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A GAZE VISUALIZER TOOL
IMPLEMENTATION OF GAZE DATA INTO LIGHTING RENDERING TOOLS USING RADIANCE AND HONEYBEE FOR GRASSHOPPER3D

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ABSTRACT

The Gaze Visualizer tool is an implementation of eye-tracking (gaze) data and a preliminary gaze responsive light driven (GR_L) model, which enables to visualize gaze behavior in a 3D space, in Grasshopper3D. The workflow from obtaining the relevant photometric quantities, retrieving gaze data, intorduction of the GR_L model to the tool and a simple data representation scheme are presented here. The final plugin is easy to use for Rhino/Grasshopper developers with only basic skills, and provides a quick estimations of the gaze respionsive visual comfort in an illustrative way, that gives the user an adequate overview of the glare-free zones in the room.

INTRODUCTION

Considering human needs in relation to indoor environment plays a crucial role in buildings' overall performance. A basic human need is a comfortable indoor environment (Monika Frontczak and Wargocki 2011) such as visual comfort with mainly psychological aspects (Bollen 2002; M. Frontczak et al. 2012). However, investigations on human body responses to indoor conditions proves to be essential (Bluyssen 2013) for better understanding of human needs. Gaze is a volitional or reflexive body response where we direct our line of sight as a visual response to the surrounding conditions. Eye-movement classes such as saccades (rapid shifts) and fixations (longer pauses) coexist with head and body movement to shift our gaze. The full contribution of these effectors (eye, head, body) to gaze ('t Hart and Einhäuser 2009) provides information on visual response to the surrounding visual environment during a real-life task ('t Hart and Einhäuser 2012; Fairchild et al. 2001) such as working in an office.

With each gaze shift when scanning our surrounding environment, a new luminance distribution is introduced across the field of view (FOV). The inherent dependencies of visual comfort on gaze behavior (Clear 2012; Sury, Hubalek, and Schierz 2010; Fry and King 1975; Yamin Garreton et al. 2015; Lin et al. 2015) is underlined by this re-adaptation mechanism (Kokoschka and Haubner 1985), which favorably or unfavorably contributes to visual comfort perception (Guth 1958; Kim and Koga 2004). A constant re-adaptation in a highly contrasted room susceptible to e.g. discomforting glare, affects our overall subjective response to visual lighting conditions such as discomfort glare (DG) (CIBSE 1994), which as well underlines the complexity of visual comfort predictions (S Hubalek and Schierz 2006; Einhäuser et al. 2007; Nuthmann and Einhäuser, n.d.) especially when no inference to visual gaze response.

The necessity of limited luminance ratios in FOV to avoid constant re-adaptation for better work performance have been addressed in some early studies (Kokoschka and Haubner 1985). However, not strong a DG predictor compare to other existing models (Van Den Wymelenberg and Inanici 2014). DG is a condition that is caused by wide range of contrast in FOV that do not impair visibility (International Illumination Commission CIE 2002). However, a negative response and eventual eye strain is caused by the presence of the disturbing lighting condition (Boyce 2014). Several models have been developed to quantify this phenomenon for artificial and daylighting conditions. These models are developed mainly by associating relevant photometric relations linked with visual visibility and luminance contrast (equation 1), as a

CIBSE, CODE. 1994. “Code for Interior Lighting.” *London: The Chartered Institution of Building Services Engineers*.

Clear, Robert D. 2012. “Discomfort Glare: What Do We Actually Know?” *Lighting Research and Technology*, 1477153512444527.

Einhäuser, Wolfgang, Frank Schumann, Stanislavs Bardins, Klaus Bartl, Guido Böning, Erich Schneider, and Peter König. 2007. “Human Eye-Head Co-Ordination in Natural Exploration.” *Network: Computation in Neural Systems* 18 (3): 267–97. doi:10.1080/09548980701671094.

Fairchild, Mark D., Garrett M. Johnson, Jason Babcock, and Jeff B. Pelz. 2001. “Is Your Eye on the Ball?: Eye Tracking Golfers While Putting.” *Unpublished Manuscript, Rochester Institute of Technology*.

