Graphics "Scheibenwurzel-Display" to Raise Traffic Safety

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Augmented reality (AR) increases traffic safety for manual drive and raises trust in autonomous driving. HUDs, transparent displays and video-AR have limits in terms of augmentation of ergonomics. We prototyped and evaluated successfully a 150 cm wide graphics RGB LED display at the bottom of the windshield. Optical measurements for selecting the best diffuser were made via FWHM and contrast.

1 Introduction

Increasing traffic safety and autonomous driving are one of the hottest trends in automotive today. Displays play an essential role such as reducing the driver distraction by Head-Up Displays (HUD) or visualizing the trajectory using autonomous mode.

However, the field of view (FOV) of HUDs is too low to provide real augmentation for many traffic situations. The visualization of an autonomous overtaking (see Fig. 1 top left) requires a FOV of about 20° by 10° (e.g., [1]; largest FOV 2023: 10° by 5°). This was the motivation to seek for alternatives to HUDs for augmentation: Fig. 1 visualizes and discusses the approaches for augmented reality (AR):

- Augmented reality (AR-) HUDs (top left)
- Transparent displays in windshield (top right)
- Video-AR (bottom left) on an existing display
- "Scheibenwurzel-Display" (bottom right, [2])

***Fig. 1** Approaches to present augmented information to drivers and passengers by different types of displays; Sources: BMW, Saint-Gobin, Mercedes, Volkswagen.*

2 "Scheibenwurzel-Display" with RGB LEDs

We propose a "Graphics Scheibenwurzel-Display" in order to achieve horizontal directional augmentation (Fig. 1 "LED Light Guide"), which could be supported by video-AR. The fundamental components and design of our prototype [2] are shown in Fig. 2:

- Left: WS2812 RGB LEDs were chosen because of their high luminance and software libraries (Arduino) for driving. They can be replaced for automotive use by ISELEDs [3].
- Center: We arranged eight stripes vertically (8 cm) with 150 cm width (active area) and 10 mm pixel pitch. The 1,200 pixels are driven at high frame rate by an Arduino Mega.
- Right: A diffuser in front of the LEDs "masks" the LED stripe structure for homogenization and to improve the visual perception.

As 10 mm LED pitch results in pixelated perception for in-car distances, we compared 10 types of diffusers by visual assessment and measurements (see §3). Four of them with very different characteristics are presented here:

- WH14: PLEXIGLAS®, translucent, diffuse
- Opal: Acrylic glass (PMMA), frosted
- Sandwich paper: Different types
- B&T: Acrylic glass, transparent, diffusing.

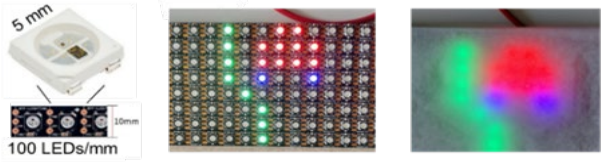

***Fig. 2** The fundamental components of our 8-line RGB LED pillar-to-pillar display using WS2812 RGB LEDs.*

3 Optical Measurements of Diffusors

We used two methods (see Fig. 3) to describe the user's perception for various distances d between LEDs and various diffusers:

- Full Width at Half Maximum (FWHM, left) is a measure how light of a single LED spreads
- Contrast (right) as modulation of the luminance between neighboring LEDs, e.g. sharpness

An Instrument Systems Lumicam was used as imaging light measurement device (ILMD, Fig. 3).

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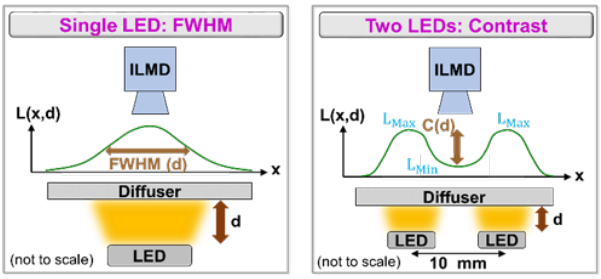

Fig. 3 *Measurement set-ups for acquiring Full Width at Half Maximum (FWHM, left, results see Fig. 4) and contrast C (modulation, right, results see Fig. 5).*

The results show Fig. 4 for WH14 for various distances d (LED to diffuser) are plotted as absolute (left) and relative (right) values for FWHM and contrast (Fig. 5). The absolute luminance drops with increasing distance d and the relative shape broadens for larger d, as the light output of the LED hits a bigger area. The chart of FWHM (left) and contrast C (right) of four diffusers are provided in Fig. 6. The characteristics of the curves match with the visual perception. Summarizing, WH14 is the most suitable diffuser regarding readability and pixilation.

