Minimally Intrusive Evaluation of Visual Comfort in the Normal Workplace

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Project aims

- Measure luminance conditions in a normal workspace.
- Collect user feedback regarding visual comfort, in particular glare perception.

Benefits of studying real workspaces:

- Customized desk layout.
- Users are carrying out their usual tasks.
- Established use of shading devices and task lighting.

- Develop data collection method for long term monitoring in real workspaces.
- Use data to improve daylight glare indices.

VisCom method
Components

User survey

Glare rating

↓

On-screen form on user's PC

Measurements

Luminance maps

↓

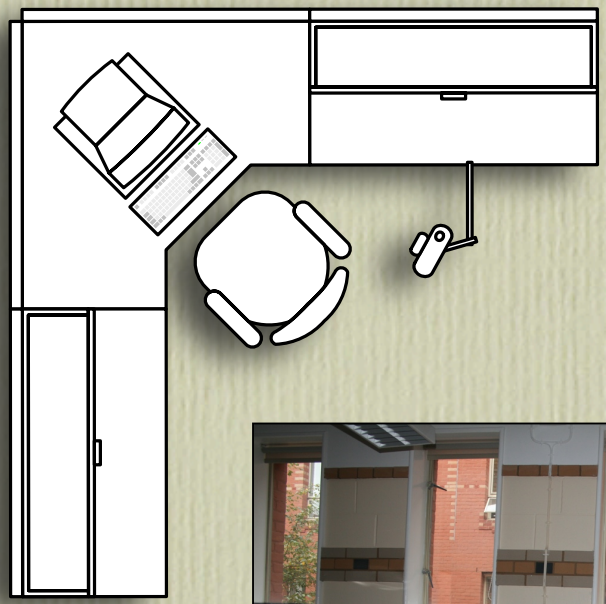
HDR capture device

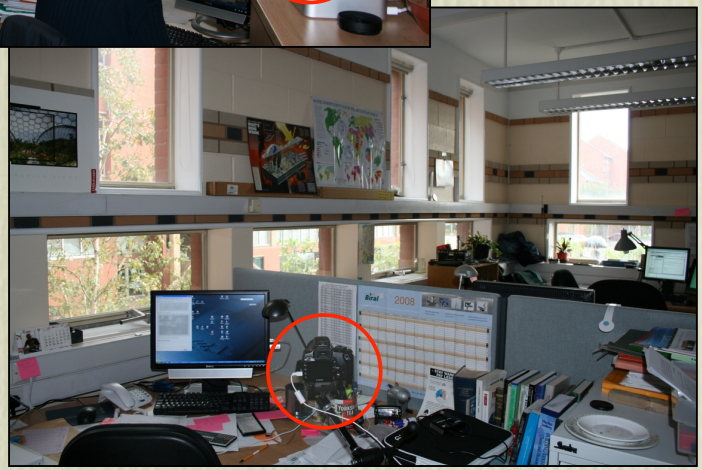
- Mac Mini
- Canon EOS 400D
- Fisheye lens

