A sensitivity analysis on glare detection parameters

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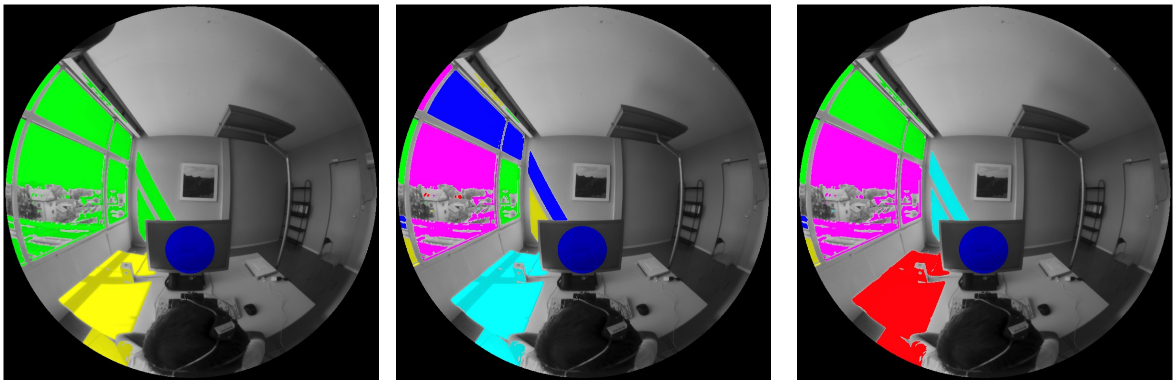
Abstract

Maximizing daylight access while maintaining a glare-free indoor environment is an ongoing challenge for daylighting design. Glare is a discomfort sensation that is produced as a result of greater variation of luminance across the visual field than the one that the eye is adapted to [1][2]. This type of discomfort sensation is one of the main drivers for building users' interaction with the façade setting [3][4] which consequently can change the building's performance over time. Optimised integration of glare-free daylight solutions thus proves to be crucial for a sustainable building design.

The existing methods for glare-free daylighting design rely on analyses on image-based advanced renderings with accurate simulation of light behaviour. These methods are becoming more commonly used for daylighting design using simulated three-dimensional geometrical model of the architectural space and employing tools such as *Radiance* [5] for rendering the light. The rendered image is an accumulation of luminance values from a fixed point of view, which creates a good basis for luminance-based metric analysis such as visual comfort metrics for glare predictions. In this approach, using fisheye view types for large field-of-view (FOV) renderings to cover the whole FOV of human eye, allows for evaluation of luminance variations for detecting glary areas perceived by the eye. As convenient as this approach seems, it has complexities in attempts to define different components of the visual comfort metrics. One of these complexities is detecting the glary image pixels. The detected pixels are then to be combined to define the glare source brightness, size and location, which are three main elements shared by different visual comfort metrics.

The existing glare source detection methods consider any image pixel of luminance value that is x-times larger than the average luminance of a visual adaptation region as a potential glare source pixel [6][7] . The visual adaptation region is the fovea region of the eye for a pre-assumed point of fixation in the space, e.g. the monitor screen. The method then searches the image based on a predefined search radius to find and combine all the glary pixels as one glare source. In this method, the value of the threshold multiplier and the search radius are decided intuitively based on the luminous environment of the studied scene. The existing recommendations for the threshold values ranges between 2 to 7 while the search radius is set to 0.2 as default. The two parameters are arbitrary and selected through trial and error over evaluation of several high dynamic range (HDR) images taken in different lighting conditions [6][8] and so far no validation has been made on their accuracy.

In this study we have made a sensitivity analysis on the threshold and search radius parameters for glare source pixels detection. In a series of experiments we took HDR images every 30 second under different sky and lighting conditions and with different façade system settings. HDR imaging techniques allow for larger difference between the brightest and the darkest areas of the registered image, representing the range of intensity levels close to the real scene. This provides an accurate, quick, and inexpensive way for lighting analysis [9]. We also gathered subjective assessments of the office workers participating in the experiment, using different measurement scales. We then made measurements for 15 different combinations of the two parameters (Threshold with 5 levels and search radius with 3 levels of treatment) (Figure: 1) on each image using the tool *Evalglare*[7]. We tested these combinations for five different visual comfort metrics including Daylight Glare Index (DGI), CIE Glare Index (CGI), Unified Glare Rating (UGR), Visual comfort probability (VCP), and Daylight Glare Probability (DGP). The idea is to investigate if the different combinations of recommended threshold and search radius make a significant



(a) Treshold 7, Radius 0.2 (b) Treshold 7, Radius 0.4 (c) Treshold 7, Radius 0.8

Figure 1: Using *Evalglare* we measured 5 different thresholds and 3 different search radius to calculate the visual comfort metrics. a, b and c show three examples, where the glare sources found with 3 different combinations are highlighted.

difference on the final output of these metrics. By comparing the prediction output to the subjective assessments, we can also conclude if a certain combination is more suitable for a specific lighting condition and visual comfort metric.

The preliminary results indicate that there is a significant effect of threshold and search radius on most visual comfort metrics. This effect is more significant for lighting conditions with lower luminance distribution levels. The sensitivity to threshold and search radius selection means that if not correctly selected, the output result could lead to over-predictions of the visual comfort condition. DGP, which is mainly dependent on the vertical illuminance at the eye level, is an exception in this result where we have only an effect of threshold parameter under lower luminance distribution levels. The study is ongoing and further analyses need to be made to have a better understanding of the effects of these two parameters and how to adjust them for an accurate visual comfort output.

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