ASSESSMENT OF DAYLIT GLARE PARAMETERS WITH IMAGING LUMINANCE MEASURING DEVICES (ILMD) AND IMAGE PROCESSING

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ABSTRACT

Image luminance measuring devices (ILMD, [1]) are widely used in different fields of application.

The assessment of glare caused by artificial lighting installations for outdoor and indoor applications is meanwhile reality.

To evaluate discomfort glare under daylit conditions, new glare assessment methods using luminance images have recently been developed.

The objective of this study is to analyse ongoing researches of mostly prototypical procedures and to realise their practical application for field measurements by using ILMD in the governmental or commercial sector.

The practical application of the DGP was in the focus of this study.

Keywords: **discomfort glare, DGP, Image luminance measuring devices (ILMD), field measurement, vertical illuminance, luminance image.**

1 INTRODUCTION

Image luminance measuring devices (ILMD, [1]) are widely used in different fields of application. The first step in using ILMDs is to evaluate the luminance images “as seen” in the image (ILMD Type I). In a further approach, not only the luminance information but also the position information of the measured luminance values and the relations between them can be used to extract relevant information for the applications (ILMD Type II). Therefore, the assessment of glare caused by artificial lighting installations for outdoor and indoor applications is meanwhile reality.

Based on this experience, particular attention is now being attached to the determination of daylit discomfort glare from windows.

One of the difficulties in the evaluation of discomfort glare from windows is the determination of the glare source area. The influence of the saturation effect complicates glare evaluation.

Furthermore, three glare evaluation methods based on luminance images have been developed to overcome this problem. These are: Daylight Glare Probability (DGP) [2], Predicted Glare Sensation Vote (PGSV) [3,4] and the statistical value-based indicators (ratios and differences between mean, maximum and median values of luminance) proposed by Osterhaus [5].

The practical application of the DGP was in the focus of this study.

2 DAYLIGHT GLARE PROBABILITY - DGP

The DGP shows the probability of persons being affected by discomfort glare, and is defined by the following equations.

$$DGP = 5.87 \cdot 10^{-5} \cdot E_V + 9.18 \cdot 10^{-2} \cdot \log\left(1 + \sum_i \frac{L_{s,i}^2 \cdot \omega_{s,i}}{E_v^{1.87} \cdot P_i^2}\right) + 0.16 \qquad (1)$$

where E_v is the vertical illuminance at the observer’s position [lx]. L_s is the luminance [cd/m^2] and ω is the solid angle [sr] of the glare source. The parameter P means Guth’s Position Index, calculated by means of the equation proposed by the IES (Eq. 2) for the visual field above the line of sight.

$$\ln P = (35.2 - 0.31889\tau - 1.22 e^{-2\tau/9}) 10^{-3} \sigma + (21 + 0.26667\tau - 0.002963\tau^2) 10^{-5} \sigma^2 \qquad (2)$$

Here, τ is the $tan^{-1}(x/y)$ [deg], x and y are the horizontal and vertical distance [m] between the point of view and the source, respectively, σ is the angle between the line of sight and the line from the observer to the source [deg].

To calculate the Position Index for the visual field below the line of sight, the following equations from experiments carried out by Iwata and Tokata [8] were used:

$\gamma = 90$ and

$\sigma = \mathrm{atan}((x^2 + (y / 1,15)^2)^{0,5} / z)$

where γ is the $tan^{-1}(x/y)$ [deg], x and y are the horizontal and vertical distance [m] between the point of view and the source respectively, and z is the horizontal distance [m] between the observer and the vertical plane including the source.

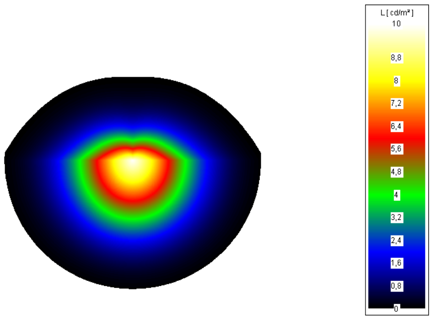

Figure 1. Luminance distribution weighted by Position Index (10 cd/m2 of uniform luminance in equisolid pixel image).

3 GLARE SOURCE THRESHOLD DETECTION

The DGP requires us to indicate the threshold luminance which helps us to determine a particular light source in the field of view as a glare source or rather as a part of the background.

Three principle methods were tested for the automatic detection of glare sources:

- Detect the average luminance of the entire image and calculate the threshold x-time higher than the average luminance with x = 4 [6]
- Take a fixed threshold value and mark every section as a glare source that is above the fixed value
- In adaption to the UGR assessment by Wolf [7] a pixel-by-pixel luminance histogram for the image was created and the first local minimum after the global maximum was detected as luminance threshold

4 SUMMARY

Finally, it can be stated that ILMD devices offer the only efficient method to measure glare parameters and to confirm simulated or empirically derived data. Throughout simple image processing methods there are nearly no bounds for integrating complex physiological equations into synthetic images. One aspect for more attention could be the spatial resolution of luminances and their solid angles in the luminance image.

The developed methods [2, 5, 6] for gathering daylit glare parameters are suitable and can easily practicable used for developing daylight glare meter based on known techniques. The given dynamic range of 1:32000 within high dynamic luminance images is not a limiting factor. This value can be reduced by scattered light effects depending on the individual measurement scenario.

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