Frontczak, M., S. Schiavon, J. Goins, E. Arens, H. Zhang, and P. Wargocki. 2012. “Quantitative Relationships between Occupant Satisfaction and Satisfaction Aspects of Indoor Environmental Quality and Building Design.” *Indoor Air* 22 (2): 119–31. doi:10.1111/j.1600-0668.2011.00745.x.

Frontczak, Monika, and Pawel Wargocki. 2011. “Literature Survey on How Different Factors Influence Human Comfort in Indoor Environments.” *Building and Environment* 46 (4): 922–37. doi:10.1016/j.buildenv.2010.10.021.

Fry, Glenn A, and Vincent M King. 1975. “The Pupillary Response and Discomfort Glare.” *Journal of the Illuminating Engineering Society* 4 (4): 307–24.

Guth, SK. 1958. “Light and Comfort.” *Industrial Medicine & Surgery* 27 (11): 570–574.

Hubalek, S, and C Schierz. 2006. “Authors’ Response.” *Lighting Research and Technology* 38 (4): 323–24. doi:10.1177/147709380603800413.

Hubalek, Sylvia, and Christoph Schierz. 2004. “LichtBlick–photometrical Situation and Eye Movements at VDU Work Places.” In *CIE Symposium*, 4:322–324.

International Illumination Commission CIE. 2002. “Lighting of Work Places Part 1 Indoor.”

Jakubiec, J, and C Reinhart. 2011. “The ‘Adaptive Zone’ - A Concept for Assessing Discomfort Glare throughout Daylit Spaces.” *Lighting Research and Technology* 44 (2): 149–70. doi:10.1177/1477153511420097.

Kim, W, and Y Koga. 2004. “Effect of Local Background Luminance on Discomfort Glare.” *Building and Environment* 39 (12): 1435–42. doi:10.1016/j.buildenv.2004.05.003.

Kokoschka, S, and P Haubner. 1985. “Luminance Ratios at Visual Display Workstations and Visual Performance.” *Lighting Research and Technology* 17 (3): 138–44. doi:10.1177/14771535850170030101.

Lin, Yandan, Steve Fotios, Minchen Wei, Yihong Liu, Weihong Guo, and Yaojie Sun. 2015. “Eye Movement and Pupil Size Constriction under Discomfort Glare.” *Investigative Ophthalmology & Visual Science* 56 (3): 1649–1656.

Nuthmann, A, and W Einhäuser. n.d. “A New Approach to Modeling the Influene of Image Features on Fixation Selection in Scenes.” *The New York Academy of Scientists*.

Sarey Khanie, Mandana, Josef Stoll, Wolfgang Einhäuser, Jan Wienold, and Marilyne Andersen. 2016. “Gaze and Discomfort Glare, Part 1: Development of a Gaze-Driven Photometry.” *Lighting Research & Technology*. SAGE Publications Sage UK: London, England, 1477153516649016. doi:10.1177/1477153516649016.

Sury, Philipp M., Sylvia Hubalek, and Christoph Schierz. 2010. *A First Step on Eye Movements in Office Settings: Eine Explorative Studie Zu Augenbewegungen Im Büroalltag*. Vol. 51. GRIN Verlag.

Ward-Larson, Greg, and Rob Shakespeare. 1998. *Rendering with Radiance: The Art and Science of Lighting Visualization*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc. http://portal.acm.org/citation.cfm?id=286090.

Ward, Greg. 1992. *RADIANCE Visual Comfort Calculation*. LESO-EPFL.

Wienold, Jan, and Jens Christoffersen. 2006. “Evaluation Methods and Development of a New Glare Prediction Model for Daylight Environments with the Use of CCD Cameras.” *Energy and Buildings* 38 (7): 743–57. doi:10.1016/j.enbuild.2006.03.017.

Wymelenberg, Kevin Van Den, and Mehlika Inanici. 2014. “A Critical Investigation of Common Lighting Design Metrics for Predicting Human Visual Comfort in Offices with Daylight.” *LEUKOS* 10 (3). Taylor & Francis: 145–64. doi:10.1080/15502724.2014.881720.

Yamin Garreton, J. A., R. G. Rodriguez, A. Ruiz, and A. E. Pattini. 2015. “Degree of Eye Opening: A New Discomfort Glare Indicator.” *Building and Environment* 88: 142–50. doi:10.1016/j.buildenv.2014.11.010.