VisCom method
Requirements

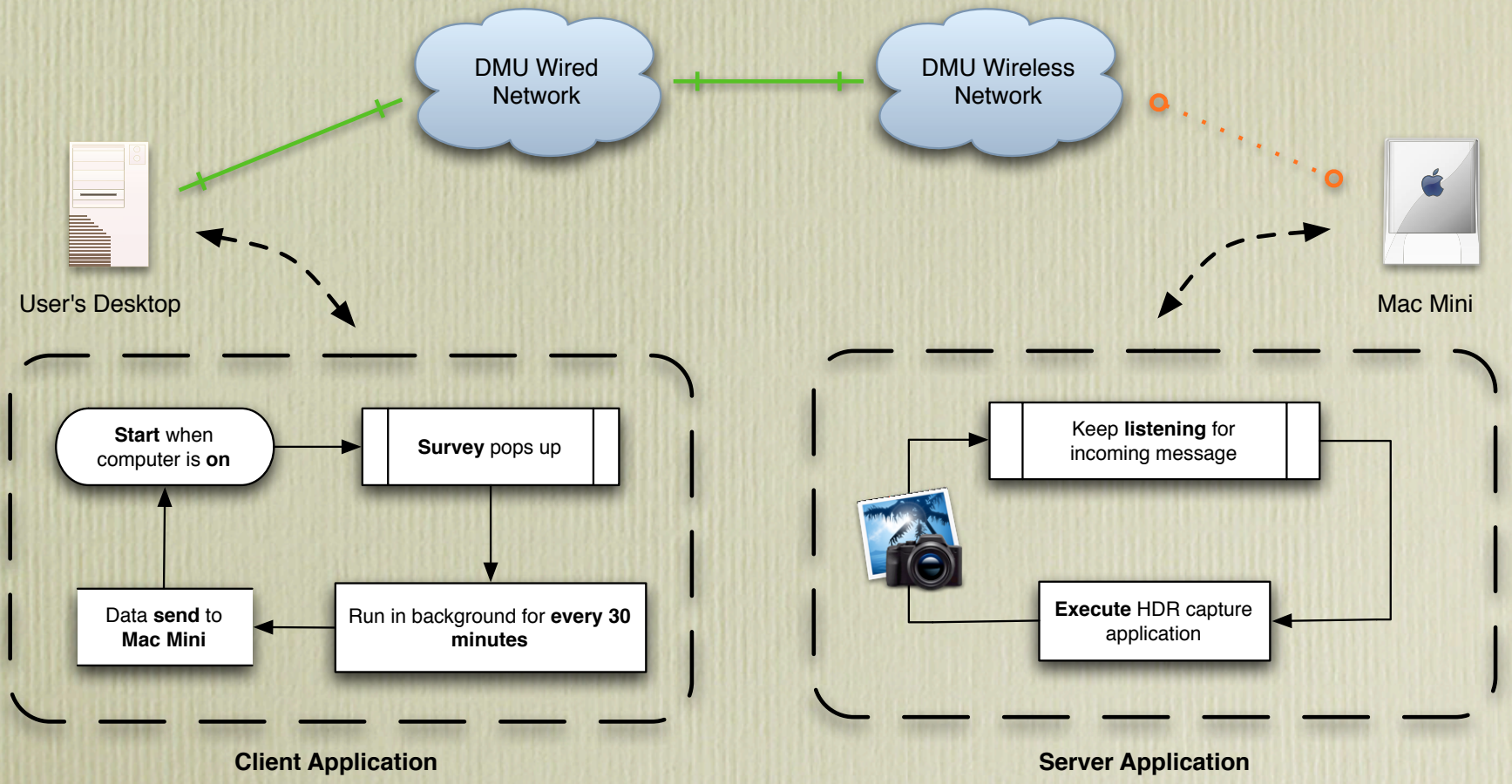
- Minimal interference with normal work patterns.
- Long term - to capture seasonal variability.
- Automated data collection and storage.
- Timing simultaneous survey completion and HDR capture.

VisCom method
Workstation setup





VisCom method
Data collection network

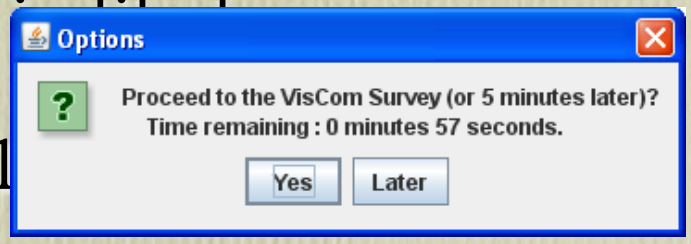


The on-sceen survey

- 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?

