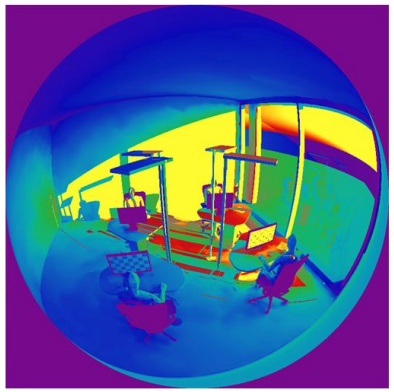
Setup: Simulation study with validated renderer



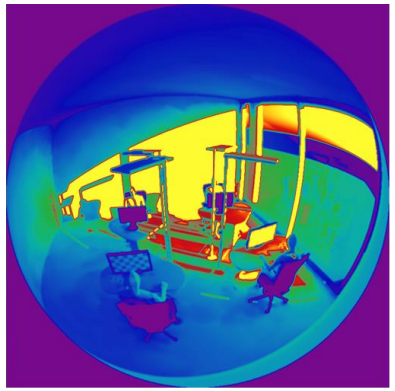
Detail	Quantity	Comment
Total timesteps considered	120	Hourly, from 9AM to 4PM (inclusive), between 1st November to 15th November
Timesteps with direct sun	71	49 hours were overcast
HDR images generated	71 (x 6)	6 camera locations
Total images analyzed	71 (x6x6)	Original + 5 distortion levels

- Model based on actual space, Six camera locations chosen.
- Images generated using RADIANCE.

