International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

PO016

PEDESTRIANS TEND TO LOOK AT SCENES WITH HIGHER LUMINANCE AND GREATER SALIENCY AT NIGHT

Xin JIANG et al.

DOI 10.25039/x46.2019.PO016

from

CIE x046:2019

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

(DOI 10.25039/x46.2019)

CIE Central Bureau
Babenbergerstrasse 9
A-1010 Vienna
Austria
Tel.: +43 1 714 3187
e-mail: ciecb@cie.co.at
www.cie.co.at

PEDESTRIANS TEND TO LOOK AT SCENES WITH HIGHER LUMINANCE AND GREATER SALIENCY AT NIGHT

Jiang, Xin, **Yang, Biao**
School of Architecture, Harbin Institute of Technology (Shenzhen), Shenzhen, CHINA

DOI 10.25039/x46.2019.PO016

Abstract

The mechanism of luminous environmental parameters influencing pedestrian visual behavior is unknown. Field experiments using mobile eye tracking glasses device (ETG) were carried out in outdoor night streets in this study. Two luminous parameters of visual scene, luminance and saliency, were examined by coded image processing and statistical analyses as main influencing factors. The results indicate that distribution of fixations has a clear tendency to higher brightness (68.45%) and greater saliency (78.21%) comparing with chance level (50%). It is suggested that pedestrians at night time tend to look at areas with higher luminance and greater saliency regardless of context of the scene.

Keywords: Luminance, Saliency, Image Processing, Statistical Analyses

1 Introduction

The use of eye-tracking technology in lighting research enable better understanding of visual behavior. Past studies have investigated the visual behaviors and visual needs of various groups of lighting users, including drivers, pedestrians, customers, pilots, etc.

Fotios and Uttley (2014) used eye tracking devices to record pedestrians' visual fixations when walking outdoors in daytime and after dark with a concurrent dual task. Better understanding on pedestrian visual task (roads, cars, person, signage, etc.) were given by analyzing critical fixations. However, the general influence of luminous environmental parameters of whole scene (luminance, color, contrast, etc.) on visual behavior is still unknown.

Toscani (2013) found that people liked to fixate at points with above-average luminance when they looked at an object. In this study, visual fixation was regarded as one of the best indicators that could reveal the visual information acquired by a head-mounted, video-based eye tracker worn by subjects. The entire procedure was operated indoor with controlled environment using crafted objects.

Apart from luminance, saliency is also a possible significant factor that extracts visual attention represented by alternation of fixation. The saliency of a target object/area is the state and characteristic by which it differs from its neighbor areas. Harel et al (2006) gave a classic algorithm named "GBVS method" to draw the saliency map of a photo.

The aim is to reveal the effects of luminance and saliency on the distribution of visual fixation of pedestrians at night. The preliminary hypothesis is that pedestrians tend to look at scenes and areas with higher luminance and greater saliency. In this paper, field experiments using mobile eye tracking glasses device (ETG) were carried out in streets, for that natural visual behavior is more expected to be found in real-life scene, comparing with in virtual visual stimuli such as image or video presented on computer screen.

2 Methods

2.1 Outdoor Experiments

Four commercial streets were selected as experimental sites, which had relatively rich visual information and complex light environment. Sixteen adults (8 women and 8 women) were divided into four groups randomly corresponding to the four experimental sites with 2 women and 2 men in each group. All had good visual acuity and normal psychological state. At each street, four subjects (2 women and 2 men) wore ETG and walked freely for about ten minutes respectively at night. Sixteen sets of data were gained in total so as to compare them in different sites. Before each experiment, the ETG was recalibrated using near infrared pupil measurement and 3-point-calibration method to ensure a precise experimental result. The ETG took videos of what the pedestrians saw and recorded fixations during experimental time.

2.2 Image Processing

After experiment, videos and images were processed by Python and Matlab. The middle frame in the sequence among all frames of each fixation was captured as target images to be processed. All time labels were given by the ETG. The level of 8-bit grayscale of the pixel/area was defined as relative luminance of that pixel/area. This won’t distort the expected results, for that the relative luminance will only be compared within the same target image.

Resolution of each image was 1280×960, and luminance of each pixel was obtained and saved into a list (named as Luminance Sequence). Luminance of the fixation points in all target images were figured out by calculating the average luminance of the circular area around the fixation point. The radius of the area was 100px, corresponding to visual angles of 10 degrees after calculation.

For each target image, added the average-fixation-luminance into the image luminance sequence and sorted the sequence elements from small to large by value. Serial number of average-fixation-luminance was got to denote the position of the average-fixation-luminance in the whole luminance sequence. Divided the serial number by the length of the sequence, the position percentage was computed to show the result more directly.

