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Visual Interference from Street Lights: Field of Driver's View Analysis

Ai-Hong Chen, Saiful Azlan Rosli, Nurulain Muhamad

Optometry, Faculty of Health Sciences,
Universiti Teknologi MARA, Cawangan Selangor, Kampus Puncak Alam, Malaysia.

aihong0707@yahoo.com, saiful2797@uitm.edu.my, aein_muhamad@yahoo.com
Tel::+603-32584415

Abstract
The study aimed to perform field of human's view analysis to predict the visual interference of drivers from street lights positioning. A concentric circle with 13 quadrants was superimposed onto a photograph taken at the reference point for the field of human's view analysis. Visual interference from light source located close to fovea would be most disturbing and gradually reduced to the peripheral. From the field of driver's view analysis superimposed with real-scenario photos, none of the street light sources was found to fall within the fovea ring. The visual interference from street lights was negligible from the driver's view.

Keywords: Visual interference; streetlight; visual field; field of view.

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1.0 Introduction

Lighting plays an important role in determining the visual performance and visual comfort of the road user. Street light is installed to improve road safety at night by providing good visibility conditions for all road users (drivers, motorcycle or bicycle riders, or pedestrians) (O'Flaherty & Bell, 1997). Street lights also promote better traffic flow at night, by providing improved delineation of road geometrics, safer overtaking opportunities, and easier observance of traffic management measures. Seeing and being seen were fundamental prerequisites for the safety of all road users. Inadequate visibility is an important factor that influences the risk of a road crash among all types of road user (Konstantopoulos, Chapman, & Crundall, 2010; Lin & Kraus, 2009). The ability to detect any obstacles and danger on the road is vital for vehicle navigation. Timely visibility could inform the driver of the presence of obstacles and critical situations on the road (Demonceaux, Potelle, & Kachi-Akkouche, 2004). Good vision is a fundamental component of safe driving, being one of the most important sensory factors for driving (Boadi-Kusi et al., 2016). Integration of human, vehicle, and environmental factors are the important elements needed to have a safe operation of an automobile in any kind of road design (Bella, Calvi, & D'Amico, 2014). These elements are essential for a road user to detect objects ahead (i.e. road sign, obstacle or pedestrian). Safety in road performance is the main consideration for the efficiency of the transport system. Road safety consideration is an important aspect in the design of the road. Concerning the sight and road design, the visibility of the road user is of utmost importance to the safe and efficient operation of a road. Before drivers can respond to the objects, they must first detect them. The detection

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angle appears to be a good measure of detectability (Vaughan W. Inman, Balk, & Perez, 2013). It has been predicted that the number of Malaysian road fatalities will continue to increase from 8,760 (the year 2015) to 10,716 (the year 2020) (Sarani, Allyana, Marjan, et. al, 2012). There are many contributing factors to road accidents. Glare from road surrounding that includes road lightings and oncoming headlamps is one of the factors (Christie & Fisher, 1966; de Boer & Schreuder, 1967; Theeuwes, Alferdinck, & Perel, 2002). Adverse visual effects which arise from the presence of unshielded light sources in the field of view lead to the glare effect. The glare effect can be caused by direct or indirect light sources. Glare, especially at night, can be mitigated by design changes in roadways, automobiles and vehicle lighting (Mace, Garvey, & Heckard, 1994). However, these can be minimized through optimization of lighting conditions and viewing angles that helps for better viewing and identifying the objects while driving particularly at night (Gao, Podladchikova, Shaposhnikov et. al, 2006). Detecting and recognizing the objects while on the road particularly at nighttime involves a complex series of sequentially occurring events, both mental and physical. Although the eyes tend to be directed toward objects of current interest, parafoveal and peripheral visual information simultaneously plays important roles in the viewing of natural scenes for object detection and recognition (Loschky, Mcconkie, & Miller, 2005). Our study aimed to perform field of human's view analysis to predict the visual interference of street lights positioning from the driver's view.