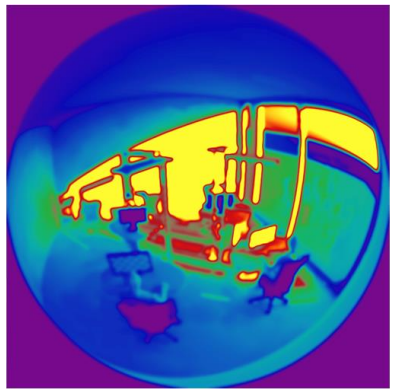
Methodology: Distortion of images



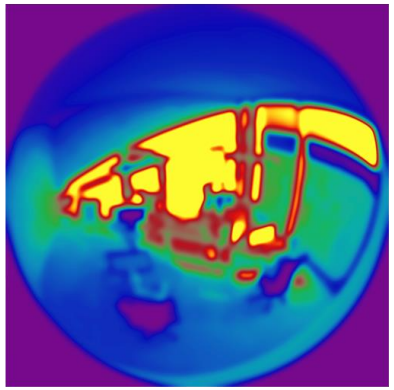
Original HDR image



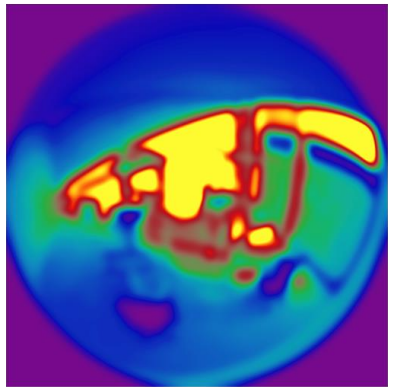
2% distortion



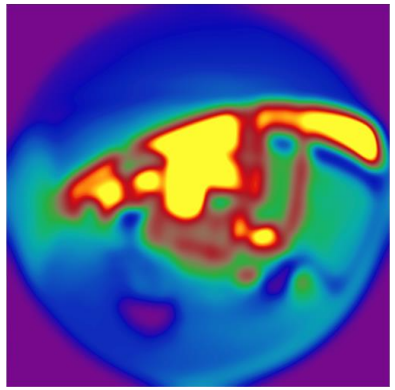
5% distortion



10% distortion



15% distortion



20% distortion

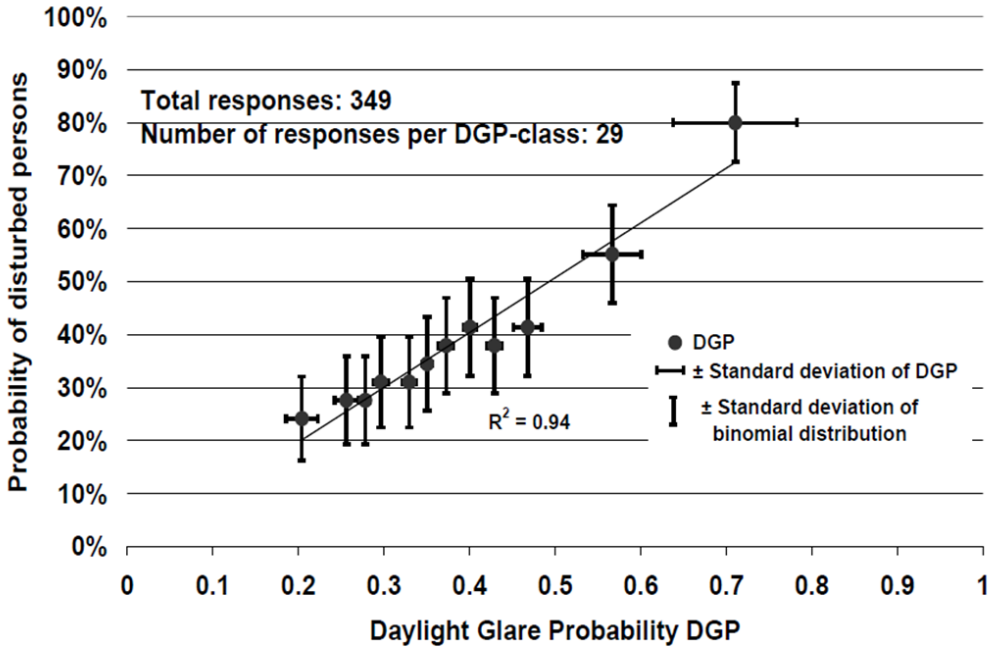
Distortion type used: Gaussian blur

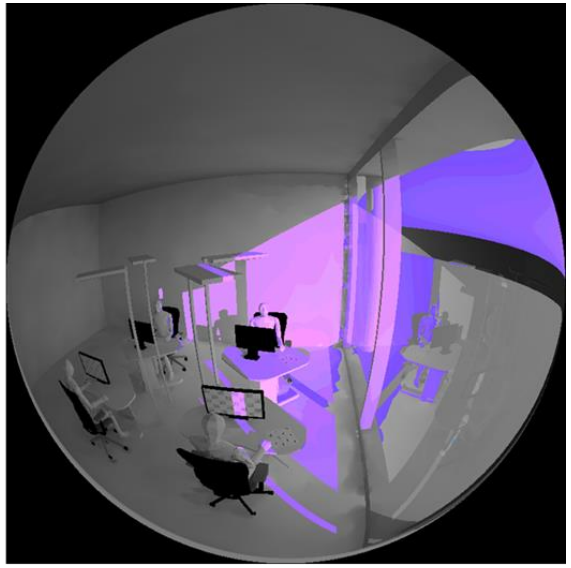
Other Distortion types evaluated: Linear, Bicubic and Lanczos

Distortion percent based on relative pixel radius.