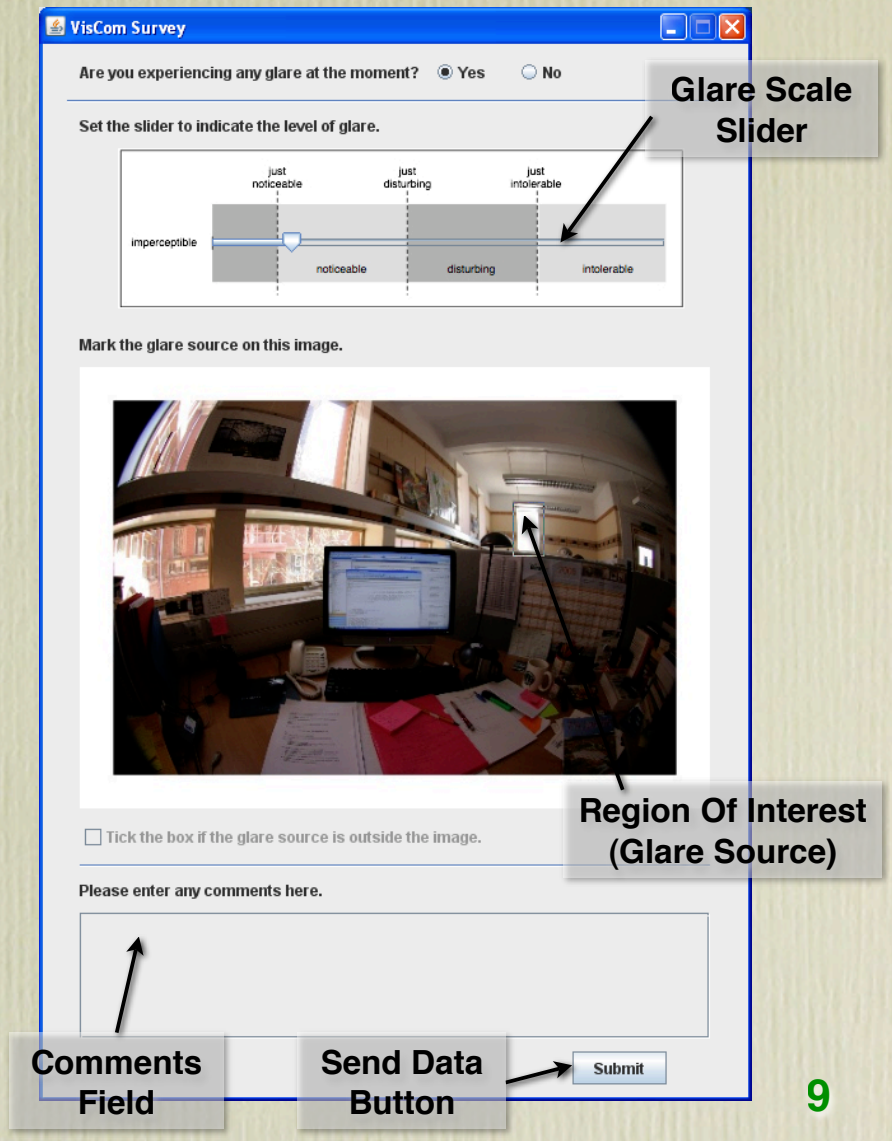
The on-sceen survey

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



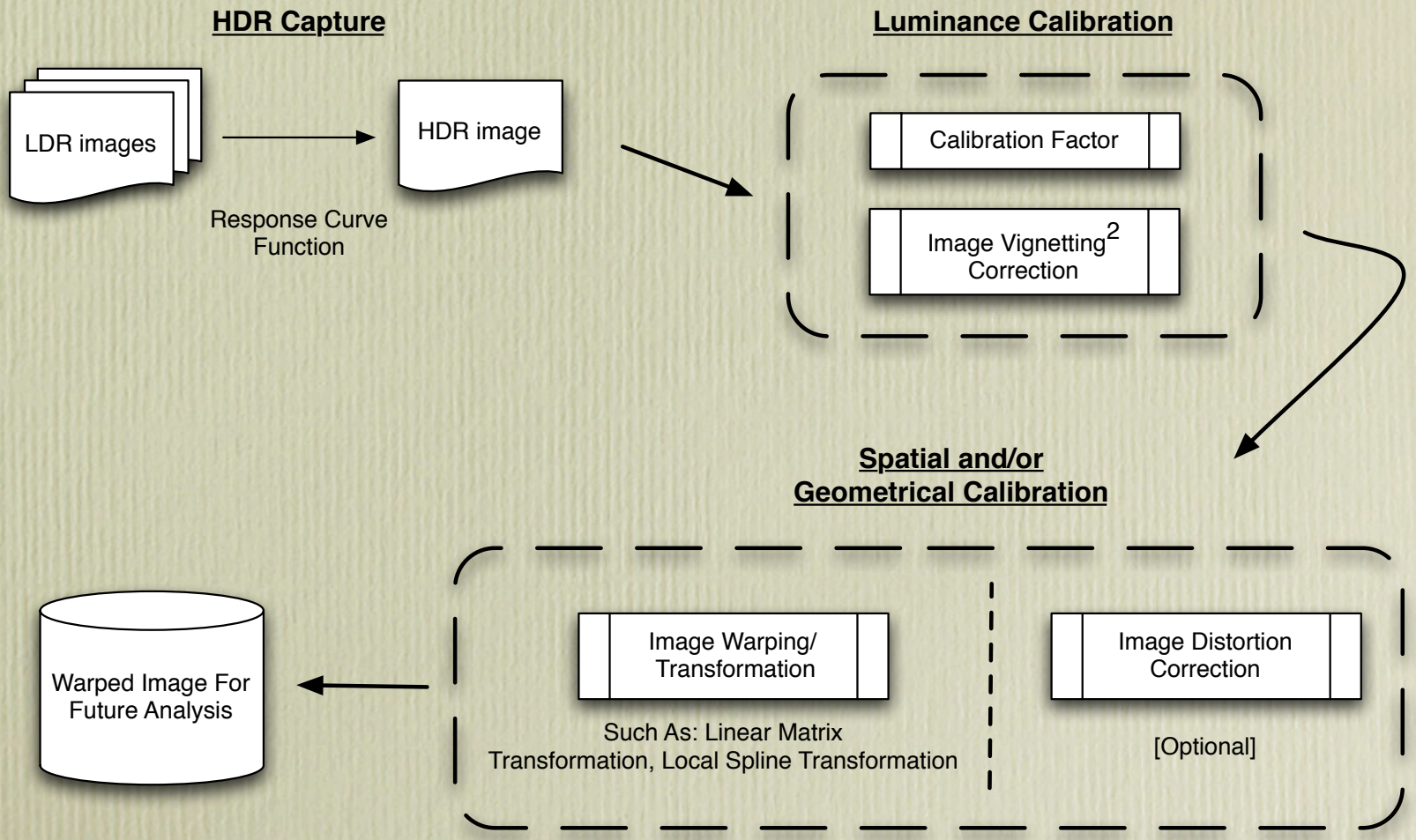
The on-sceen survey

- 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.



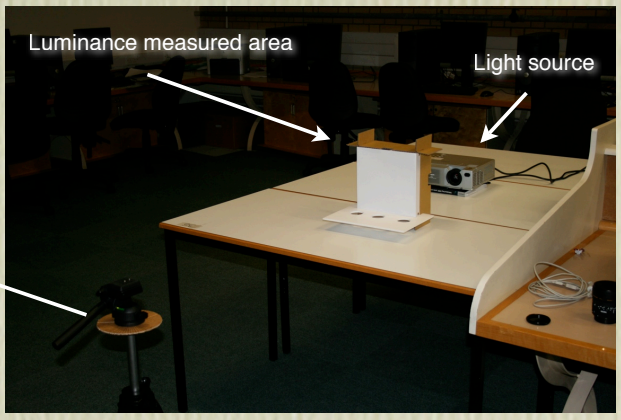