2.0 Methodology

The cross-sectional study design was employed. Six study sites were designated to represent 6 different types of road designs: Roundabout, Fork junction, T-junction, Crossroad, Y-junction and Junctions with island. One pre-determined reference point was identified from the schematic diagram of each road design. The pre-determined points varied according to road design to reflect the practicality of the real scenario. The criterion in determining the point of reference was a point that might cast the most visual interference for the drivers (inclusion of most street lights within the field of driver's view). Photographs were taken from those reference points using a digital camera. The field of human's view analysis was subdivided into 4 rings (fovea ring, parafovea ring, perifovea ring, peripheral ring) and 4 quadrants (superior, inferior, nasal, temporal). A total of 13 quadrants was formed: fovea, superior parafovea, inferior parafovea, leavo parafovea and dextro parafovea; superior perifovea, inferior perifovea, leavo perifovea and dextro perifovea; superior peripheral, inferior peripheral, leavo peripheral and dextro peripheral. A concentric circle with 13 quadrants (Fig. 1) was superimposed onto photographs taken at the reference points for the field of human's view analysis. The number of streetlights on each quadrant was calculated. The angle of substances for fovea, parafovea, perifovea and peripheral was 5°, 8°, 18° and more than 18° respectively. Visual interference was presumed to be more if more street lights fell under inner rings compared to outer rings. The glare was reported to increase when degree angle decreases (Johannes J Vos, 2003; Patterson, Bargary, & Barbur, 2015). Visual interference from a light source located close to fovea should be most disturbing and gradually reduced from parafovea, perifovea to the peripheral. The flow of the research study was summarized in Fig. 2.

3.0 Results

Field of human's view analysis was carried out by identifying the total number of streetlights found for each quadrant for all 13 quadrants: fovea, superior parafovea, inferior parafovea, leavo parafovea and dextro parafovea; superior perifovea, inferior perifovea, leavo perifovea and dextro perifovea; superior peripheral, inferior peripheral, leavo peripheral and dextro peripheral. The analysis was repeated for 6 different road designs: Roundabout (Fig. 3), Fork junction (Fig. 4) T-junction (Fig. 5), Crossroad (Fig. 6), Y-junction (Fig. 7) and Junctions with island (Fig. 8). From the field of driver's view analysis superimposed with real-scenario photos, none of the street light sources was found to fall within the fovea, superior parafovea, inferior parafovea, leavo parafovea and dextro parafovea, superior perifovea, inferior perifovea, leavo perifovea and dextro perifovea, inferior peripheral and dextro peripheral ring, as in Table 1. From field of human's view analysis, street light source located at the superior peripheral visual field in 5 out of 6 road designs (83.3%), while street light was found at leavo peripheral in 1 road design (16.7%). From the Table 1, the mean and standard deviation of street light height, separation of street light and light post, road width and distance between light post (also have been illustrated in Fig. 3 to 8) were calculated. Different road designs displayed different parameters. Variation of those parameters was negligible as depicted by the standard deviation values. Less variability of street light height, separation of street light and light post, road width and distance between the light post in each road design reflected the consistency of design.

4.0 Discussion

The main purpose of installing street lightings was to improve visibility, to reduce vehicular accidents and to increase the perception of safety and security (Bruneau & Morin, 2005; Mustafa, 2005). Our field of driver's view analysis (83.3% street light at superior peripheral visual field & 16.7% at leavo peripheral) supported that current road lighting installation was sufficient to illuminate the road without causing any disturbing visual interference to road users. All positioning of street lights were at the peripheral region of the human visual field, which was far from the foveal region. The closer the light source to the line of sight, the more light scattering; leading to the loss of retinal image contrast and the resultant reduction in spatial vision. Reductions in spatial vision have been noted previously with decreasing glare angle of the 5-degree visual field, as a consequent of the foveal region being affected (Johannes J Vos, 2003; Patterson et al., 2015). The detection angle or angle of observation was a good measure of detectability in any kind of visual interference investigation (Vaughan W. Inman et al., 2013). High intensity of street light might lead to glare problem, but depending on the vertical and horizontal distances of the street light from the eye. To attain a high efficiency of the lighting installation (efficiency being expressed as mean road surface luminance per unit of power installed), light fittings favoured high intensities emitted at a small angle to the horizontal (de Boer & Schreuder, 1967). If the width of the road, the height of the columns, the spacing between the columns and the dimensions of the lights were controlled properly, glare could be limited.