Methodology: Quantifying glare with DGP

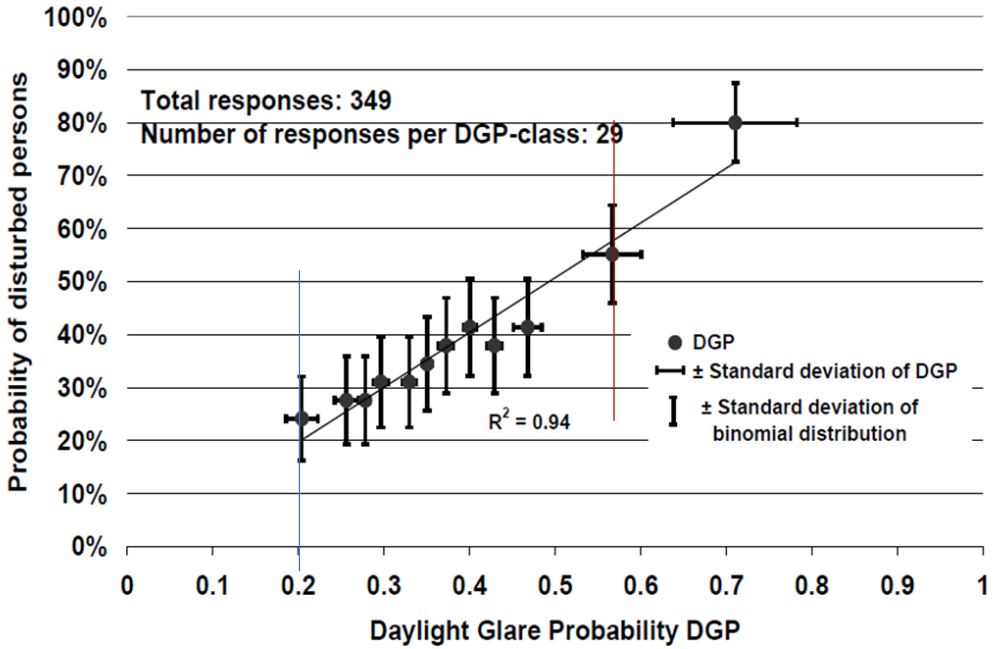
(Weinold 2005,2009,2013,2018)