The operation was repeated for all target images and the average position percentage of each video could be summarized, revealing the luminance level of the area that the subject preferred to fixate at.

All target images of each subject were processed into saliency images using GBVS method (Figure 1). Saliency images are actually grayscale images so the luminance-sorting progress above was carried out again. The luminance sequence of each target image and the average-fixation-luminance were obtained. Serial number and position percentage of average-fixation-luminance were calculated after adding the average-fixation-luminance into luminance sequence and sorting them. Thus average position percentage of each subject was computed to analysis the effect of saliency on fixation area.

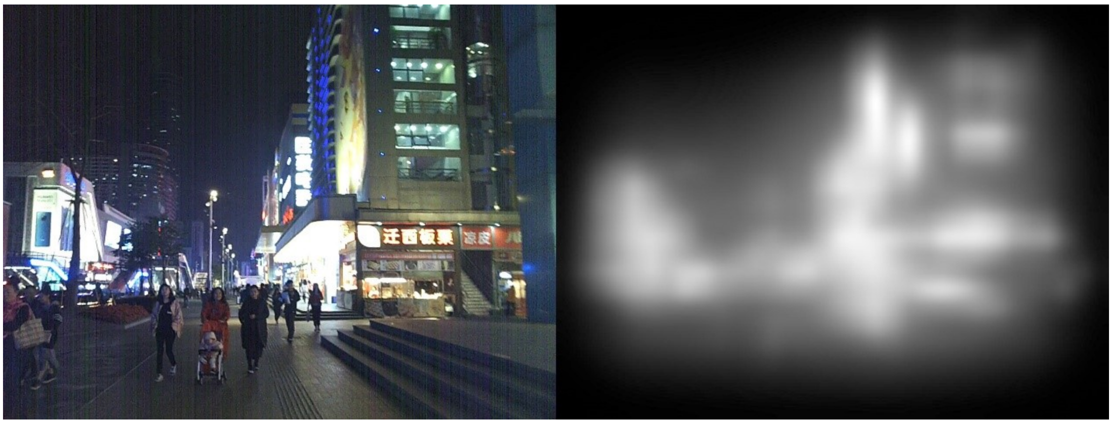

Figure 1 – An example of saliency Image processed by GBVS method

3 Results

3.1 Data Processing

Sixteen videos were taken and numbers of target frames of them were got (Table 1). Video name “M1N” means the video was taken by male subject 1 in the night and similarly the video taken by female subject 2 was named “F2N”.

Table 1 – Numbers of target images of all videos

Video	Number	Video	Number
M1N	624	F1N	828
M2N	534	F2N	553
M3N	731	F3N	849
M4N	681	F4N	474
M5N	689	F5N	582
M6N	614	F6N	536
M7N	548	F7N	460
M8N	829	F8N	610

M7N was randomly selected as an example to present the data processing procedure. After calculating, the sequence of position percentages of M7N was showed in Figure 2. Each point in the line chart showed the position of the average-fixation-luminance in the image luminance sequence of that target frame. An approximate distribution of luminance could be read from line chart.

The target images were transferred into saliency images and then were processed in the same way above. The sequence of position percentages of M7N was got in Figure 3. In this line chart, position percentages of the average-fixation-luminance were used to describe the distribution of saliency, showing the effect of saliency on fixation area.