The visual resolution was also been reported to rely primarily on the location of the glare source within the visual field (Intriligator & Cavanagh, 2001). Different road designs require different street lightings installation and positioning. The lighting provided should not only reveal the presence of objects but also gave the driver ample warning when approaching a roundabout. A confusing array of lighting units in the line of sight should be avoided, and some shielding of the light source might be necessary to guide the driver safely around the island and not across it (Lennox, 1946).

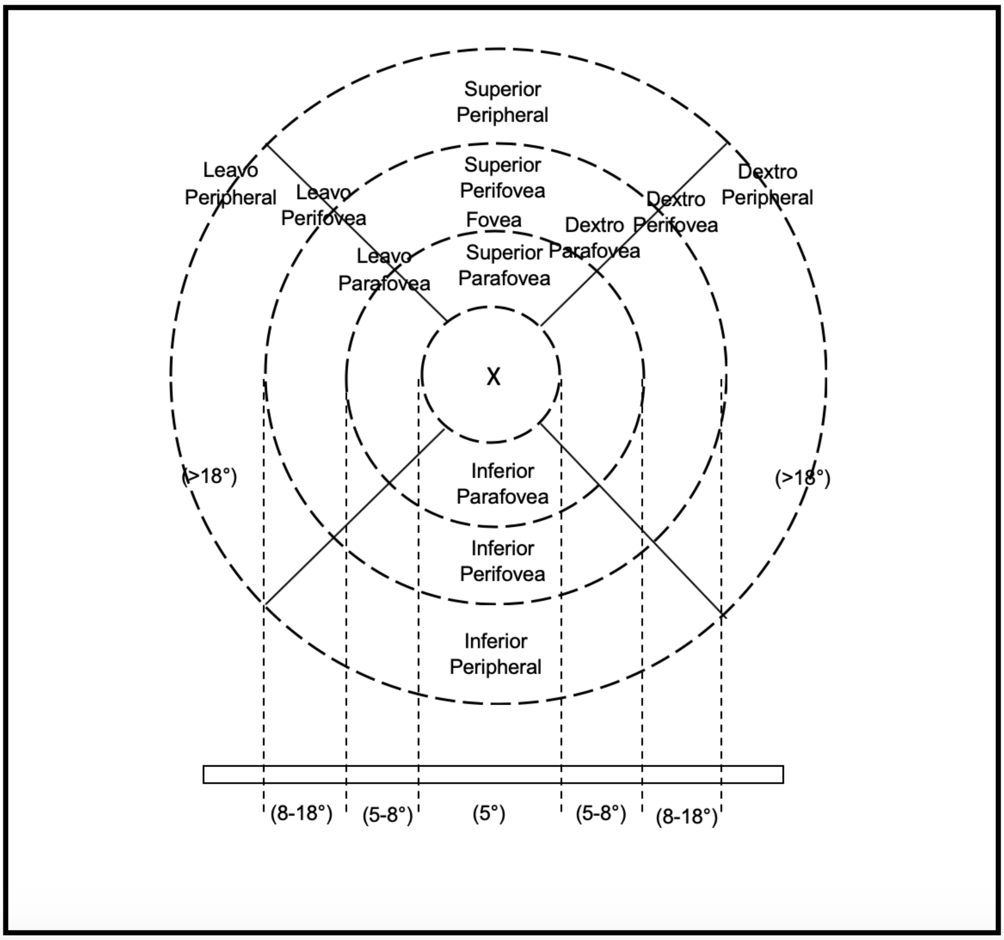

Fig. 1: A concentric circle with 13 quadrants (fovea, superior parafovea, inferior parafovea, leavo parafovea and dextro parafovea; superior perifovea, inferior perifovea, leavo perifovea and dextro perifovea; superior peripheral, inferior peripheral, leavo peripheral and dextro peripheral). X indicated the line of sight of the driver

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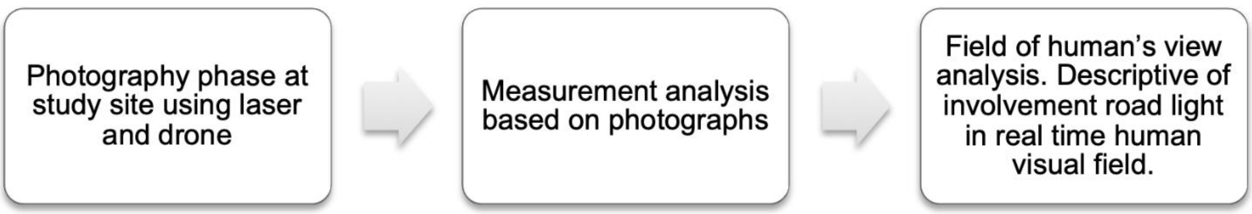