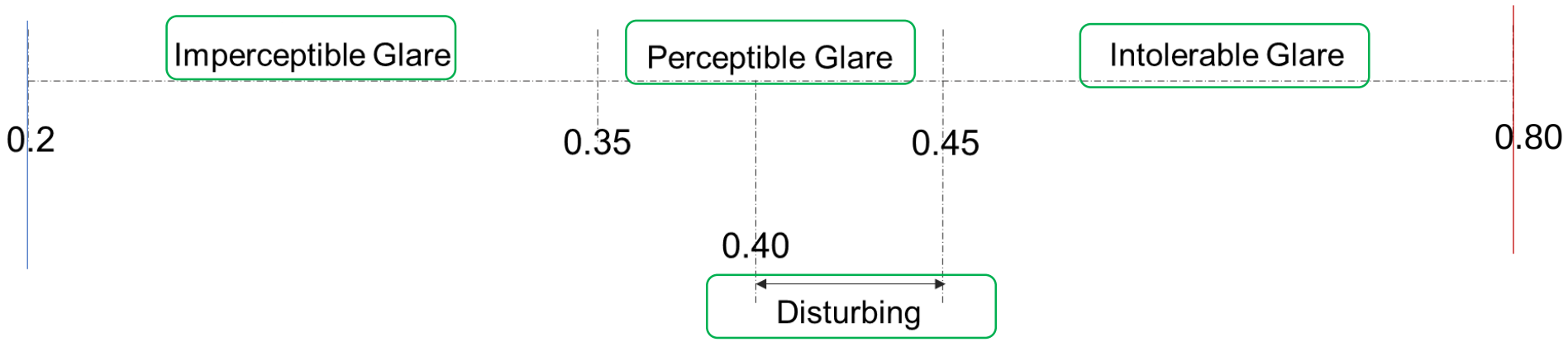




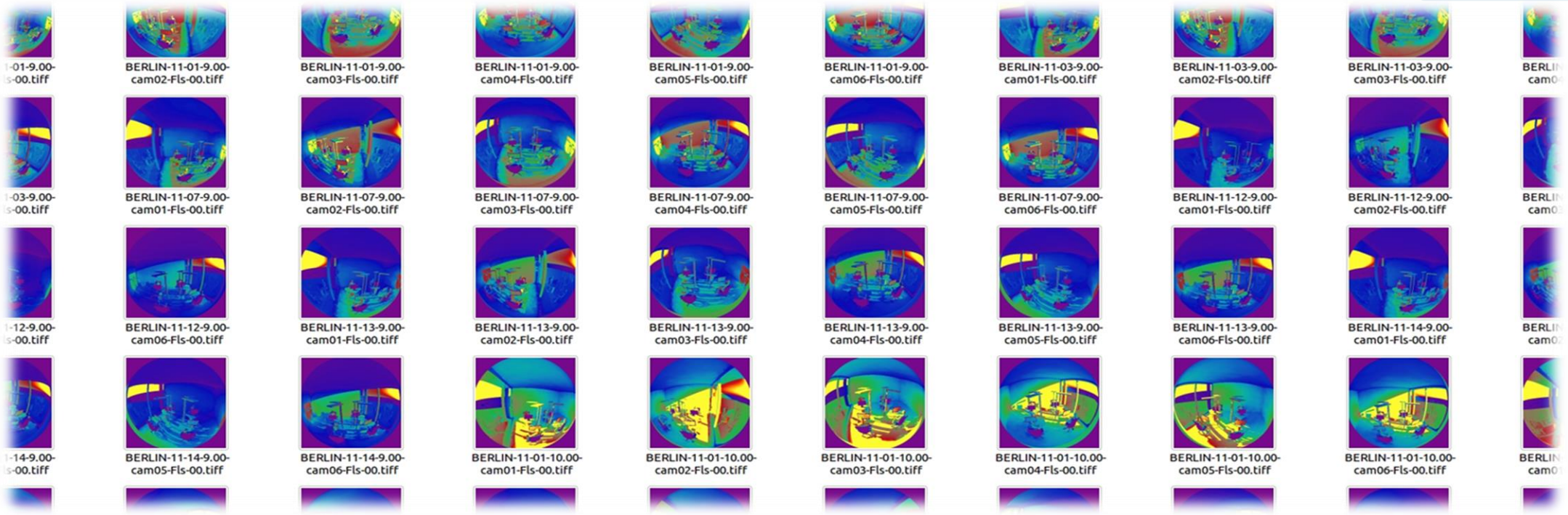
Daylight Glare Probability: Percentage of people disturbed by daylight

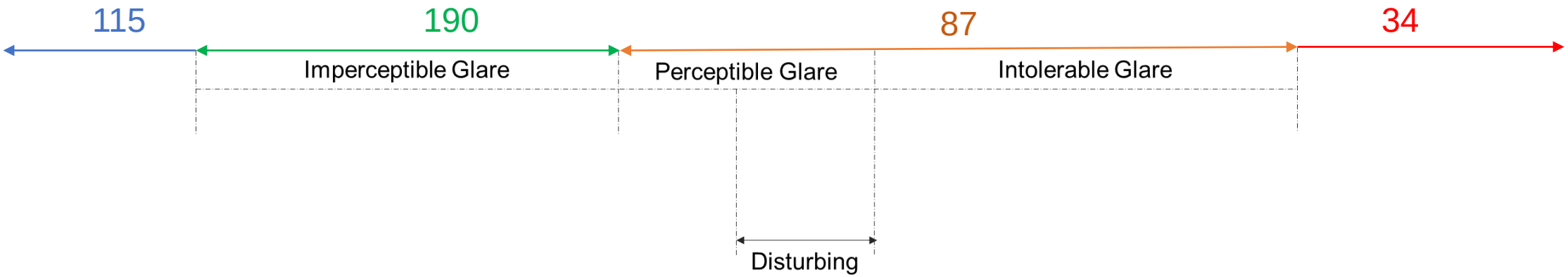
DGP is binned into categories based on perception