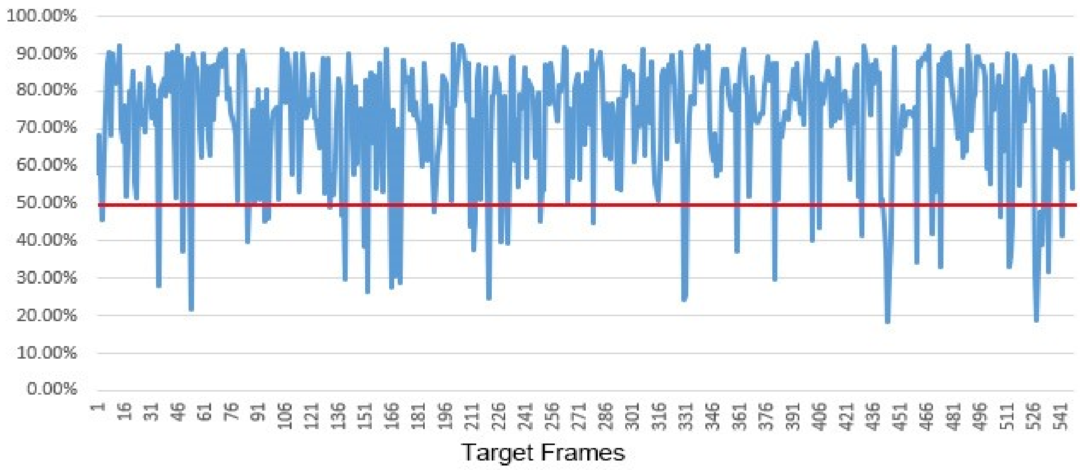

Figure 2 – Position percentages of luminance of M7N

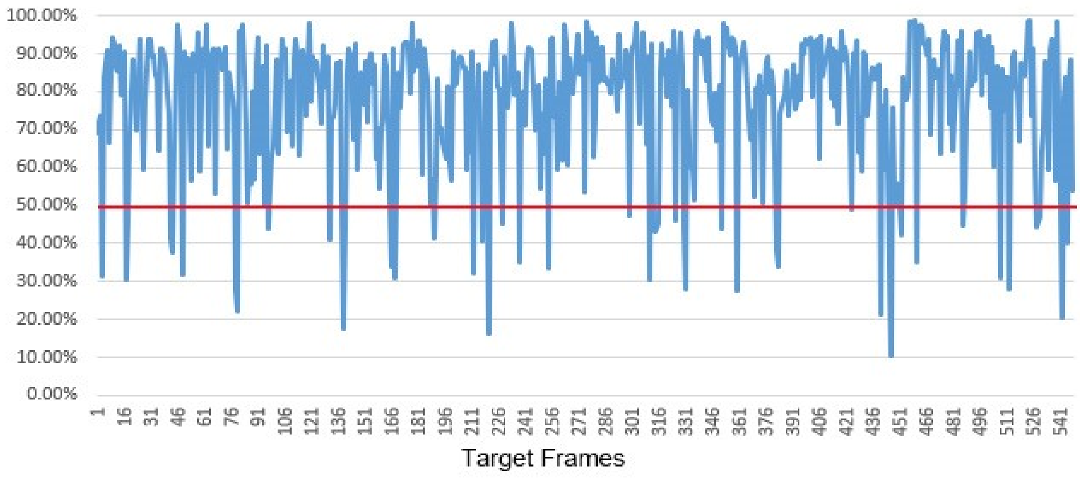

Figure 3 – Position percentages of saliency of M7N

The results of luminance and saliency were separated in the graphs above. Bivariate graphs of the position percentages of luminance and saliency were drawn in Figure 3.3 to see the joint distribution of luminance and saliency. This made the results more precisely and intuitively.

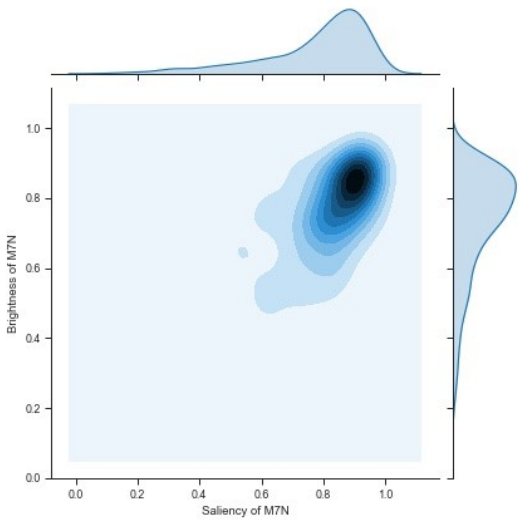

Figure 4 – Bivariate graph of luminance and saliency of M7N

3.2 Analysis

For each video of the experiment, two sequences of position percentages of average-fixation-luminance were extracted, one from initial target images describing luminance, and one from saliency images for saliency. Two average position percentages were computed respectively from two sequences of position percentages to represent the average level of luminance and saliency that the subject preferred during the experiment. The average position percentages of all subjects of both luminance and saliency are showed in Table 2:

Table 2 – Results of average position percentages of all subjects

Subject ID	**Luminance**	**Saliency**
F1N	67.63%	75.15%
F2N	71.98%	78.59%
F3N	68.95%	82.67%
F4N	69.11%	80.79%
F5N	71.28%	74.05%
F6N	69.87%	73.17%
F7N	70.36%	76.16%
F8N	67.63%	80.13%
M1N	67.42%	78.42%
M2N	65.54%	82.82%
M3N	61.03%	82.00%
M4N	68.14%	79.62%
M5N	71.62%	77.78%
M6N	69.11%	77.69%
M7N	72.74%	77.62%
M8N	62.79%	74.64%
AVERAGE	**68.45%**	**78.21%**

For each group of average position percentages, a single sample t-test was made to see if there was significant difference between the average value of this group and chance level (50%) (Table 3). It’s clear in the table that average position percentages of both luminance and saliency have significant difference with chance level (50%).