[1] Osterhaus, K.E., Solar Energy, Vol. 79, 2005, pp. 140 - 158.

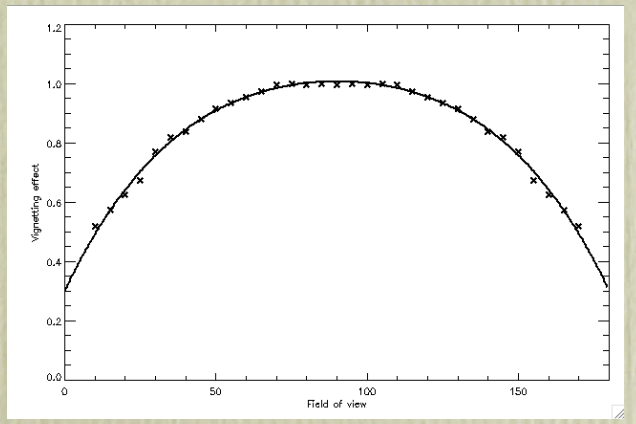
HDR capture & calibration



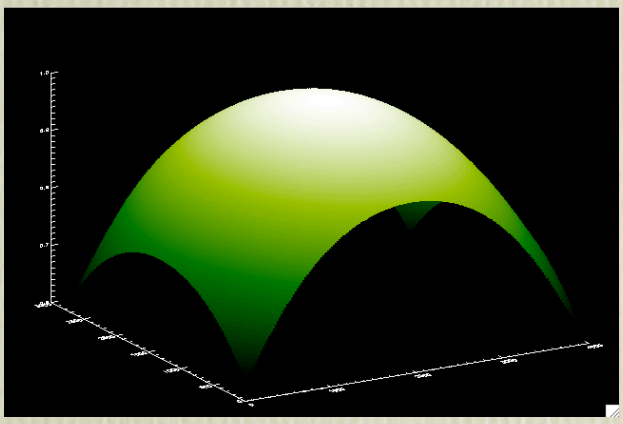
[2] Axel Jacobs and Mike Wilson. Determining lens vignetting with HDR techniques, 2007.