Fig. 2: The flow of research study

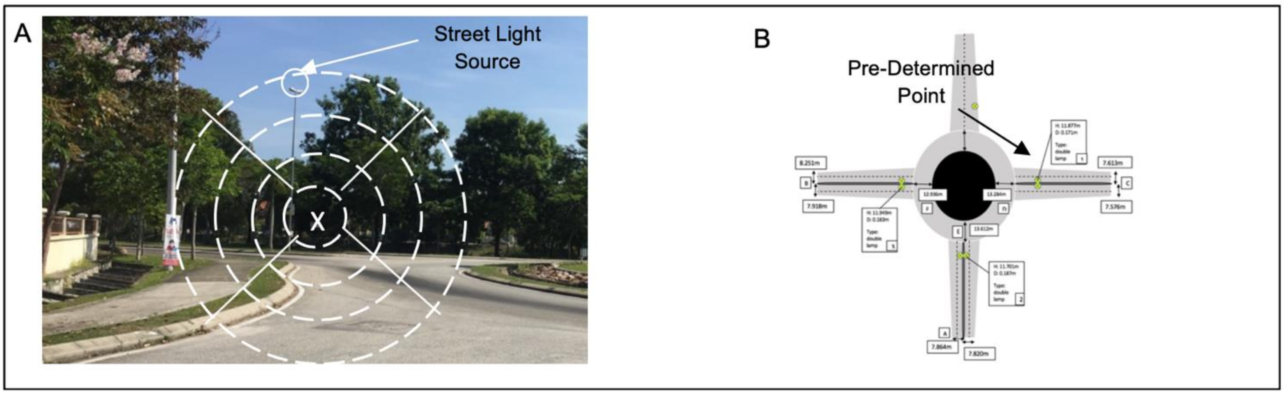

Fig. 3: Roundabout field of human's view analysis. (A) Superimposed of a full concentric circle on the photo. (B) Schematic diagram of road design in a real scenario (show pre-determined reference point that the photo was taken).

Fig. 4: Fork Junction field of human's view analysis. (A) Superimposed of a full concentric circle on the photo. (B) Schematic diagram of road design in a real scenario (show pre-determined reference point that the photo was taken).