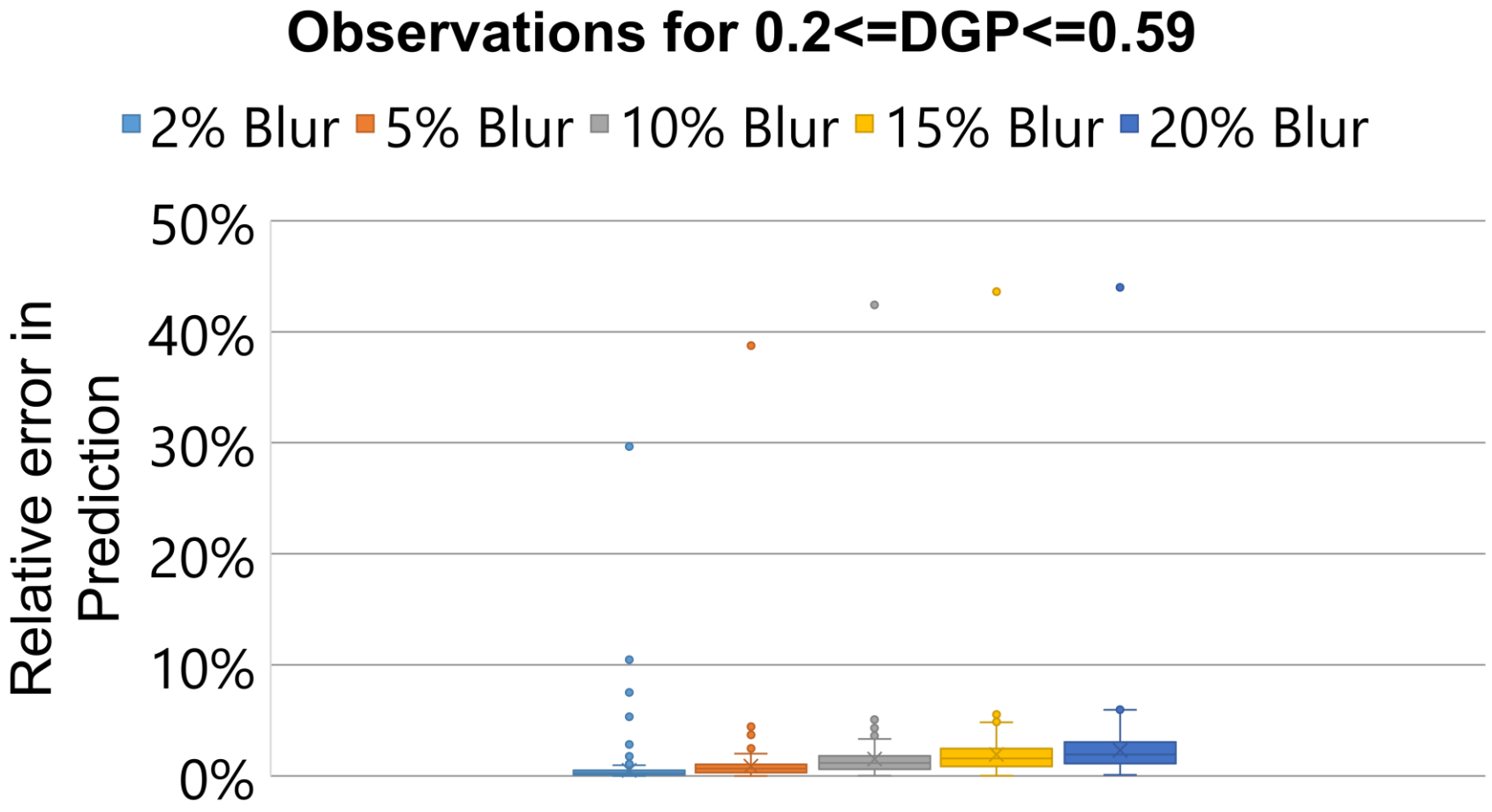


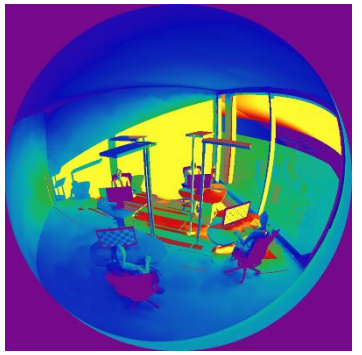
Results: Glare categorization for the 426 images