HDR capture & calibration



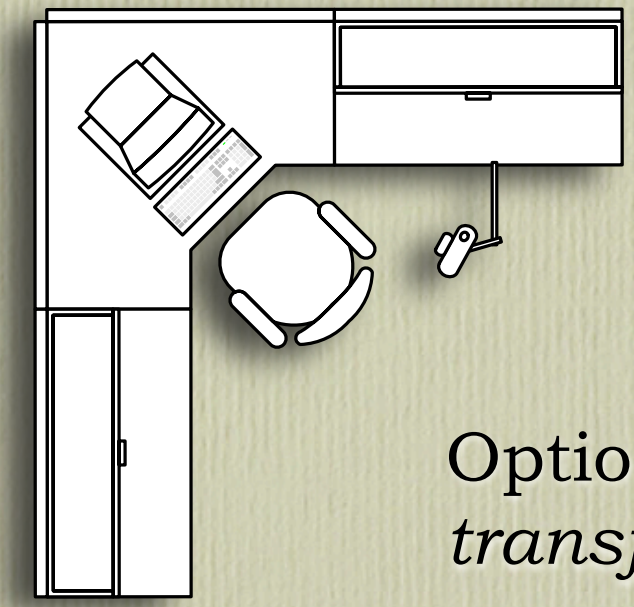


Measured data points (cross) and vignetting function (solid line)



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]

[3] Richard I. Hartley and Andrew Zisserman. Multiple view geometry in computer vision. Cambridge University Press, 2003.

[4] C.Ó. Sánchez Sorzano, P. Thévenaz, M. Unser. Elastic Registration of Biological Images Using Vector-Spline Regularization. IEEE Trans. Biomedical Engineering, 52(4): 652-663, April 2005.

[5] Gert Wollny, Frithjof Kruggel. Computational Cost of Non-Rigid Registration Algorithms Based on Fluid Dynamics. IEEE Trans. Med. Imaging 21(8): 946-952 (2002)

Image warping

Linear transform

Source image

Target image

- 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 pre-processing step.

Warped image

Image warping

Spline transform

Source image

Target image

- Imagine the image is a piece of plastic sheet.
- Stretches can be done locally, rather than the use of global matrix.

Warped image

Image warping - *Comparison*

Linear transform

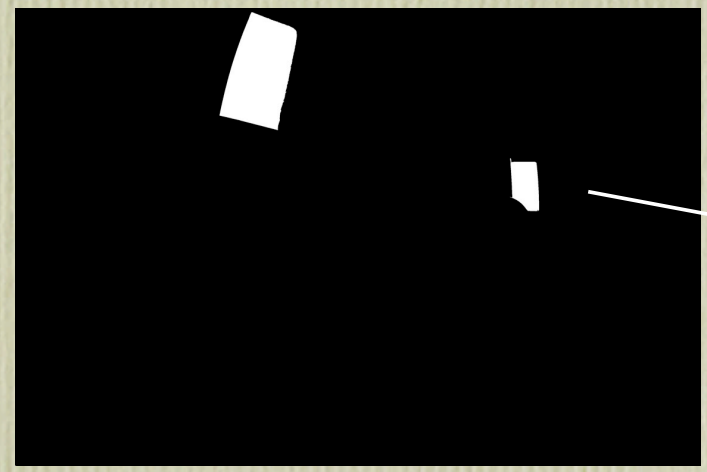
Spline transform

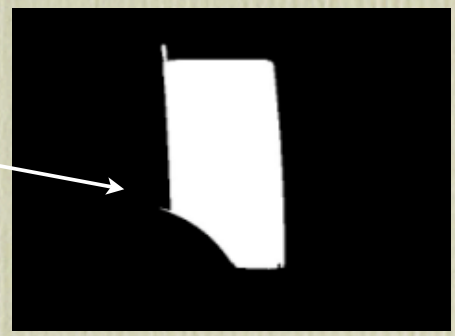
- Difficult to assess the performance of the methods visually

