HUMAN AND COMPUTER RECOGNITION OF NIGHTTIME PEDESTRIANS

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Summary

This study investigates recognition and detection abilities of nighttime pedestrians by observers and using a photographic method. The examination of the visibility of nighttime pedestrians is done and afterwards evaluated by two methods. In the first method observers were asked to detect a pedestrian from a slowly moving vehicle. In each attempt, detection distance was recorded. From the place of detection, a digital photography was taken from the still vehicle. Analysis of the digital photography in computer graphic software is the keystone of the second method. The article also shows potential effect of retroreflector positioning on recognition of nighttime pedestrians.

Keywords: pedestrian, recognition, detection, visibility, retroreflector.

1. INTRODUCTION

Reduced visibility is the major contributor to pedestrian accidents at night. The visible distance of dark-clad pedestrians is typically less than one-third of the stopping distance at normal highway speed. [1] Statistics show, that number of driven kilometres is minor during nighttime traffic, but accidents, which happen in dark or in lower visibility conditions are usually tragic. When scaled by the number of miles driven, pedestrian fatality rate is three times higher at night. Part of the reason is a bigger chance of driver drinking and fatigue, but the critical factor is lower visibility due to reduced ambient illumination. [3]

This study is oriented on investigating and evaluating of visibility of still object – pedestrian. Measurements were made during night. In this article, there are included: 3 measurements, in 2 different sites, with 2 different vehicles, with 2 different groups of observers. Measurements and evaluation were made using 2 methods. In the first method, let us say "human method", we measured distances, when pedestrian was recognized by observer from the moving vehicle. In the second method, let us say "computer method", digital photographs were evaluated using a computer software. These digital photographs were taken from the still vehicle right from the place, where observer had detected a pedestrian. It allowed us to compare these two methods. We could analyze applicability and reliability of computer method. Furthermore, in 2 measurements there was investigated an effect of retroreflector positioning on recognition of silhouettes of pedestrians.

2. METHOD

2.1. Task

Observers performed a recognition task while seated in the rear passenger's seat of a vehicle, with head positioned above and between front seat backs. Two vehicles were used, in each case, with low beam lamps. Specifically, an observer's task was to say stop right in the moment of recognition of a silhouette of a pedestrian. The pedestrian was standing on the right side of the road, ahead of the vehicle. In each attempt, the vehicle was stopped as soon as possible, always with the same, specially trained driver. The speed of the vehicle was being held approximately on the level of 17 km/h.

2.2. Observers

35 observers participated in this study. 31 observers were aged between 20 and 27 and 4 were aged between 45 and 60. There were 11 females and 25 males in general. All observers were licensed drivers.

2.3. Sites

There are three measurements included in this study from two different sites. The first measurement was done on 19th June 2007 in Dresden, Germany. The second and the third measurement was done on 8th December 2007 in Dolný Hričov, Slovakia.

Since other vehicles, either preceding or oncoming, would influence the visibility of the pedestrians, the measurements were conducted on rural roadway section with no traffic (Dresden) and on the landing runaway of the airport Žilina in the time without operation (Dolný Hričov).

2.4. Equipment

There were two different vehicles with different headlights used in this study. In the first measurement, we used Mercedes Benz S 500 (made in 2007) with bi-xenon factory headlights. In the second and the third measurements, we used Škoda Octavia 1,6 GLX (made in 1999) with factory headlights, but with new bulbs OSRAM Bilux H4 12V, 60/55 W.

For measuring distances, we used measuring tape and white chalk. For taking digital photographs, we used digital SLR camera Nikon D70s with lens AF-S DX Zoom-Nikkor 18-70mm f/3.5-4.5G IF ED. We used tripod.

2.5. Procedure

The observers were seated in the middle of rear seat. There were two people in the vehicle during one measurement – driver and observer. They were told that this study investigated how well drivers can recognize pedestrian at night. Particularly, the observers were instructed to say stop whenever they were sure, they recognized pedestrian as a person (silhouette was relevant). The observers had known, where the pedestrian was standing – on the right side of the road. So, they had expected, where the pedestrian were going to appear. However, they were instructed to direct their gaze primary not on the right side of the road. The pedestrian was dressed in dark clothes, as shows fig. 1: black shoes, blue/grey denim jeans, dark matte jacket, and black cap with white marking.

Fig. 1. Photography of the pedestrian

After stopping the vehicle, detecting distance was recorded and digital photography was taken. Camera was mounted on a tripod. The tripod was mounted and fixed on the right front seat.

Conditions and digital photographs parameters:

Common parameters:

Sensibility ISO: *200*, Resolution: *3008 x 2000*,
Colour space: *Adobe RGB*, File: **.NEF*, *after WB calibration converted to *.JPG*,
Long time noise reduction was activated.