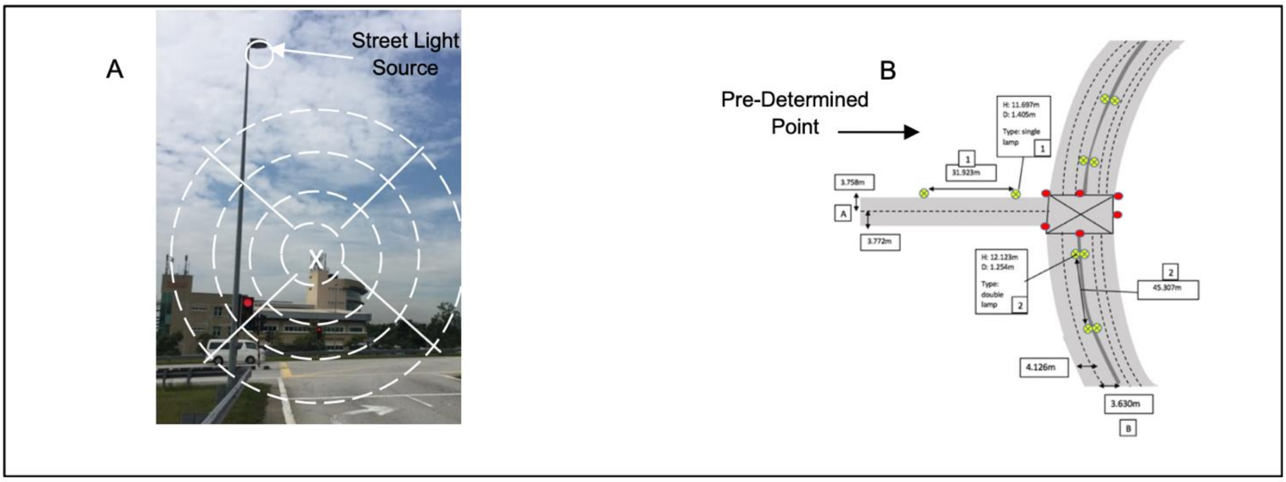

Fig. 5: T-Junction field of human's view analysis. (A) Superimposed of a full concentric circle on the photo. (B) Schematic diagram of road design in a real scenario (show pre-determined reference point that the photo was taken)

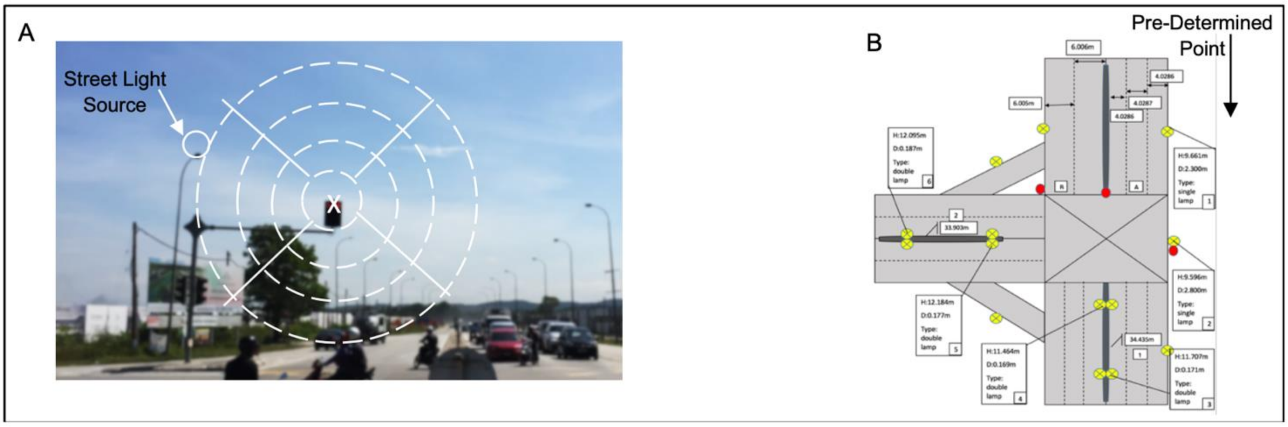

Fig. 6: Crossroads field of human's view analysis. (A) Superimposed of a full concentric circle on the photo. (B) Schematic diagram of road design in a real scenario (show pre-determined reference point that the photo was taken).

