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DOI

[10.25039/x46.2019.PO061](https://doi.org/10.25039/x46.2019.PO061)

Publication date

2019

Document Version

Final published version

Published in

Proceedings of the 29th CIE SESSION Washington D.C., USA, June 14 – 22, 2019

Citation (APA)

Abreu Vieira Viula, R., & Hordijk, T. (2019). A method for estimating fisheye lens' field-of view angle and projection for HDR luminance capture. In *Proceedings of the 29th CIE SESSION Washington D.C., USA, June 14 – 22, 2019* (pp. 1108-1112). Commission Internationale de l'Eclairage. <https://doi.org/10.25039/x46.2019.PO061>

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PO061

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DOI 10.25039/x46.2019.PO061

from

CIE x046:2019

Proceedings
of the

29th CIE SESSION

Washington D.C., USA, June 14 – 22, 2019

(DOI 10.25039/x46.2019)

The paper has been presented at the 29th CIE Session, Washington D.C., USA, June 14-22, 2019. It has not been peer-reviewed by CIE.

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A METHOD FOR ESTIMATING FISHEYE LENS' FIELD-OF-VIEW ANGLE AND PROJECTION FOR HDR LUMINANCE CAPTURE

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DOI 10.25039/x46.2019.PO061

Abstract

The calculation of field-of-view luminance based metrics for visual discomfort from glare evaluation in real scenes via HDR (High Dynamic Range) luminance capture does generally require the use of wide view fisheye lenses. This paper presents an easy to implement and low-cost method to estimate a fisheye lens' total field-of view and projection method, which is required for accurate glare evaluations.

Keywords: HDR luminance capture, Fisheye lenses, Projection methods, Glare measurement

1 Introduction

The calculation of field-of-view luminance based metrics for visual discomfort and glare evaluation in real scenes via HDR (High Dynamic Range) luminance capture does generally require the use of wide view fisheye lenses (Inanici, 2006) (Wienold and Christoffersen, 2006) (Jacobs, 2007).

The field-of-view and type of projection of the lens is a requirement for correct capture of the solid angle and position of the glare sources in a visual scene and in this way, for the production of accurate glare evaluations (Wienold, 2014).

It is known that the exact view angle and lens projection type is not always provided by the manufacturers of fisheye lenses and it is left to the researcher to make sure these are known prior to any measurements.

Ideally this estimation is performed with specific materials such as very sturdy tripods with high precision rotating heads or cameras mounted on motorised heads (Jacobs, 2012). However, these materials are not readily available to most researchers and research labs.

This paper describes a low-cost method to perform the estimation of the field-of view and projection method of fisheye lenses based on a single photograph and an easy to built physical set-up.

This lens' projection estimation method has the advantage of avoiding the need to find the camera's nodal point for parallax correction, which is required when using a method that involves the rotation of the camera (Jacobs, 2012).

The method was used to estimate the projection and field-of-view of a Sigma 4,5mm F2,8 EX DC HSM Circular Fisheye.

2 Fisheye lenses projection methods

Fisheye lenses produce a hemispherical view that requires some form of distortion to be able to be represented as a planar image. Every lens has its own distortion that should match one of the hemispherical projection equations (Table 1) that describe the relation between the entrance angle and the location on the image (Bettonvil, 2005).

The most common fisheye lenses have an equi-angle and or an equi-solid angle projection. The equi-angle lenses produce angular distances of equal size across the image view while the equi-solid angle (also called Lambert azimuthal equal-area) lenses accurately represent

area in all regions of the view. There are other hemispherical projection methods such as the orthographic and the stereographic, being the first one also used by fisheye lenses.

Table 1 – Equations for different projection methods (Bettonvil, 2005)

Projection	Equation
Equi-solid angle	$r(\theta) = 2 f \sin(\theta/2)$
Equi-angle (or equidistant)	$r(\theta) = f \theta$
Stereographic	$r(\theta) = 2 f \tan(\theta/2)$
Orthographic	$r(\theta) = f \sin(\theta)$
Rectilinear (no distortion)	$r(\theta) = f \tan(\theta)$

where

- θ is the entrance angle, measured from the optical axis;
- f is the lens' focal length;
- r is the distance at the image plane measured from the optical axis.

As mentioned before fisheye lens' projection and full field-of-view are required for correct calculation of the position and size of glare sources in image-based glare evaluations. This is even more important when using Radiance-based software like Evalglare (Wienold, 2009). Radiance (Ward, 1994) only supports views with equi-angle or orthographic projection. A HDR fisheye image with an equi-solid angle projection, a common type of fisheye lens, needs therefore to be re-projected into one of the supported view types to be used in Radiance and Evalglare calculations.

3 Method

The method here presented consists of projecting 10° interval marker lines onto a set-up of two vertical planes forming a right angle. This set-up is modelled in a CAD drawing as shown in Figure 2. It contains a horizontal triangular base to facilitate the positioning of the camera in alignment with the centre of the model.

