Personalized HMI to enrich the user experience and reduce driver distraction

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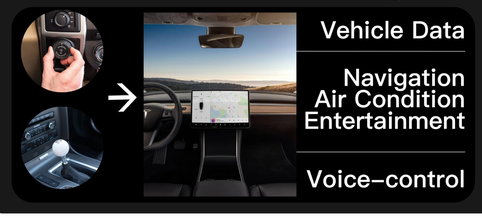
Abstract

In the modern era of automotive advancement, human-machine interface (HMI) systems have redefined how drivers interact with their vehicles. This paper delves into the evolution of these interfaces, from mechanical controls to the ubiquity of touchscreens, and the inherent challenges posed by their design in ensuring driver safety. The expanding capabilities of HMIs have introduced features such as entertainment, navigation, and real-time performance data, but their safe integration remains paramount. The research problem posits how HMIs can be personalized to maximize user experience without compromising safety. This study incorporated an experiment involving six testers (split between novice and experienced drivers) to assess their interaction with a traditional HMI interface. Behavioral, objective, and subjective measures were used, including heart rate monitoring and eye-tracking. Preliminary results highlighted potential pitfalls in current HMI designs, such as unclear icons and excessive menu layers. An advanced HMI design is proposed, focusing on a user-centric approach, intuitive layout, and information prioritization to minimize cognitive load and distractions. The evaluation underscores the need for further research, considering real-world driving scenarios and a more diverse participant demographic.

Introduction & Background



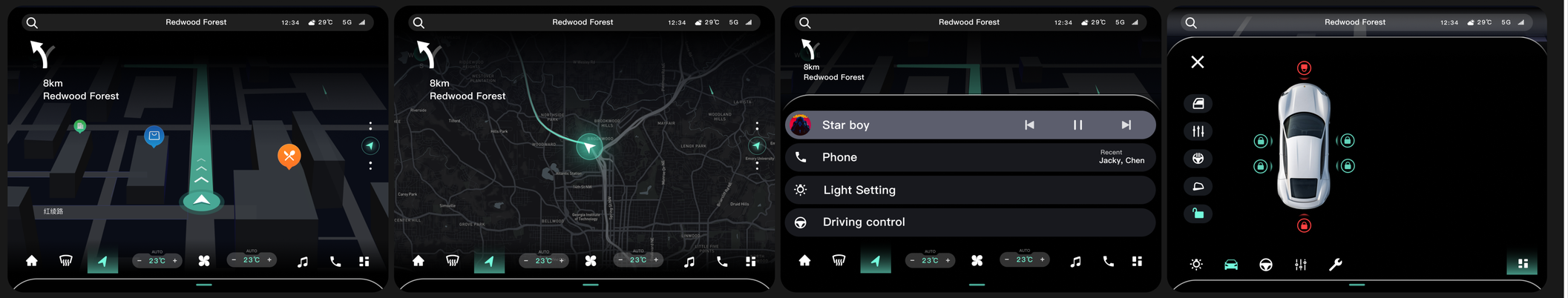
In the automotive evolution, the integration of Human-Machine Interface (HMI) systems has drastically changed the driving experience. Once purely mechanical, modern cars now boast advanced HMI technologies that offer not just performance data but also entertainment, navigation, and climate controls. However, touchscreen displays, which lack physical buttons, pose safety concerns as they can distract drivers. The rise of voice assistants and smartphone mirroring systems like CarPlay and Android Auto further blend in-car and mobile experiences. As vehicles become more digital, the challenge lies in designing HMIs that are intuitive, safety-compliant, and personalized, ensuring both user satisfaction and safe operation.

Design

Low Cognitive Load: Progressive disclosure has been introduced to reduce the amount of visual load, while the map fades out as your eye gradually goes deeper into the road, which reduces the overall cognitive load on the screen while clearing up any areas where content is expanding.

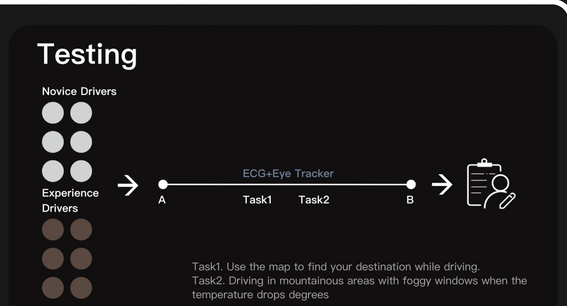
Smart Menu: Based on the user's behavior at a specific time of day, each application appears in the following order.

Clear Visual Guidance: Guide drivers to perform correct operations through appropriate colors, icons, animations and other visual elements. After the driver performs an operation, timely feedback and confirmation are given to ensure that the driver's operation is performed correctly.



Study Methodologies within UCD

Testing



Task1. Use the map to find your destination while driving.
Task2. Driving in mountainous areas with foggy windows when the temperature drops degrees

Results

Objective analysis:
- The average heart rate of novice drivers and experienced drivers is similar, and there are almost no fluctuations during the task.
- Eye tracking data may show that novice drivers and experienced drivers spend no significant difference in the time spent on the HMI, but at the same time spend more time determining whether there is feedback after clicking the defogging function button.

Behavioral analysis:
- Novice drivers may make more driving errors than experienced drivers.
- Experienced vs. novice drivers can complete tasks faster with less HMI interaction (novice drivers are not familiar with the defogging icon and spend more time looking for it).

Heatmap:
- The siri icon in the search box on the HMI is confusing.
- Deforest Button

Interview summary:
- Switch between 3D and 2D maps.
- Reduce navigation visual load.
- Will bring the experience of using the HMI interface that has been used to the new HMI interface (Mind model).
- Top frequently used applications
- Feedback for function buttons.

Conclusion & Further Work

Conclusion:
The evolution of the Human-Machine Interface (HMI) in vehicles underscores a paradigm shift from traditional tactile controls to advanced digital interfaces. This study delved into the balance between enhancing user experience while ensuring safety. Our experiments with novice and experienced drivers illustrated that while modern interfaces might appear sophisticated, their cognitive demands can be challenging. Despite some limitations, such as the disparity between simulator and real-world experiences, the research underlined the importance of intuitive design, information hierarchy, and immediate feedback in HMIs. Future HMIs should prioritize minimizing distractions, leveraging personalization, and catering to a diverse age range. As vehicles become smarter, embedding user-centric designs into the heart of the driving experience is not just desirable—it's imperative.

Further work:
- The huge gap between the experience of the simulator and the real driving may be the reason why the participants' ECG did not change. In the future, EEG can be used instead of ECG to obtain more accurate data.
- The brightness of the display was so low that participants could only see the road clearly with the high beams on. All the participants basically failed to turn on and off the lights as required during the driving process, which led to an increase in the participant's error rate.
- The resulting personalized HMI design has not been experimentally proven to reduce driver distraction.
- The average age of the participants is young, and future samples with a larger age gap can be looked for.