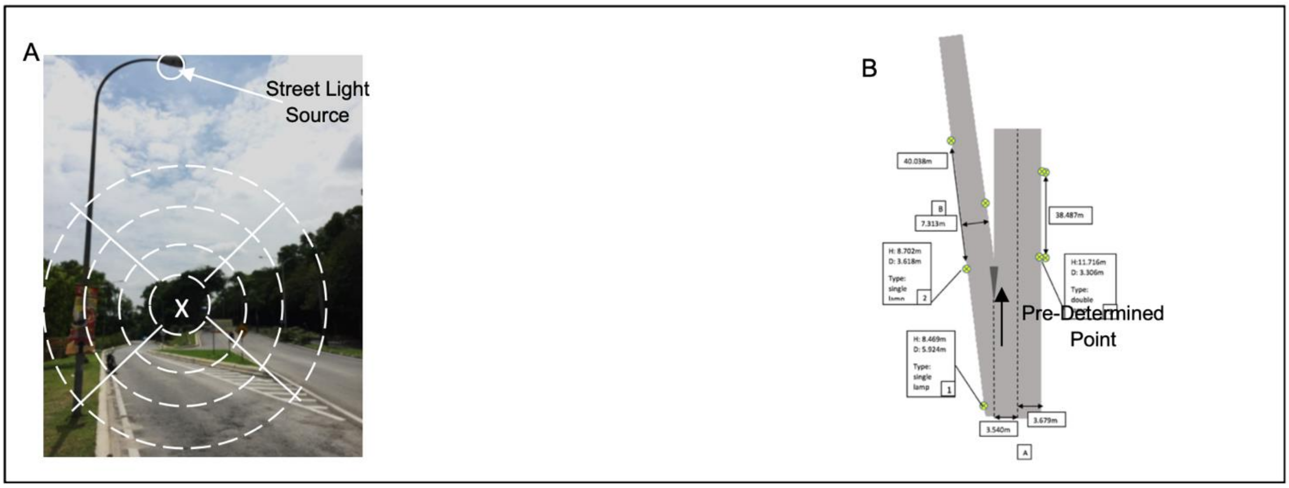

Fig. 7: Y-junction field of human's view analysis. (A) Superimposed of a full concentric circle on the photo. (B) Schematic diagram of road design in a real scenario (show pre-determined reference point that the photo was taken).

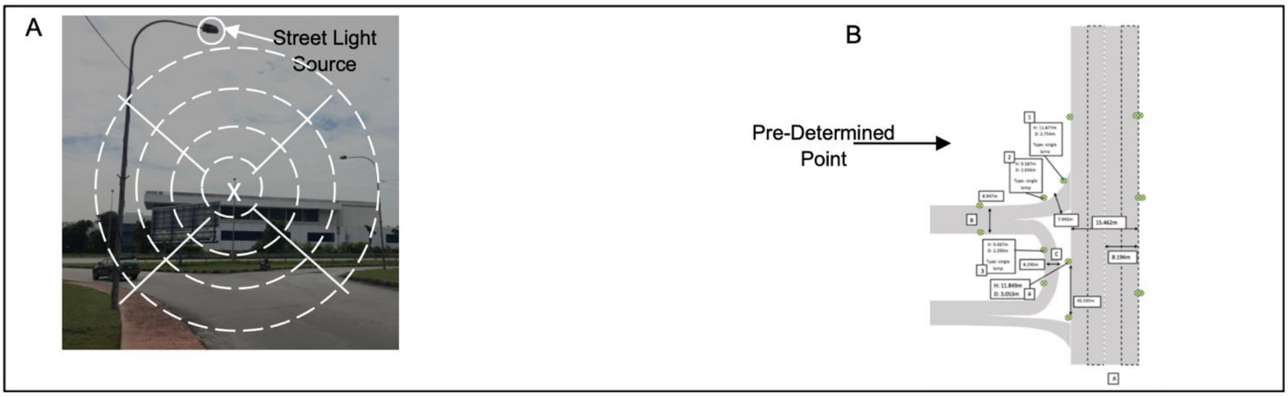

Fig. 8: Junction with Island field of human's view analysis. (A) Superimposed of a full concentric circle on the photo. (B) Schematic diagram of road design in a real scenario (show pre-determined reference point that the photo was taken).

Table 1. The summary of visual field quadrant analysis among six road designs.

		Road design					
Visual field quadrant		Roundabout	Fork Junction	T-Junction	Crossroads	Y-Junction	Junction with Island
Fovea							
Superior Parafovea							
Inferior Parafovea							
Leavo Parafovea							
Dextro Parafovea							
Superior Perifovea							
Inferior Perifovea							
Leavo Perifovea							
Dextro Perifovea							
Superior Peripheral		x	x	x		x	x
Inferior Peripheral							
Leavo Peripheral					x		
Dextro Peripheral							
Mean and standard deviation (m)	Street light height	11.84 ± 0.13	12.79 ± 1.95	11.91 ± 0.30	11.11 ± 1.17	9.63 ± 1.79	10.72 ± 1.36
	Separation of street light from post	0.18 ± 0.01	3.53 ± 1.07	1.33 ± 0.11	0.97 ± 1.24	4.28 ± 1.43	2.53 ± 0.46
	Road width	7.85 ± 0.26	3.80 ± 0.36	3.82 ± 0.22	4.82 ± 1.08	4.84 ± 2.14	8.40 ± 0.51
	Distance between light post	NA	47.24 ± 0.53	38.61 ± 9.46	34.15 ± 0.35	39.27 ± 1.10	45.80 ± 0.28

In any kind of junction or intersection, lighting was necessary to produce brightness, as seen by the observer, against which any object in the surrounding areas could be visible (Lennox, 1946). Road accident at a crossroad in Malaysia was reported at the third place that causing fatal (Mustafa, 2005). However, there was no specific factor that caused the high numbers of the accident reported. Multifactorial improper designs might be the cause. Lack of safe sight distance due to reduced visibility at night time and excessive unshielded light on road user's field of view were believed to play a major role.