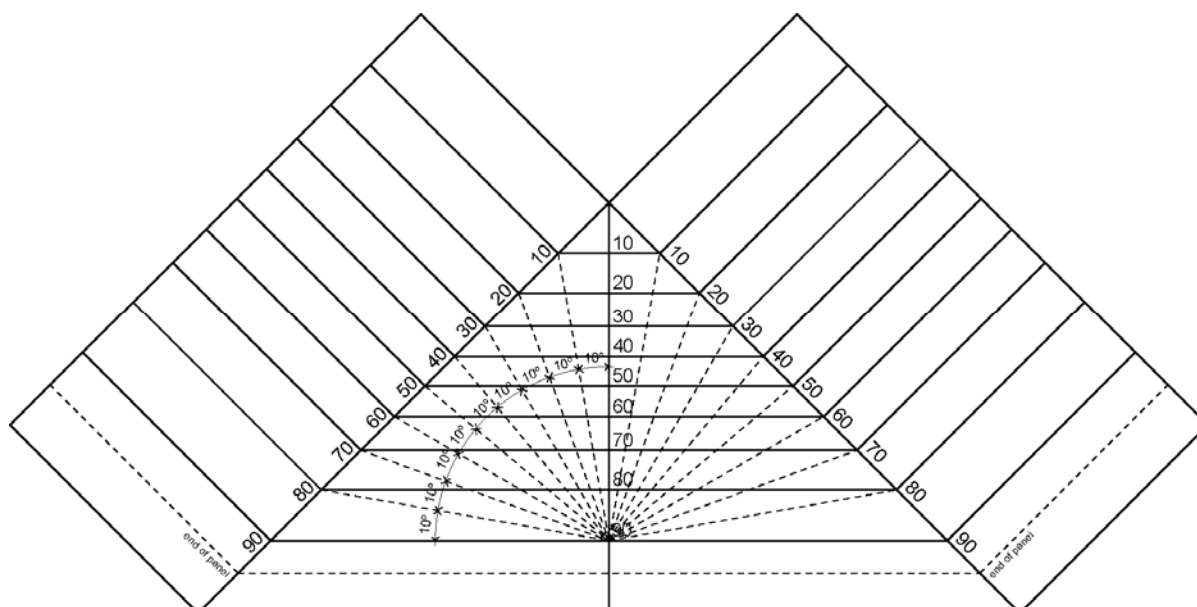


Figure 1 – Planar view of the set-up

This drawing is printed and fixed onto two 1m-length polystyrene boards with enough thickness to support itself vertically and be mounted on a table (Figure 2). The camera is aligned with the 90° marker line and a photograph from that position is taken.



Figure 2 – Physical set-up

The second step consists of finding the linear distances corresponding to the 10° interval curves for each projection method that one wants to test. Table 2 shows the linear distances r from the centre of the image corresponding to angles θ 10° to 90°, of a 4,5 mm lens. Figure 3 shows the distortion of each projection for that lens.

Table 2 – Linear distance r (mm) for angle θ , for a 4,5 mm lens

Angle θ	Equi-solid angle	Equi-angle	Stereographic	Orthographic	Rectilinear
10	0,78	0,79	0,79	0,78	0,79
20	1,56	1,57	1,59	1,54	1,64
30	2,33	2,36	2,41	2,25	2,60
40	3,08	3,14	3,28	2,89	3,78
50	3,80	3,93	4,20	3,45	5,36
60	4,50	4,71	5,20	3,90	7,79
70	5,16	5,50	6,30	4,23	12,36
80	5,79	6,28	7,55	4,43	25,52
90	6,36	7,07	9,00	4,50	7,3E+16

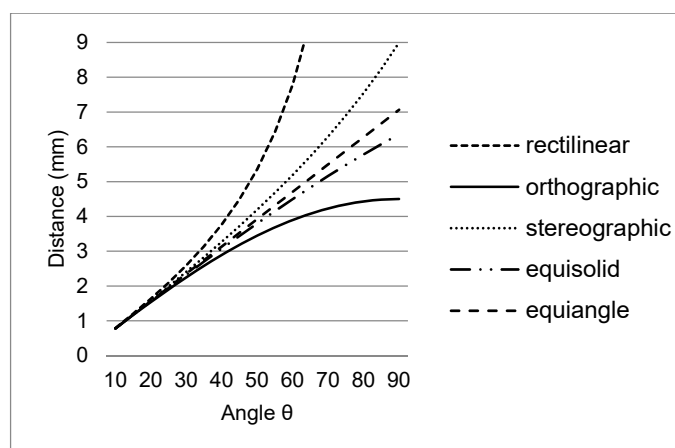


Figure 3 – Distortion of different fisheye projection methods, for a 4,5 mm lens

The third step consists of plotting in a CAD drawing the curves for the projections that one wants to test. In this case, only the equi-angle and equi-solid angle projections were considered.

The photographed image of the physical set-up is overlaid with these curves to find with which projection does it match, using common image processing software (Figure 4).

It can be seen that there is an almost exact match between the curves of the equi-solid angle projection and the corresponding markers of the physical set-up. The slight mismatch can be explained by a deviation between the centre of the image and the centre of the fisheye lens, an eccentricity that has also been found in (Jacobs, 2012).