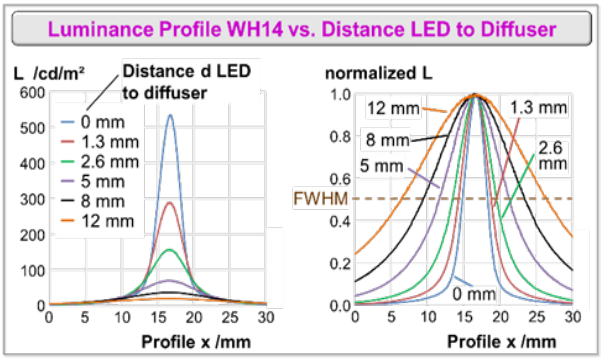

Fig. 4 *Luminance profiles for FWHM (left raw data, right normalized; only WH14 shown) of a LED with diffuser.*

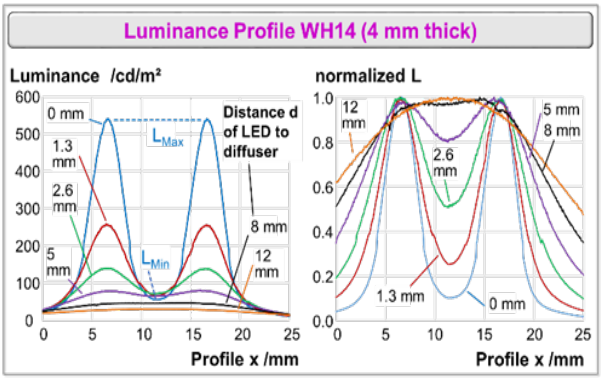

Fig. 5 *Luminance profiles for contrast C (left raw data, right normalized) of two LEDs for WH14.*

4 Evaluation of Scenarios with Subjects

The evaluation was performed in a seating buck with video projection (two examples show Fig. 7). Our 20 subjects rated the “Scheibenwurzel-Display” as “great & valuable”, details see [2].

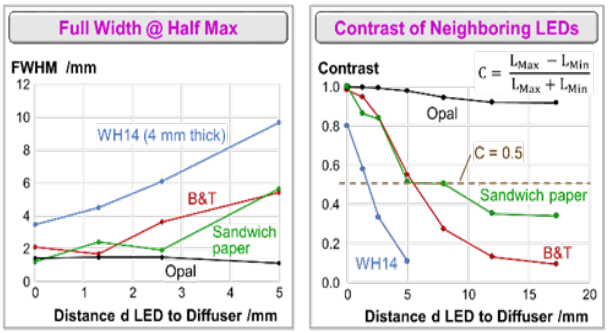

Fig. 6 *Measurement results with distance d from the LED(s) to the diffuser: FWHM (left), Contrast C (right).*

Fig. 7 *Examples of dangerous situations: Pedestrian enters road (left) and navigation directs to the left lane (right), which is occupied by a car. Subjects rated these examples as being very helpful to raise traffic safety.*

5 Summary

We have developed, prototyped and successfully evaluated a graphics pillar-to-pillar RGB LED “Scheibenwurzel-Display”. The following results and achievements were made:

- The display has a size of 150 cm x 10 cm with 150 by 8 RGB LEDs (1,200x WS2812, 10 mm)
- Many diffusers were visually assessed and measured. A “WH14” diffuser (4 mm thick) was evaluated as highly suitable.
- 20 subjects evaluated the prototype in a 1:1 scale seating buck incl. video very positively.

Our findings help to design “Scheibenwurzel-Displays” with optimized user information and augmentation. It’s combination with video-AR on an existing display results an optimum combination for augmented reality in terms of ergonomics and cost.

References

[1] K. Blankenbach, “Requirements and System Aspects of AR-Head-Up Displays,” in IEEE Consumer Electronics Mag. **8**(5):62-67 (2019)

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