A New Device for Dynamic Luminance Mapping & Glare Risk Assessment in Buildings

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A new Device for dynamic luminance mappings & glare risk assessment in Buildings

- Introduction
  - Visual comfort
  - High Dynamic Range (HDR) imaging technique
- Methodology
  - IcyCAM
  - Calibrations and vignetting correction
  - Validation in real scenes
- Results
  - Luminance maps
  - Glare risk assessments
  - Discussion: different angles of fisheye lens
- Conclusion
Visual comfort • High Visual Performance & Low Discomfort

• Glare assessment

<table>
<thead>
<tr>
<th>Glare Indexes</th>
<th>Disturbing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daylight Glare Index</td>
<td>DGI</td>
</tr>
<tr>
<td>Unified Glare Index</td>
<td>UGR</td>
</tr>
<tr>
<td>Daylight Glare Probability</td>
<td>DGP</td>
</tr>
</tbody>
</table>

• Luminance ratio

Offi ce with Video Display Terminal (VDT)

Task area: adjacent surroundings < 1:3
Task area: remote surroundings  < 1:10
Luminance mapping and glare risk assessment by High Dynamic Range (HDR) imaging

- What is luminance mapping?

- How to find glare indexes?
High Dynamic Range imaging technique
To create an « HDR » > combination of several LDR images (different exposures)

- **Problem:** assessment under dynamic daylight
- **Goal:** to produce fast & simple HDR images
A camera-like light censor
Swiss Center for Electronics and Microtechnology (CSEM), Switzerland

- 130 dB intra-scene dynamic range due to the logarithmic compression
- Recorded in 780 µs - 2s exposure duration
Spectral sensitivity calibration

- Monochromatic light (between 380-780 nm)
- Spectroradiometer: emitted radiance

CIE standard error from $V(\lambda)$: $f' = 8.3\%$
Photometric calibration

- White light (Xenon: 4100K, CRI 93 + Metal Halide: 6000K, CRI 90)
- Luminance meter: luminance

![Graph showing luminance vs grayscale with an exponential fit (R^2 = 0.97)]
Vignetting correction

- Constant light source
- Different angles

Equipped with 120° Fisheye lens

![Graph showing relative intensity vs. degrees from center]

- Measured Data from IcyCAM
- Polynomial Function; $R^2 = 0.97$
Luminance maps: Comparison of luminance map by IcyCAM

- with luminance measured by luminance meter
- with luminance extracted from HDR Nikon Coolpix (classical HDR)

Comparison of luminance map by IcyCAM

Targets: Color charts & Room Elements

Electric Light
- IcyCAM: $R^2 = 99.44\%$
- Luminance Meter
- Classical HDR CCD Camera

Daylight
- IcyCAM: $R^2 = 97.31\%$
- Luminance Meter
- Classical HDR: $R^2 = 96.88\%$

~100 ms: IcyCAM
~60 ms: HDR
~8 min: luminance meter

$R^2 > 0.994$
$R^2 > 0.969$
Glare risk assessment

- different durations

<table>
<thead>
<tr>
<th>Time</th>
<th>DGP</th>
<th>DGI</th>
<th>UGR</th>
<th>Background Luminance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IcyCAM &lt;1s</td>
<td>0.18</td>
<td>11.71</td>
<td>13.91</td>
<td>42.34</td>
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<tr>
<td>IcyCAM ~ 10s</td>
<td>0.18</td>
<td>11.66</td>
<td>13.85</td>
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<td>IcyCAM ~ 20s</td>
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<td>IcyCAM ~ 50s</td>
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<td>IcyCAM ~ 60s</td>
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<tr>
<td>‘Classical HDR’ ~ 60s</td>
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<td>11.49</td>
<td>13.52</td>
<td>49.79</td>
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</tbody>
</table>
Glare risk assessment

- different durations

### Results

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<tr>
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<tbody>
<tr>
<td>IcyCAM &lt;1s</td>
<td>0.23</td>
<td>11.61</td>
<td>15.53</td>
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<td>0.23</td>
<td>12.55</td>
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<td>IcyCAM ~ 30s</td>
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<td>11.36</td>
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<td>0.23</td>
<td>11.60</td>
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<td>IcyCAM ~ 50s</td>
<td>0.23</td>
<td>11.58</td>
<td>15.62</td>
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<td>IcyCAM ~ 60s</td>
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<td>0.23</td>
<td>10.79</td>
<td>15.21</td>
<td>215.14</td>
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</tbody>
</table>
• Different lighting conditions
• Different durations
• Changes of each parameters
- Different lighting conditions
- Different durations
- Changes of each parameters

<table>
<thead>
<tr>
<th>Relative differences (%) from IcyCAM &gt;1s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric light</td>
</tr>
<tr>
<td>Variable daylight</td>
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</table>

- DGP
- DGI
- UGR
- Background Luminance
Glare risk assessment

IcyCAM
• DGP = 0.228
• DGI = 12.55
• UGR = 16.70

‘Classical HDR’
• DGP = 0.23
• DGI = 10.79
• UGR = 15.21

Main Parameters
• Glare Source Intensity (luminance/size/location)
• Background Luminance
• Vertical Illuminance

Light Source I
- 1127 lx
- Vertical Illuminance
- DGI = 12.55
- UGR = 16.70
- Background Luminance = 102 cd/m²

Light Source II
- 6929 cd/m²

Background Luminance
- 6579 cd/m²

Light Source I
- 6579 cd/m²

Light Source II
- 7672 cd/m²

Background Luminance
- 215 cd/m²
Discussion: Different angles of fisheye lens

- Comparing IcyCAM 120° fisheye with Canon5D 180° full frame fisheye (worked in LBNL, Berkeley)
Different angles

- Comparing IcyCAM 120° fisheye with Canon5D 180° full frame fisheye (worked in LBNL, Berkeley)
Conclusion

• Summary

  • Highly correlated luminance mapping: HDR imaging vs luminance meter

  • Advantage of IcyCAM: Rapid image captures with greater benefit in dynamic daylight

• Future work

  • To use IcyCAM also under dynamic outdoor light conditions – ‘sky scanner’

  • To use IcyCam with circadian sensitivity filters in order to assess luminance distribution related to physiological functions in humans
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