Measurement 1 parameters:

Date and time: *19.6.2007*, *23:00 – 2:00*
Weather cond.: *clear sky, light wind,15-17°C*
Shutter speed: *15s*, Aperture: *9*,
WB: *3800 K,* Colour space: *Adobe RGB*
Focal length: *18mm (27mm equal to 35mm film)*

Fig. 2. Sample photography – measurement 1

Measurement 2 parameters:

Date and time: *8.12.2007, 19:40 – 21:00*
Weather cond.: *clear-somewhat cloudy, humid, foggy, stronger wind occasionally, 4-6°C*
Shutter speed: *10s*, Aperture: *5,6*,
WB: *4000 K,* Colour space: *Adobe RGB*
Focal length: *40mm (60mm equal to 35mm film)*

Fig. 3. Sample photography – measurement 2

Measurement 3 parameters:

Date and time: *18.12.2007, 19:20 – 21:00*
Weather cond.: *clear-somewhat cloudy, light wind, 1-2,5°C*
Shutter speed: *10s*, Aperture: *5,6*,
WB: *4000 K,* Colour space: *Adobe RGB*
Focal length: *44mm (66mm equal to 35mm film)*

Fig. 3. Sample photography – measurement 2

Computer method

1. *WB calibration and JPG creation.*

*.NEF file was recorded during the measurement. The reason was simple. It allowed us to make a white balance calibration. All photographs, in particular measurement, they were calibrated to the same WB value. NEF file works in 12 bit depth for each of RGB channel and also enables specific photography settings: sharpness, tone compensation, colour mode, saturation. There it was used the best configuration to distinguish pixels with the similar level of luminosity: sharpness-high, tone comp.-low contrast, colour mode-Nikon Adobe

RGB, saturation-moderate. After this process, NEF was converted and saved as JPG with the highest quality.

2. JPG processing

For JPG processing, it was used conventional graphic software – Corel Photo Paint, which provides useful statistical information about a bitmap picture. A histogram is very good tool, how to measure luminosity distribution in a picture or in a selected area. The histogram represents a bar graph of the total number of pixels that appear at different levels of luminosity. The horizontal axis represents the luminosity level, while the vertical axis represents the number of pixels at each luminosity level found within the current image. The left side of the horizontal axis represents the darkest tones within the image, while the right side represents the lightest tones within the image. The histogram provides these statistics: weighted arithmetic mean, standard deviation, median, range, … JPG file distinguishes 256 levels (8 bit) of luminosity in one pixel.

Drivers detect pedestrians by their contrast, the difference in brightness between pedestrian and background. The keystone of the computer method was to compare luminosity of the pedestrian and luminosity of the background. There was used "mask" tool, which provides possibility to cut area of the pedestrian from the background. Histogram of the pedestrian was displayed. It was used "invert mask" tool, what allowed us to display histogram of the background. The difference of weighted arithmetic means of the pedestrian and the background is the measure of the contrast.

3. RESULTS

Primary task was to measure detecting distances and compare human to computer method. Secondary task was to investigate an effect of retroreflector positioning on recognition of silhouettes of pedestrians. Graphic charts show the results – figure 4 and 5. Correlation coefficient indicates the strength and the direction of a linear relationship between two variables – detection distances and differences of weighted arithmetic means of luminosity. The problem of visibility and recognition is complex and there is a great contribution from complicating factors.

