Letter

Perceived Brightness Evaluation of LED Light in Daytime Fog

Bobby Arief KURNIAWAN, Mohamad Fauzi bin ZAINI, Yoshio NAKASHIMA
and Mamori TAKAMATSU

University of Toyama

Received January 13, 2009, Accepted August 24, 2009

ABSTRACT

Investigation of the brightness of LED on traffic information board or traffic signs under foggy conditions is an important practical consideration, because LED becomes fainter and contrast is reduced. Especially when fog occurs at daytime, fog appears to be white. In these conditions brightness of LED is much dispersion into the fog. In this paper, by evaluating LED brightness with human visual sensitivity, it is understood that in daytime fog condition and different fog densites do affecting brightness evaluation. The colored LED light that contains a red component has high brightness evaluation point and the blue component has low brightness evaluation in all fog densities. However, blue color that containing red color also has high evaluation point. This paper result can contribute to air and land traffic safety which can prevent further accident happen.

KEYWORDS: brightness evaluation, LED light, daytime fog, dense fog

1. Introduction

Fog can be hazardous to traffic safety. Major traffic accidents with dense fog have occurred on expressways in Japan and serious accidents have often occurred in dense fog in various places. Fog is produced by suspension of very fine droplets in the air, so the amount of scattering is even larger and there is more loss of contrast and more backscatter. The amount of contrast lost depends on the size and density of the moisture droplets suspended in the air.

In optical fields, there exist several studies on fog, which places emphasis on the scattering of light and analysis of absorption characteristics. However, the actual state is that we have very few research papers in which color vision and visual characteristics of LED brightness in dense fog have been fundamentally and quantitatively measured using a psychological method.

There are several ways of measuring LED brightness. Two general types are prominent: psychophysical measurement and psychological measurement. Physical measurement measures the energy emitted or reflected by the source. Unfortunately this measurement of light does not represent what people see. For that reason, in this experiment we used psychological measurement to evaluate the LED brightness in fog.

2. Method

The equipment that is used in this experiment is shown in Figure 1. In this figure, the rectangular parallelepiped at the center is a fog generator, in which two windows consisting of acrylic plates are mounted on the both end of

Figure 1 System setup of experiment in plane view

Figure 2 LED Display Device
the rectangular case made of styrene foam, 1.8m in length, 0.45m in height and 1.0m in width. The interior has been painted all black except the acrylic windows to prevent any useless irregular reflection of light. Set on one of the windows of the box are LED display and the light receiver of illuminance meter, while the light source and the subject are set on the other windows. Fogging was performed inside of the styrene case and the change of LED brightness can be seen through the other window. The light source, as set in the upper right portion (Figure 1), is intended to measure the density of fog. To simulate daytime situation in this experiment, we used fluorescent lamp with illuminance value of 360 lx inside the styrene case. This illuminance value of fluorescent lamp is to simulate daytime situation of morning condition in winter season. In order to prevent the light from fluorescent not over lapping to the side that we measuring fog, only enlighten the half part of fog inside the styrene case.

Namely, the density of fog is determined by measuring the transmitted light from the light source with the illuminance meter in this experiment. The transmitted light from the light source with the illuminance meter consist of transmitted light directly from the light source and scattered by fog. To use the transmitted light in this experiment on behalf of the both light because of a very small amount of the latter. If the fog occurs in sufficient density in the case, the transmission of the light from the light source reduces, and consequently the value of the illuminance meter decrease as much. If conversely the density of fog reduces, the transmission of light increases, and accordingly the value of the illuminance meter increase as much. Note however that the amount of light source has been adjusted beforehand so that the pointer of illuminance meter should indicate 450 lx (corresponding to 100% of transmission) under the condition on no fog. The fog densities that use to observe this experiment are 6.8% (30 lx), 11% (50 lx), 22% (100 lx) and 33% (150 lx).

In this experiment droplet size of 10 µm and 50 µm were observed. Droplet size 10 µm is simulating size for radiation fog, 50 µm is to simulate advection fog.

Figure 2 shows the light on the left side being a white reference light, its illuminance level has been set to 30 cd/m². What appears on the right is one of the twelve test stimulus that seem to be of the same brightness after matching with the left one. Four color (R, Y, G and D) and two each of their intermediate colors make up the 12 colors that were used for observation in fog are show in Figure 3. The color differences between test stimulus light were all arranged to be constant respectively.

The experimental procedure, first of all, under of no fog condition, the subject was to match the test stimulus light on the right side with the white reference light on the left. This matching method was attempted for all 12 color of test stimulus light.

Figure 3 Plot point of 12 test stimulus colors in CIE1976 chromaticity diagram

Figure 4 Relationship between hue and LED evaluation brightness point

(a) Fog droplet size 10µm (Radiation fog)

(b) Fog droplet size 50µm (Advection fog)
After matching all the stimulus color, a sufficient density of fog was generated in the case and the subject was to observed the left white reference light not through the fog, and the right test stimulus light through the fog (Figure 2). The next task of the subject was to evaluate relatively the brightness of the test light which was observed through the fog. 10 points are given if the test light as bright as the white reference light. For example 5 points were given if the brightness of the test stimulus light was perceived as 50% of the white reference light and 7 points if the percentage was 70%. If this response was 10 points, therefore, it indicated that the brightness perceived even in the fog was same as that observed with no fog.

3. Experiment result and discussion

Result from the experiment can be seen in Figure 4(a) and (b). The experiment results are an average from 5 subjects with 5 trials per person. All graph parameters are fog density. When the fog density becomes thicker, it is harder to see LED light brightness inside the fog. In daytime fog condition, there was non selective scattering from visible light of fluorescent lamp (simulated sun) that causes fog to appear white. As the result, the brightness of Bluish Red (BR), Green and Red color LED is brighter than others. However, Blue had evaluation brightness in dense fog, also Greenish Blue (GB) and Bluish Green (BG) color of LED brightness are fainter. In dense fog of daytime fog condition, some subject could not see the GB, BG, YG, RY and YR color in their full color, but can only see monochromatic color light.

At any of the transmission factors, namely at any fog density, the brightness evaluation of including the Red component was high.

4. Conclusion

The fog effect is the result of reduced contrast. We see object not base on their absolute brightness or darkness, but on their difference between their brightness and background. Fog lowers contrast substantially, causing objects to become fainter and less distinct.

With visual perception under daytime fog the visual acuity of the subjects was lower due to fog droplet increase and caused the perception that all brightness of colored LED decreased with an increase in droplet sizes.

From this experiment we are now confident that our finding about these colors LED in fog together with the valuable result obtained from the experiment concerning visibility in dense fog, it can certainly give some hints to improve the vision and visual characteristics in dense fog.

Further experiments with more various size of droplet size are required to know how much droplet size can affect the LED light.

Reference