→ Glare patch analysis with comparison metrics

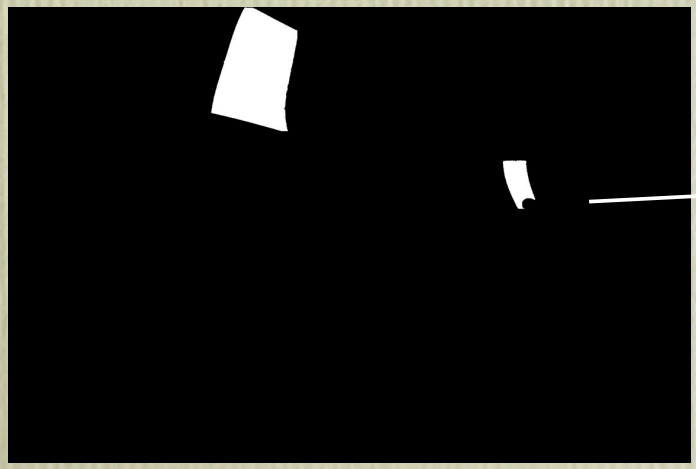
Image warping

Binary glare patch extraction

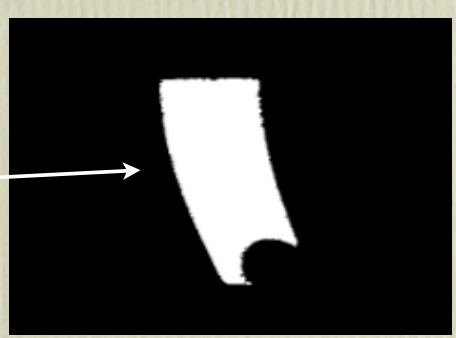




Target Image



Glare source binary image (manually extracted)



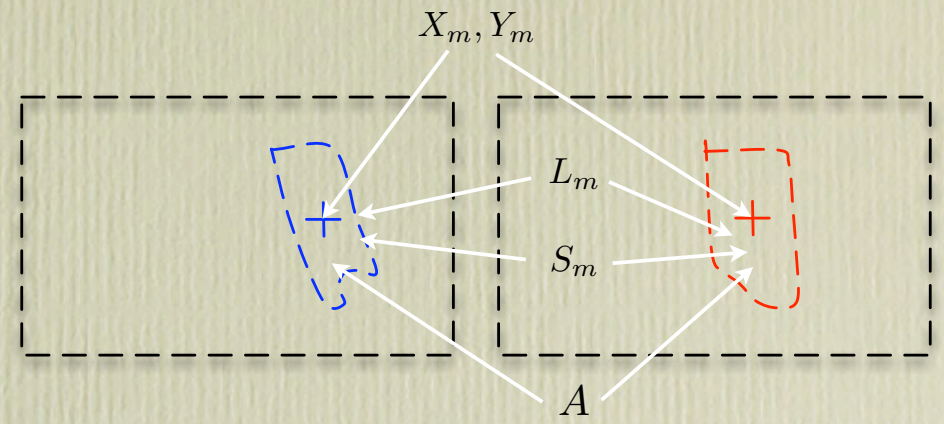
A glare patch

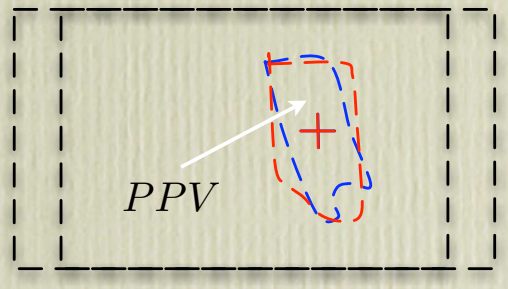
Warped Image

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).





