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Poster

A Study on the Changes in Attention Awareness Induced by Attention Guidance Methods in Driving Simulators Using Biometric Data

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Abstract

Driver distraction is a leading cause of delayed reactions and accidents. To address this, driving simulators provide a controlled setting to safely simulate a circumstance that needs a quick response, allowing drivers to practice and improve reaction times. This study develop three attention guidance methods within a driving simulator to enhance drivers' focus and responsiveness in such circumstances. The methods' effects on driver attentiveness and response are evaluated through objective and subjective measures, including electrocardiogram data and questionnaires. The results indicate that the Arrow and Point methods potentially reduce psychological burden, and aid in accident prevention.

CCS Concepts

• ***Interaction*** → *Human-Computer Interfaces;* • ***Interaction*** → *Assistive Interfaces;* • ***Methods and Applications*** → *Computer Vision;*

1. Introduction

Visual distractions increase a risk of speeding and accidents, especially for younger drivers. In a circumstance that needs their quick response, visual distractions delay reactions and heighten stress, making accidents more likely [SYZ*22]. Driving simulators mimic distracted driving by safely replicating real scenarios to measure driver reactions and develop interventions. The authors' previous work shows that well-designed attention guidance methods could provide a good discipline for reducing accidents by making drivers refocus and cope with visual distractions.

Physiological data such as brain waves and heartbeats provides an objective criterion to evaluate the impact of attention guidance methods on drivers. The study [RMM*24] examines the relationship between cognitive impairment, mental workload, and heart rate variability (HRV), showing that HRV decreases under high mental workload, indicating reduced physiological adaptability. The decrease in HRV is associated with psychological stress and distraction, leading to longer reaction times and increased driving errors. RMSSD [SG17] is one of HRV metrics for assessing short-term heart rate variability and parasympathetic nervous system activity.

$$\mathrm{RMSSD} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N-1}(RR_{i+1} - RR_i)^2} \qquad (1)$$

, where RR_i and RR_{i+1} are successive RR intervals at the time i, and N is the number of RR intervals.

This study will explore the effects of the previously proposed three attention guidance methods on drivers' mental load of attention with RMSSD during driving using a driving simulator.

2. Attention Guidance Methods

In this study, three attention guidance methods are developed: Point, Arrow, and Dusk. They are summarized as follows:

- **Point Method :** The Point method uses a small blue dot on the target object to attract the driver's attention (Figure 1). The dot appears when the driver is within 30 meters of the target and remains until the target is passed.
- **Arrow Method :** The Arrow method uses a dynamic blue arrow at the screen's center to guide the driver's attention toward the target(Figure 2). As the driver nears within 30 meters of the target, the arrow moves from the center towards the target and remains until the target is passed.
- **Dusk Method :** The Dusk method uses a shadow layer around the target to direct the driver's attention (Figure 3). The shadow appears when the driver is within 30 meters, lasting for 1.0 second. Its intensity decreases from 0.4 to 0.0 toward the target, ensuring visibility and reducing accident risks.

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Figure 1: *The Point method.*

Figure 2: *The Arrow method.*

Figure 3: *The Dusk method.*

3. Experiment

The experiment evaluates how different attention guidance methods could affect drivers' mental load of attention to a circumstance that needs their quick response. Subjects are asked to drive on the given route over four laps under four conditions: "No Hint," "Point Method," "Arrow Method," and "Dusk Method." On the sidewalk seven pedestrians walk and they might cross suddenly the road. They are the targets that the subjects pay attention to and the method is supposed to guide the subjects eyes to as well. Each condition lasts 7 minutes. Thirteen subjects (1 female, 12 males) took part, with 6 holding driver's licenses. The procedure involves a 10-minute practice,an almost 7 minute driving in a randomly selected condition with electrodes attached, a 15-minute rest, and a questionnaire. It repeats until all the four conditions are tested. The questionnaire assesses their subjective responses to the method such as drivers' stress and their perceived effectiveness from attention guidance methods. Both stress and effectiveness are rated on a 1-to-7 scale, where 1 represents the lowest level of stress or effectiveness, and 7 represents the highest.

4. Result

Figure 4 shows an average of RMSSD value at each condition. RMSSD is higher for the Arrow and Dusk methods, indicating comparatively reduced stress, but a one-way ANOVA shows it is not statistically significant [$F(3,48)=0.1907$, $p> .05$]. Figure 5 shows an average of accident rate, which is defined as the rate of incidents involving collisions with pedestrians, at each conditions. The No Hint condition has the highest rate (15.38%), while the Arrow method had the lowest (3.30%). A one-way ANOVA [$F(3,48)=3.39$, $p< .05$] confirms significant differences between these condition,and successive multiple comparison tests show that the Arrow method has a significant difference from No Hint[MD = 0.85, $p < .05$]. Figures 6 and 7 are the results of the questionnaire about the subjects' perceived stress and the method's effectiveness at each condition. They show the high stress at No Hint and the lowest one at the Arrow method. A one-way ANOVA confirms a significant difference among the conditions[$F(3,48)=3.68$, $p< .05$], and successive multiple comparison tests show that both the Arrow [MD = 1.38, $p < .05$] and Point [MD = -1.23, $p < .05$]

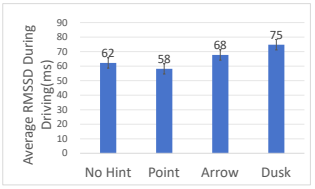

Figure 4: *Average RMSSD values during driving.*

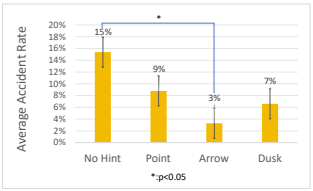

Figure 5: *Average accident rates across four conditions.*

methods have a significant difference from the No Hint condition. Figure 7 illustrates variations in the perceived effectiveness at each condition, with the Arrow method rated the most effective and the Dusk method the least. A one-way ANOVA confirms these differences are statistically significant[$F(2,36)=8.75$, $p< .05$]. The successive multiple comparison tests show the Arrow method's superior performance in enhancing the effectiveness of attention guidance methods, as indicated by significant differences compared to Dusk [MD = -2.31, $p < .05$] and Point [MD = -1.46, $p < .05$].

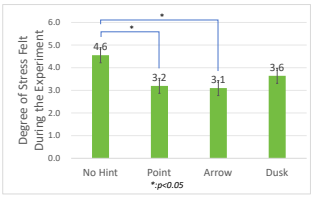

Figure 6: *Degree of stress felt during the experiment.*

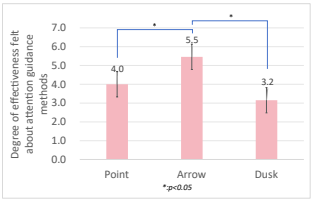

Figure 7: *Degree of effectiveness felt about attention guidance methods.*

5. Conclusions

This study examined the effects of three attention guidance methods on drivers' mental load of attention during driving using a driving simulator. The result showed that accident rates were significantly lower under the Arrow method compared to No Hint, highlighting its potential to improve driver safety, and the Arrow and Point methods significantly reduced the drivers' stress. The Arrow method was also rated as the most effective guidance method, showing its benefit in enhancing driver attention. Future studies will expand participant numbers and assess long-term effects under varying weather conditions to enhance driver training and safety.

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