Enhancing the Young Driver's Experience: The Impact of Gamified AR-HUD Interfaces on Fatigue Management, Concentration Improvement, and Boredom Reduction during Long-Distance Monotonous Driving

Goldsmiths
UNIVERSITY OF LONDON

By Zhengxiong Yu, 33765648
Academic Supervisors : Nicolas Hine

Abstract

This study developed a gamified AR-HUD interface for young drivers to combat fatigue on long drives. Using a variety of research methods (usability testing, eye-tracking, EEG recordings, user interviews and other qualitative research methods), the interface was found to be effective in maintaining attention and minimising distractions. Whilst enhancing the driving experience and reducing fatigue, some features may also be distracting. The balance between safety and playfulness is crucial and provides insights for future automotive interface design.

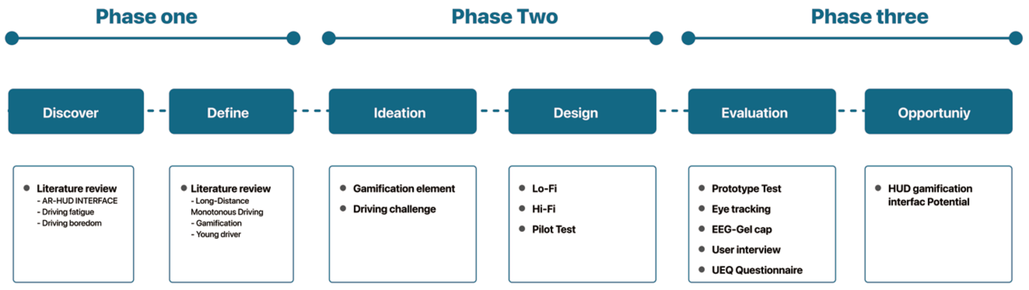
Introduction & Background

The car is no longer an ordinary means of transport for people. With the rapid enhancement and development of technological innovations in modern devices and the high demands of the current society, the amount of time people spend in their cars has gradually increased and the car has become a second living space for the drivers.Schroeter, Oxtoby & Johnson (2014)studied that it is a well-known fact that driving is actually boring, and when the driver remains in this state for long periods of time it can lead to dangerous driving behaviour. More importantly, excessive driving time not only increases driver fatigue and speed, but also seriously reduces driver alertness, attention and driving performance, and may jeopardise transport safety and lead to serious injury accidents (Ting, Hwang, Doong, Jeng, 2008).

In order to reduce the state of boredom and fatigue in people's daily driving activities, automobile manufacturers have developed more and more advanced and high-level in-vehicle infotainment systems, and the comfort of the driving process has been improved, but the interface of the controls and displays has become more and more complex, which results in the need for drivers to exert a certain amount of mental effort to complete the operations during driving.Schnelle-Walka & Radomski (2019) Study that different driving tasks compete for the driver's attention, the driver's attention will be diverted from the road outside the vehicle to the devices and controls inside the vehicle, the driver will be faced with both visual information from the road ahead and information provided by the in-vehicle systems, which will increase the driver's cognitive load and impose an additional burden, and prolonged periods of being in such a state will put the driver into danger.

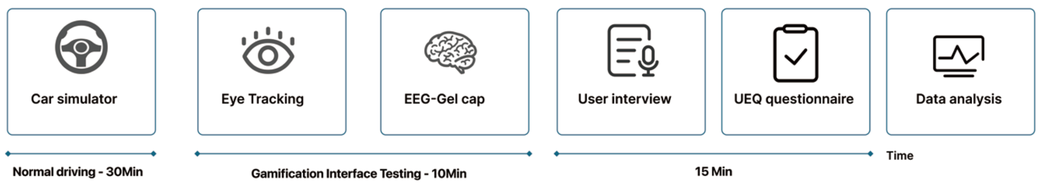
Study Methodology

After completing the literature review, the AR-HUD interface, driving fatigue & boredom, has been further deepened. And it was found that in young drivers are very prone to fatigue or boredom during long-distance driving, leading to safety accidents. Therefore, we wanted to explore whether adding gamification elements to driving activities could effectively alleviate driving boredom and enhance drivers' car control skills and performance. A number of ideas for gamified driving activities were then produced, and the design of low-fidelity and high-fidelity interfaces was completed as well as pre-tested. Formal testing of the HUD gamified interface was then conducted and data was captured by professional equipment (eye-tracker, EEG), and then data analysis revealed that the AR-HUD gamified intervention was an effective intervention to help drivers improve their attention and alertness.