Target Image

Warped Image	Glare Patch	Background
Glare Patch	*True Positive*	*False Positive*
Background	*False Negative*	*True Negative*

$$PPV = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

Image warping

Comparison metrics - Geometry

	X_m	Y_m	S_m	A	PPV
Linear Transform	13.23%	28.77%	56.45%	37.95%	88.99%
Spline Transform	1.60%	5.38%	3.16%	10.04%	73.72%

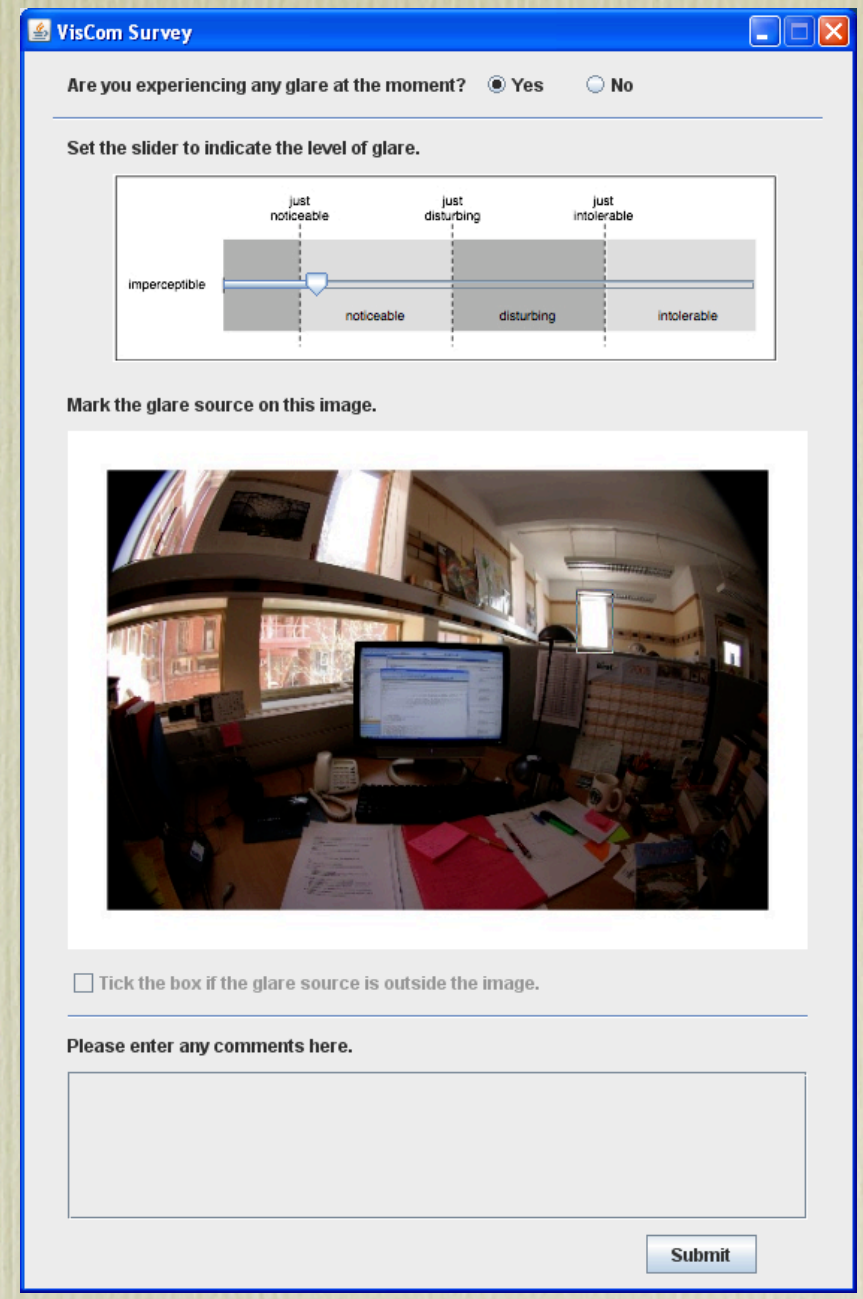
➡ The spline method performs better than the linear transformation, based on metrics related to the geometry of the glare patch.

The data (so far)

- Five Workstations
- March - May 2008:

  refinement of method
- Since May 2008:

  data collection



Survey response data

May - October 2008

	< noticeable	> just noticeable	> just disturbing	> intolerable
WS1	152	4	3	2
WS2	2	15	3	0
WS3	7	9	2	0
WS4	9	30	10	0
WS5	33	11	0	0
total	***203***	***69***	***18***	***2***

< 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.

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