5.0 Conclusion

The visual interference from street lights in all 6 different types of road designs was negligible from the driver's view.

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References

Bella, F., Calvi, A., & D'Amico, F. (2014). Analysis of driver speeds under night driving conditions using a driving simulator. *Journal of Safety Research*, *49*(February), 45–52.

Boadi-Kusi, S. B., Kyei, S., Asare, F. A., Owusu-Ansah, A., Awuah, A., & Darko-Takyi, C. (2016). Visual function among commercial vehicle drivers in the central region of Ghana. *Journal of Optometry*, *9*(1), 54–63.

Bruneau, J., & Morin, D. (2005). Standard and Nonstandard Roadway Lighting Compared with Darkness at Rural Intersections. *Transportation Research Record: Journal of the Transportation Research Board*, 116–122.

Christie, A., & Fisher, A. (1966). The effect of glare from street lighting lanterns on the vision of drivers of different ages. *Transactions of the Illuminating Engineering Society*, *31*(4_IEStrans), 93–108.

de Boer, J. B., & Schreuder, D. A. (1967). Glare as a criterion for quality in street lighting. *Transactions of the Illuminating Engineering Society (London)*, *32*(2), 117–135.

Demonceaux, C., Potelle, A., & Kachi-Akkouche, D. (2004). Obstacle detection in road scene based on road detection and motion analysis. *IFAC Proceedings Volumes*, *37*(8), 442–447.

Gao, X. W., Podladchikova, L., Shaposhnikov, D., Hong, K., & Shevtsova, N. (2006). Recognition of traffic signs based on their colour and shape features extracted using human vision models. *Journal of Visual Communication and Image Representation*, *17*(4), 675–685.

Intriligator, J., & Cavanagh, P. (2001). The spatial resolution of visual attention. *Cognitive Psychology*, *43*(3), 171–216.

Johannes J Vos. (2003). On the cause of disability glare and its dependence on glare angle, age and ocular pigmentation. *Clinical and Experimental Optometry*, *86*(6), 363–370.

Konstantopoulos, P., Chapman, P., & Crundall, D. (2010). Driver's visual attention as a function of driving experience and visibility. Using a driving simulator to explore drivers' eye movements in a day, night and rain driving. *Accident Analysis and Prevention*, *42*(3), 827–834.

Lennox, B. E. C. (1946). Street Lighting, 170–183.

Lin, M. R., & Kraus, J. F. (2009). A review of risk factors and patterns of motorcycle injuries. *Accident Analysis and Prevention*, *41*(4), 710–722.

Loschky, L. C., Mcconkie, G. W., & Miller, M. E. (2005). The Limits Of Visual Resolution In Natural Scene Viewing. *Visual Cognition*, *12*(6), 1057–1092.

Mace, D. J., Garvey, P. M., & Heckard, R. F. (1994). Relative visibility of increased legend size vs brighter materials for traffic signs - Transport Research International Documentation - TRID.

Mustafa, M. N. (2005). *Overview of current road safety situation in Malaysia*.

O'Flaherty, C., & Bell, M. G. (1997). *Transport planning and traffic engineering*. Elsevier.

Patterson, E. J., Bargary, G., & Barbur, J. L. (2015). Understanding Disability Glare: Light Scatter and Retinal Illuminance as Predictors of Sensitivity to Contrast. *Journal of the Optical Society of America*, *32*(4), 576–585.

Sarani, R., Allyana, S., Marjan, J. M., & Voon, W. S. (2012). *Predicting Malaysian Road Fatalities for the Year 2020 Predicting Malaysian Road Fatalities for the Year 2020 - MIROS*.

Theeuwes, J., Alferdinck, J. W., & Perel, M. (2002). The relation between glare and driving performance. *Human Factors*, *44*(1), 95–107.
Vaughan W. Inman, Balk, S. A., & Perez, W. A. (2013). *Traffic Control Device Conspicuity*.