Table 3 – Single sample t-test

	t	**df**	**sig**
Luminance	23.050	15	$p<0.001$*
Saliency	37.218	15	$p<0.001$*

(*: $p<0.05$)

Based on the data, in the night subjects clearly looked at areas with higher luminance level according to the average position of 68.45%. Relatively speaking, saliency has a greater effect than luminance, concluded by an average position percentage of 78.21% in the night.

To see the joint distribution of luminance and saliency position percentages across gender, all data of the same sex were integrated together. Two bivariate graphs were drawn in Figure 5 (female in night and male in night).

Both of the graphs show a similar distribution. Therefore, gender is not an influencing factor. Position percentages of saliency are higher than that of luminance in general. This implies saliency is a more influential and precise factor than luminance.

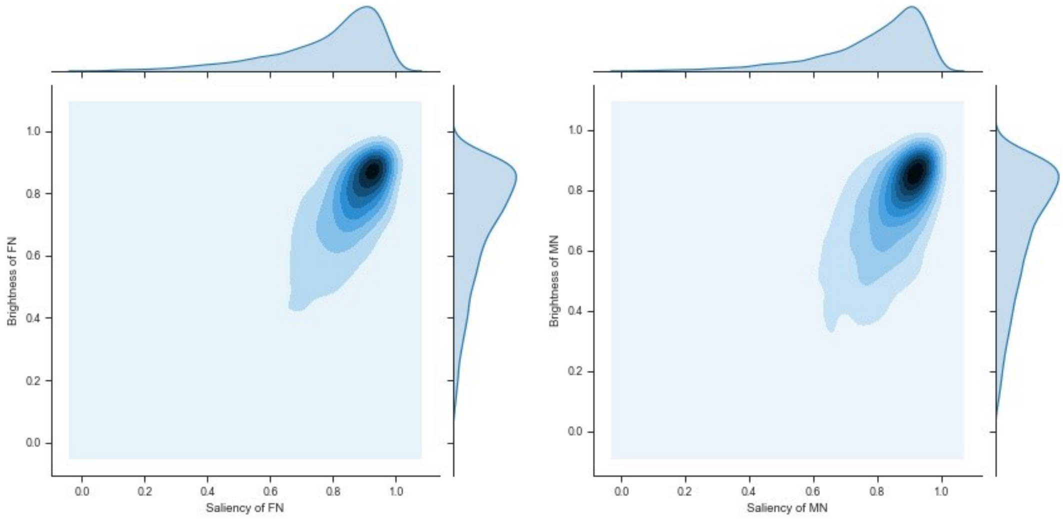

Figure 5 – Bivariate graphs of luminance and saliency of female and male

4. Conclusion

This study focuses on the effect of luminance and saliency of visual scene on distribution of fixation. Field experiments using mobile eye tracking glasses device (ETG) were carried out in outdoor night streets in this study. The results of image and data processing indicate that distribution of fixations has a clear tendency to higher brightness (68.45%) and greater saliency (78.21%) comparing with chance level (50%). It is suggested that pedestrians at night time tend to look at areas with higher luminance and greater saliency regardless of context of the scene. Current results are based on day experiment so further study on day and night comparison is expected.

References

Fotios S , Uttley J , Cheal C , et al. 2014. Using Eye-tracking to Identify Pedestrians Critical Visual Tasks. Part 1. Dual task approach[J]. Lighting Research & Technology.

Fotios S , Uttley J , Yang B . 2015. Using Eye-Tracking to Identify Pedestrians Critical Visual Tasks. Part 2. Fixation on pedestrians[J]. Lighting Research and Technology. 47(2):149-160.

Toscani M, Valsecchi M, Gegenfurtner K R. 2013. Optimal sampling of visual information for lightness judgments[J]. Proceedings of the National Academy of Sciences. 110(27):11163-11168.

J. Harel, C. Koch, and P. Perona. 2006. Graph-Based Visual Saliency. Proceedings of Neural Information Processing Systems (NIPS).

X. Hou, J. Harel, and C. Koch. 2012. Image Signature: Highlighting Sparse Salient Regions. IEEE Trans. Pattern Anal. Mach. Intell. 34(1): 194-201 (2012)