Minimally Intrusive Evaluation of Visual Comfort in the Normal Workplace

B. Painter, D. Fan, J. Mardaljevic

Institute of Energy and Sustainable Development
De Montfort University, Leicester, UK
Project aims

• Measure luminance conditions in a normal workspace.

• Collect user feedback regarding visual comfort, in particular glare perception.

• Develop data collection method for long term monitoring in real workspaces.

• Use data to improve daylight glare indices.

Benefits of studying real workspaces:

• Customized desk layout.

• Users are carrying out their usual tasks.

• Established use of shading devices and task lighting.
VisCom method

Components

User survey

Glare rating

On-screen form on user’s PC

Measurements

Luminance maps

HDR capture device

• Mac Mini
• Canon EOS 400D
• Fisheye lens
VisCom method

Requirements

- Minimal interference with normal work patterns.
- Long term - to capture seasonal variability.
- Automated data collection and storage.
- Timing simultaneous survey completion and HDR capture.
VisCom method
Workstation setup
VisCom method

Data collection network

**DMU Wired Network**

**DMU Wireless Network**

- **User's Desktop**
  - Start when computer is on
  - Data send to Mac Mini
  - Run in background for every 30 minutes

- **Survey pops up**

- **Client Application**

- **Server Application**
  - Keep listening for incoming message
  - Execute HDR capture application

- **Mac Mini**
The on-screen survey

- Every 30 minutes during working hours.
- Input of weather data possible - trigger survey only if glare is likely.
- User can delay survey.
- Self-elected survey start if glare is experienced.
- Question: VisCom survey?
The on-screen survey

- Every 30 minutes during working hours.
- Input of weather data possible - trigger survey only if glare is likely.
- User can delay.
- Self-elected survey start if glare is experienced.
- Dialog box: Proceed to VisCom survey?
The on-screen survey

- Java form.
- Glare scale (based on Osterhaus\(^1\)).
- Image for selection of glare source.
- Max 5 clicks to complete and submit.
- Submission of survey triggers image capture.

HDR capture & calibration

HDR Capture

LDR images → HDR image

Response Curve Function

Luminance Calibration

- Calibration Factor
- Image Vignetting² Correction

Spatial and/or Geometrical Calibration

- Image Warping/Transformation
  - Such As: Linear Matrix Transformation, Local Spline Transformation
- Image Distortion Correction
  - [Optional]

Warped Image For Future Analysis

HDR capture & calibration

Measured data points (cross) and vignetting function (solid line)

Digital filter
Image warping

- Camera does not accurately capture Field Of View

Warping required

Options: linear transform$^3$, spline transform$^4$, and others such as CFD$^5$


Image warping

*Linear transform*

- Feature points selection such as Harris corner detector or SIFT.
- Apply a 3 x 3 global matrix across the whole image.
- Distortion correction as a preprocessing step.
Image warping
*Spline transform*

- Imagine the image is a piece of plastic sheet.

- Stretches can be done locally, rather than the use of global matrix.
Image warping - *Comparison*

- Difficult to assess the performance of the methods visually
  - Glare patch analysis with comparison metrics
Image warping

*Binary glare patch extraction*

Glare source binary image (manually extracted)

Target Image

Warped Image

A glare patch
Image warping

Comparison metrics - Geometry

- Patch centre: \((X_m, Y_m)\),
- Mean solid angle: \((S_m)\),
- Total surface area in pixel: \((A)\),
- Positive Prediction Value: \((PPV)\).

\[
PPV = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}
\]

Target Image

<table>
<thead>
<tr>
<th>Warped Image</th>
<th>Glare Patch</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glare Patch</td>
<td>True Positive</td>
<td>False Positive</td>
</tr>
<tr>
<td>Background</td>
<td>False Negative</td>
<td>True Negative</td>
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Image warping

Comparison metrics - Geometry

<table>
<thead>
<tr>
<th></th>
<th>$X_m$</th>
<th>$Y_m$</th>
<th>$S_m$</th>
<th>$A$</th>
<th>PPV</th>
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<tbody>
<tr>
<td>Linear Transform</td>
<td>13.23%</td>
<td>28.77%</td>
<td>56.45%</td>
<td>37.95%</td>
<td>88.99%</td>
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<tr>
<td>Spline Transform</td>
<td>1.60%</td>
<td>5.38%</td>
<td>3.16%</td>
<td>10.04%</td>
<td>73.72%</td>
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</tbody>
</table>

The spline method performs better than the linear transformation, based on metrics related to the geometry of the glare patch.
The data (so far)

- Five Workstations
- March - May 2008: refinement of method
- Since May 2008: data collection
Survey response data

May - October 2008

<table>
<thead>
<tr>
<th></th>
<th>&lt; noticeable</th>
<th>&gt; just noticeable</th>
<th>&gt; just disturbing</th>
<th>&gt; intolerable</th>
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<tbody>
<tr>
<td>WS1</td>
<td>152</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>WS2</td>
<td>2</td>
<td>15</td>
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<td>7</td>
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<td>0</td>
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<tr>
<td>WS5</td>
<td>33</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>203</td>
<td>69</td>
<td>18</td>
<td>2</td>
</tr>
</tbody>
</table>

< noticeable: There is some glare in the field of view, but it does not affect user at all.

noticeable: Conditions which are uncomfortable but could be tolerated for the duration of a working day.

disturbing: lighting conditions which the user could tolerate while completing the present task (for approximately 15 to 30 minutes).

intolerable: extreme glare which the user cannot tolerate and in which he/she would require an immediate change of the lighting conditions in order to continue working.
Outlook

- Further investigate effect of warping on luminance data.
- Process HDR data and link with survey answers.
- Test and apply method in other locations.
- Expand data set, i.e. to include other workstation layouts, task and demographics.
- Use data to assess existing glare metrics.
- Develop new glare metric for use in climate-based daylight simulation studies.
Thank you.

bpainter@dmu.ac.uk
dfan@dmu.ac.uk
jm@dmu.ac.uk

Institute of Energy and Sustainable Development
Queens Building
The Gateway
Leicester
LE1 9BH
UK