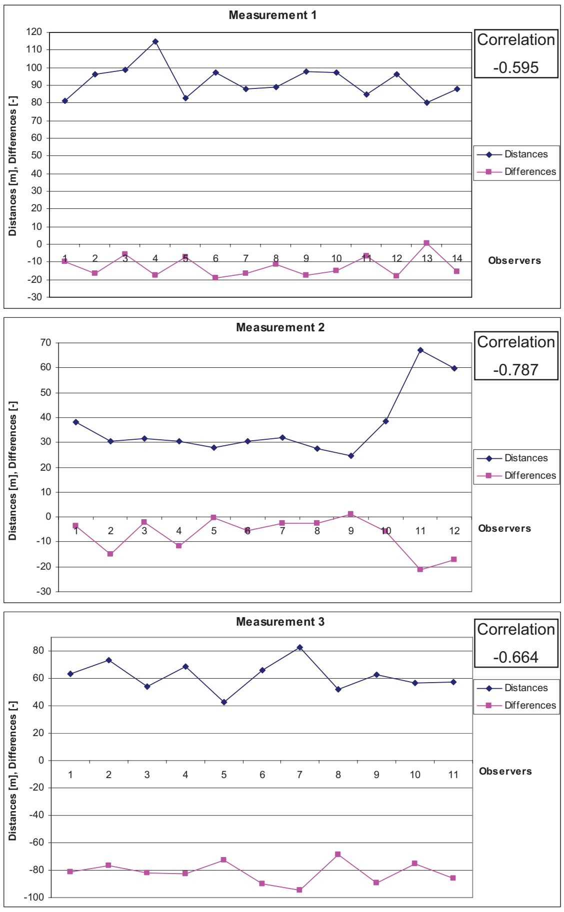

Fig. 4. Human – Computer recognition

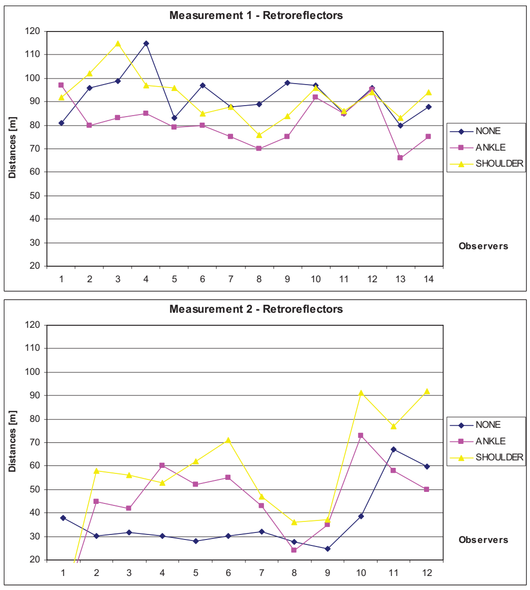

Fig. 5. Effect of retroreflector positioning

Correlatio	Negative	Positive
Small	-0,3 to -0,1	0,1 to 0,3
Medium	-0,3 to -0,5	0,3 to 0,5
Large	-0,5 to - 1,0	0,5 to 1,0

Fig. 6. Interpretation of a correlation coefficient

DISCUSSION

In the primary task we investigated recognition distances of the pedestrian in different conditions. Graphic charts – Fig. 4, shows distances, when the pedestrian was recognized by an observer. Mean recognition distances and standard deviation shows Fig. 7.

Measurement	Mean recognitio n distance	Standard deviatio n
1	**92,29 m**	9,33
2	**36,53 m**	12,66
3	**61,82 m**	10,47

Fig. 7. Arithmetic mean of recognition distances

The longest distances were measured in the measurement 1, when there was favourable weather and the measurement was done with Mercedes S with bi-xenon headlights. The shortest distances were measured in the measurement 2, when there was foggy weather and the measurement was done with Škoda Octavia. Thus, the influence of weather is evident. Foggy weather is one of the most dangerous weather conditions. It is also confirmed by the road accidents. When scaled by total number of traffic accidents, fatality rate is the highest in foggy weather.

The computer method, which we have tried, is not enough accurate. It is confirmed by a correlation coefficient. To improve accuracy, reliability and objectivity of the used method, it is necessary to improve evaluating process of the photographs. There are some proposed improvements:

a) An algorithm, which would be able to separate (automatically and reliable) pedestrian from background.
b) In the evaluation of luminosity of background, to divide it to close and far background. Another option would be to develop an integral method with stronger importance of the close background. However, there is a question what is the close background.
c) The same or similar process with pedestrian as in the case of background.

The best solution though would be to develop a method, which would be able to evaluate the contrast between pedestrian and background, reliable and quick. The existence of the algorithm, which would be able to recognize reliable the pedestrian by an analysis of an image, in visible, IR spectrum or using fused image, is the condition for developing intelligent and maybe autonomous vehicle safety system. The biggest problem is with the reliability, because there are uncountable different traffic situations in different weather conditions.

The secondary task was to investigate an effect of retroreflector positioning on recognition of nighttime pedestrians. Fig. 5. shows the results. It is necessary to point out, that we deal with static pedestrian and we tried to recognize the silhouette. We predicted, that the position of the retroreflector on the ankle would be the best for recognition. It is obvious from the Fig. 6., that the longest recognition distances were in the case of shoulder position. From the study of the photographs it is obvious and visible, that the ankle position of the retroreflector causes glare of the observer and also driver. Consequently, the ability to recognize a silhouette is reduced. There is no doubt, that the application of the retroreflector, whether fixed to shoulder or ankle, enabled visibility of the light spot from the long distance (more than 200 m).

Generally, many researches confirmed that pedestrians are visible at greater distances when they wear a reflective tag or vest. However, there are some drawbacks to reflective material. One is that reflective material sends light primarily in one direction. If the headlights hit the material at the wrong angle, the reflected light goes in the wrong direction and does not hit the driver's eye, and the reflector will appear dark. Further, if the reflective material covers a small part of the body, then the driver may detect its light but may not recognize it as being a person. Reflective material may also cause pedestrians to be overconfident. [3]

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