Based on this overlay, the linear distance between the centre and the periphery of the image is 6,5009 which corresponds to an angle of 92,494° and a lens' total field-of-view of 184,988°.

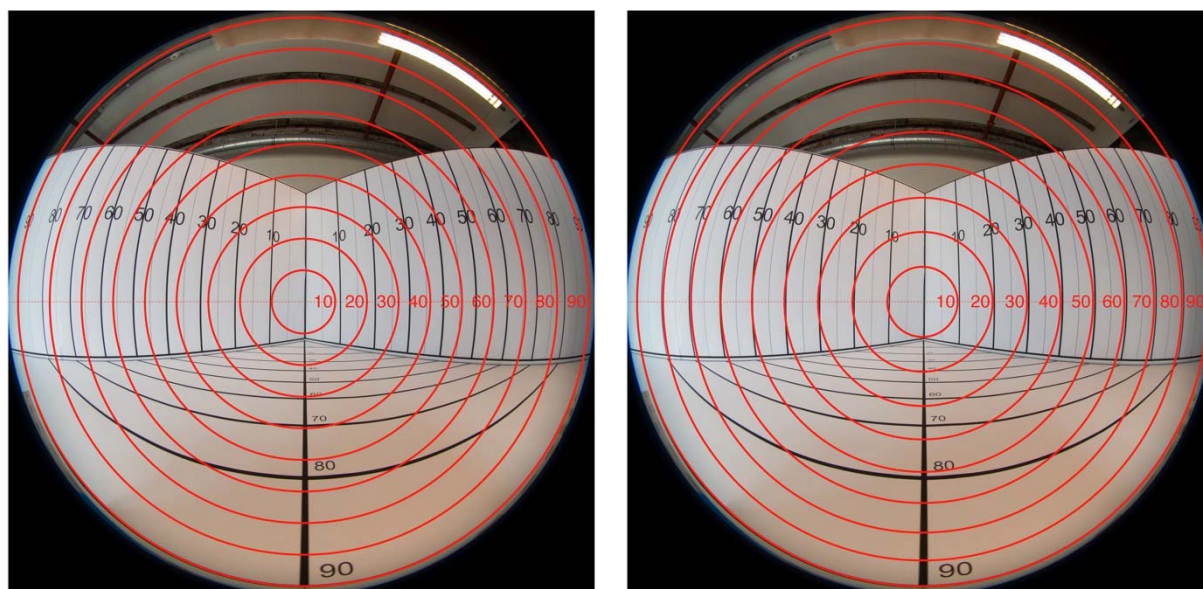


Figure 4 – Overly of the photograph of the set-up with the curves of an equi-angle (left) and equi-solid angle (right) projection

4 Conclusion

An easy to implement method to estimate a fisheye lens projection and total field-of-view was presented in this paper, using the case of a Sigma 4,5mm F2,8 EX DC HSM Circular Fisheye as an example.

Using this method it was possible to find that the lens has an equi-solid angle projection and a total field-of-view of around 185°. The manufacturers information regarding the lens projection is therefore confirmed but not the lens total view-angle, which was thought to be of 180°.

This method is based on a single photograph taken from a fixed position and has therefore the advantage of not requiring the rotation of the camera and therefore the need for additional steps (i.e. parallax correction) and mechanisms.

There is however the need to adjust the horizontal position of the camera to compensate for the existing pixel eccentricity of the image produced by fisheye lenses, in order to obtain more precise results.

5 Acknowledgements

The authors would like to thank Jan Wienold from EPFL for his views and discussions. Raquel Viula is funded by the Portuguese Fundação para a Ciência e Tecnologia (FCT) under the POCH programme, with grant number SFRH/BD/ 93536/2013.

References

- Bettonvil, F. 2005. Fisheye lenses. *Journal of the International Meteorological Organization*, 33(1), 9–14.
- Inanici, M.N. 2006. Evaluation of high dynamic range photography as a luminance data acquisition system. *Lighting Research and Technology*, 38(2), 123–134.
- Jacobs, A. 2012. Glare Measurement with HDR Photography. In: *11th International Radiance Workshop*. Copenhagen, DE: radiance-online.org.
- Jacobs, A. 2007. High Dynamic Range Imaging and its Application in Building Research. *Advances in Building Energy Research*, 1(1), 177–202.
- Ward, G.J. 1994. The RADIANCE Lighting Simulation and Rendering System. In: *Proceedings of the 21st Annual Conference on Computer Graphics and Interactive Techniques*. SIGGRAPH '94. New York, NY, USA: ACM, 459–472.
- Wienold, J. 2014. Daylight Glare analysis and metrics. In: *13th Radiance Workshop*. London, UK: radiance-online.org.
- Wienold, J. 2009. Evalglare, a Radiance based tool for glare evaluation. In: *8th International Radiance Workshop*. Boston, US: radiance-online.org.
- Wienold, J. and Christoffersen, J. 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), 743–757.