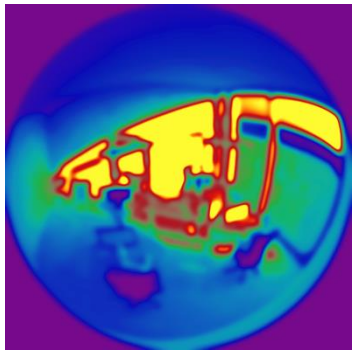


Results: DGP calculated for the (190+87) distorted images

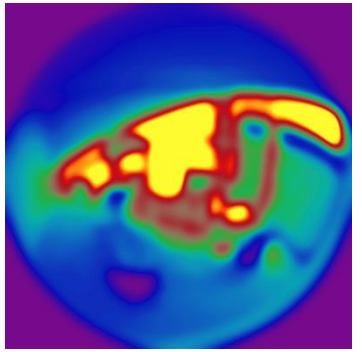




Original

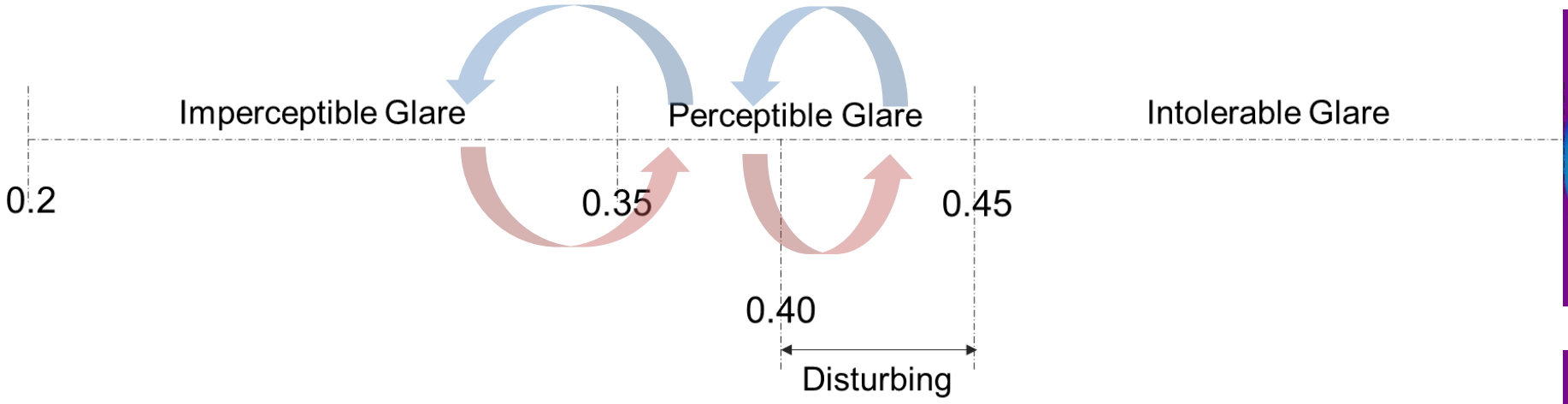


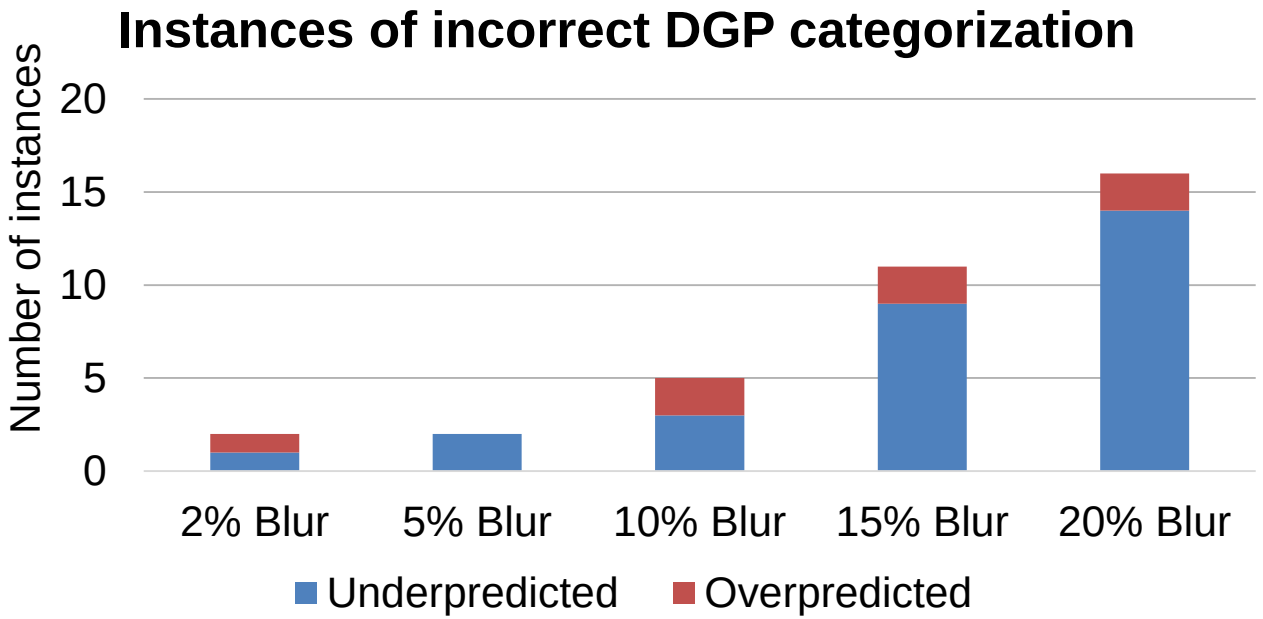
5%

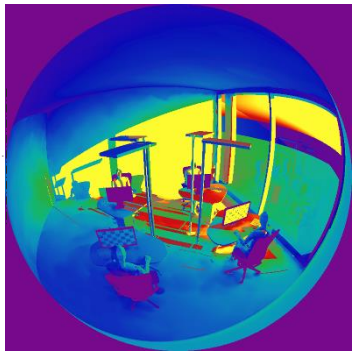


20%

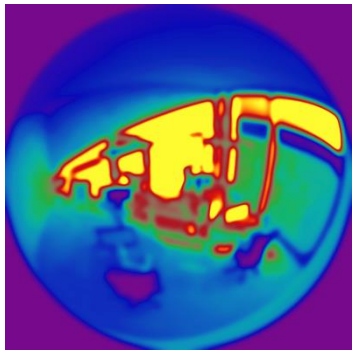
DGP categorization for (87) images with perceptible glare



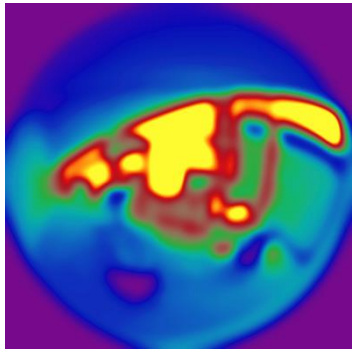




Original



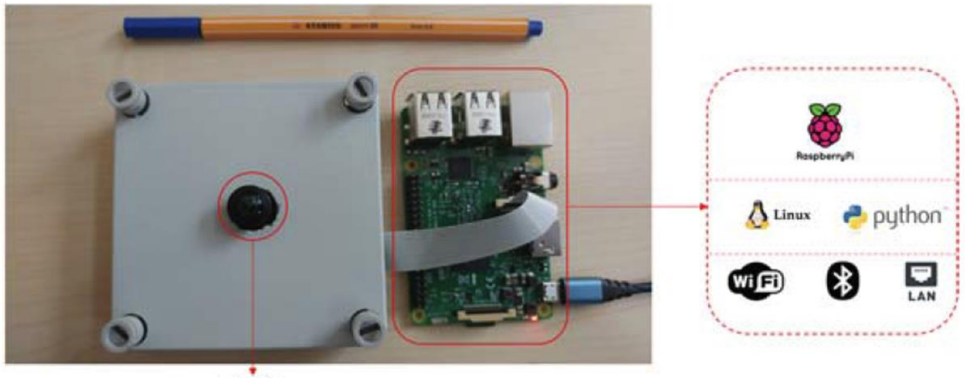
5%

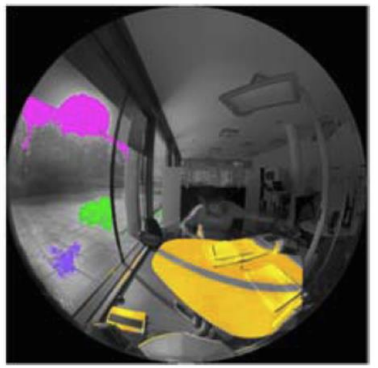


20%

Conclusions

- Relative error margin of 5% with obfuscated images.
- Incorrect categorization restricted to single category.
- Glare mostly under-predicted. Direct or reflected light sources get obscured.
- In a real-world implementation, categorization errors can be handled by a correction factor.
- Application of obfuscated images seems feasible.





Thank you! Questions or comments?

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