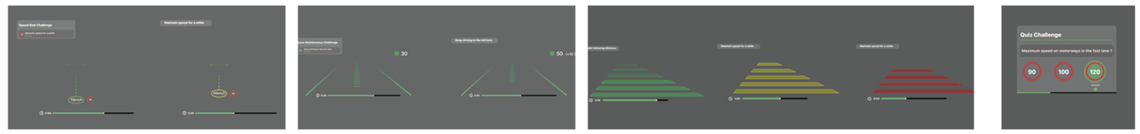
Testing & Evaluation

Participants underwent a 40-minute driving task (30-min normal driving, 10-min gamified testing), with effects of fatigue and boredom observable post-30 minutes. The full experiment, including familiarisation, testing, rest, interviews, and UEQ completion, spanned 100 minutes. Data analysis will prioritize eye-tracking data to discern attention shifts and distractions with the gamified interface. Video recordings will be cross-referenced to assess facial reactions, driving patterns, and game screen dynamics. Additionally, EEG data will be evaluated for brain workload.



Design

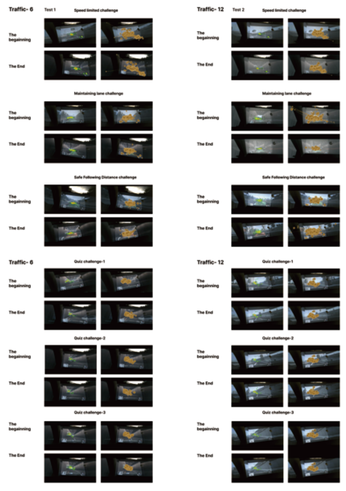
The idea for the HUD gamification challenge came primarily from the fact that common driving mistakes (not being able to maintain lane, not being able to control speed well, not being able to keep a safe distance between cars) can help to help drivers improve their car's control and driving performance



Speed limited challenge | **Lane Maintenance Challenge** | **Following Distance Challenge** | **Quiz Challenge**

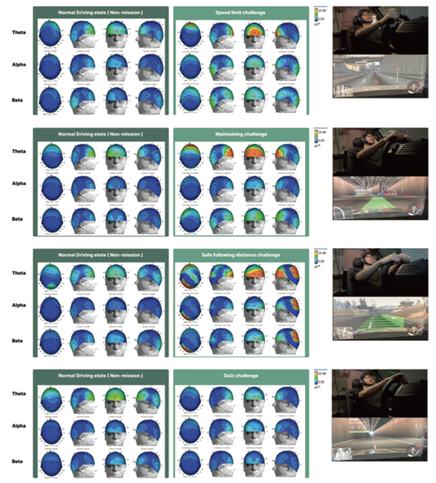
Research Results

Eye Tracking - Heat Map



Heat map analysis showed that participants were usually able to concentrate and experienced slight distractions in some cases (speed limit challenges), mainly due to the settings of the game interface

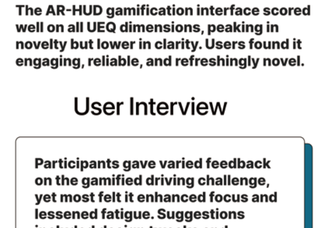
EEG



Brainwave analyses showed varied activity during driving tasks. Increased Theta waves indicated active engagement, while stable Alpha and Beta waves suggested a manageable brain load without overburdening.

UEQ Questionnaire

Scale	Mean	Comparison to benchmark	Interpretation
Attractiveness	1.00	Below average	50% of results better, 25% of results worse
Perspicuity	0.63	Bad	In the range of the 25% worst results
Efficiency	0.88	Below Average	50% of results better, 25% of results worse
Dependability	1.00	Below Average	50% of results better, 25% of results worse
Stimulation	0.94	Below Average	50% of results better, 25% of results worse
Novelty	1.31	Good	10% of results better, 75% of results worse



The AR-HUD gamification interface scored well on all UEQ dimensions, peaking in novelty but lower in clarity. Users found it engaging, reliable, and refreshingly novel.

User Interview

Participants gave varied feedback on the gamified driving challenge, yet most felt it enhanced focus and lessened fatigue. Suggestions included design tweaks and enhanced visuals/audio. Younger drivers favored it, but distraction concerns remain.

While promising, the gamified challenge needs refinement for diverse drivers.

Conclusion & Future work

- **The main findings were that the HUD gamified interface was better at focusing driver attention on the main driving task and that the EEG showed that the gamified interface did not significantly increase the cognitive load of the drivers.**
- **The HUD gamification interface can improve driver concentration and situational awareness to a certain extent, and reduce driving fatigue and boredom, but it still needs to be optimised in order to balance gameplay and safety.**
- **Expanding the diversity of the research sample**
- **Consider real-world road testing**
- **Perform technical and design optimisation**
- **An in-depth exploration of eye-tracking heat maps & sweep trajectories, and brain activity**