
Get to the Head: Why We Currently Miss the Full Potential of Head-Mounted Displays in Vehicles

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Figure 1: We present an example of how consequent consideration of HMD user needs influences interior design. Surfaces in the cars interior (within reach of passengers) could provide tactile feedback to improve in-vehicle VR experiences. Figure shows a photomontage of [1] and [5].

ABSTRACT

Current concepts of automated vehicles include an increasing usage of internal infotainment displays. Although being visually appealing, such display concepts introduce drawbacks in terms of ergonomics – neck stress and unnatural interaction with a display in the side door – and increase the price. Additionally, occupants of a vehicle often occlude screens for others or their seating orientation might complicate viewing a specific display. Other design concepts introduce the usage of hand-held devices to transmit information about the car. We propose to use augmented and virtual reality head-mounted displays instead of fixed screens to overcome these issues. While concepts that based on displays and handheld devices consequently design for the use of these devices, there are no concepts that showcase interior designs for HMD usage. Current advances to use HMDs inside the car just showcase the possibility to wear a headset while being in the car. Important questions for the interior concept, such as the storage of HMDs, the integration with the existing HMD and the consequent use of the interior to support interaction in VR, have not yet been addressed. We present two exemplary scenarios that showcase the possible impact a consequent design for HMDs could have on the vehicles interior. With our proposal we want to foster the discussion on the possibilities of HMDs and the needs on the interior design to make use of the full potential of VR experiences in the car.

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Figure 2: Examples of displays in interior concepts of automated vehicles. Red arrows indicate the position of attached screens. A [13], B [6], C [3], D [8]

KEYWORDS

head-mounted displays; autonomous vehicles; automotive; interior design

POSITION STATEMENT

The number of AV prototypes (SAE level 4 and 5 [10]) with a full interior concept increases steadily (e.g., [2–4, 6, 8, 13, 15]). Figure 2 and Figure 3 show a selection of such interior concepts. In the following sections, the letters included in Figures 2, 3 and 4 are used as references.

In a comparison of interior design and user interface concepts, we see a trend towards spacious automated cars [A-H]. Some automated vehicles use the metaphors of luxury living or bedrooms [A,C,E,F] for a single person. Other concepts aim on multiple persons using the car, e.g., families going on holidays or strangers commuting to work [A,B,C,D,G,H].

In both aforementioned levels of automation screens are used everywhere in the car. Interior designers use panoramic screens in the door [A,C] or under the windshield [C], as tabletop displays between the users, at the roof [A,B] or huge displays at the front window of the car [D]. For this position paper we do not consider the specific information displayed, but concentrate on the interior design for information visualization in general in the car.

We suspect that the decision for fixed displays was not made on the basis of ergonomics and usability. In many concepts screens are placed in the car that are only visible in certain configurations [C,D]. Huge screens beneath the windshield are not usable if the front row passengers turn around [C,D]. When sitting next to a door display, the angle to the display might be too steep to easily see the screen [A,C]. Additionally, less displays inside a vehicle provide more possible storage space and reduce weight as well as maintenance effort. Hence, avoiding big hardware pieces could benefit the environment and lower the price of future automated vehicles. From an ergonomic perspective, most of these displays are not positioned according to standards that prevent stress for the viewer. For example, screens positioned in the center stack, roof or door require turning the head [A,B,C,J]. Long-term use of such displays might stress the users neck and lead to injuries. Screens should be positioned central to the user to avoid turning the head during usage. The interaction with door displays puts unnecessary load on the users body. Touching the horizontal surface on the door is not possible without creating effort in the arm and upper body, since the user must turn the hand 90 degrees inwards to perform touch gestures. Interaction with the other hand, away from the door, requires to detach the shoulder or even the back from the seat, creating yet another unnecessary physical effort.

The display technology and electronics must meet automotive standards in terms of: robustness (e.g., vibrations), viewing angles, safety requirements and changing lighting conditions and further. To overcome these issues, some concepts integrate mobile hand-held devices (Figure 3). However, these

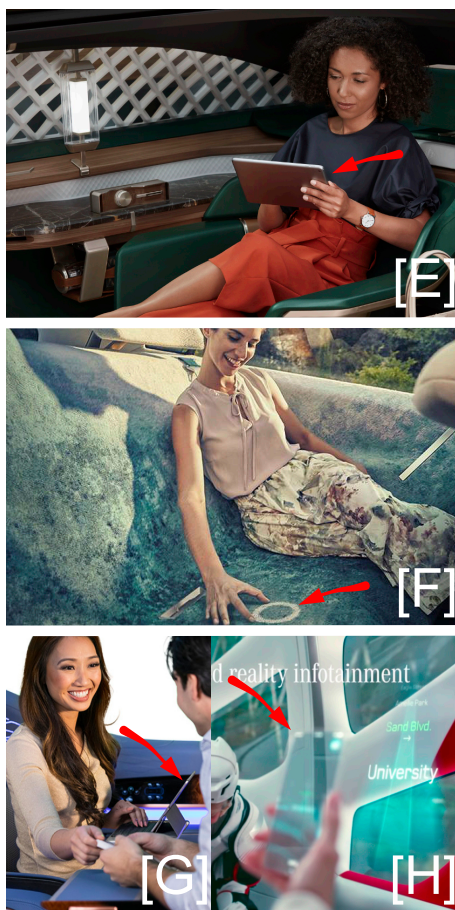


Figure 3: Examples for concepts without traditional displays. As a replacement, mobile devices are an integral part of the interior concept. Red arrows indicate the current position of mobile devices. E [15], F [2], G [19], H [4]

devices are just a substitutions of screens for private work and do not support group work. Important to our argumentation is that the interior concepts shown in Figure 3 and 2, consequently integrate those devices. For example they provide storage or charging spaces for handheld devices.

To overcome the issues introduced by the concepts of screen and hand-held based devices *head-mounted displays* (HMDs) featuring either augmented or virtual reality are introduced. Rober et al. already licensed a patent regarding an HMD used inside of a vehicle [17]. The company Holoride [1] develops a standard that connects an XR device to the vehicle's databus [1]. The scientific community addresses the usage of HMDs in cars by publications (e.g., [11]) and workshops (e.g., [16]). Industry showcases the usage of HMDs in cars (Figure 4). However, proposed concepts have focused on application design rather than making use of the interior to support the HMD usage. Figure 4 shows exemplary that today HMD based applications are designed without making use of the interior. As we demonstrate in Figure 1, the Holoride application [1] (Figure 4) could make use of the interior by providing passive haptic feedback in order to improve interaction. Another example might be that AR HMDs do not perform well in bright sunlight. The concept of Kun and colleagues [11] that provides a skype chat via a Hololens, positioned above the center stack, might be supported by an interior that offers a tidied up and dark background leading to more contrast in the visible image. We therefore argue that the development of future in car HMD based applications should always consider the interior design to create the best experience.

We suggest to foster interior design for the integration of HMDs, as they will become more available in the near future, are versatile to use, cost efficient and solve a number of ergonomic issues. Furthermore, they enable a simple separation of passengers. Hence, users can have their own display or collaborate with selected individuals. There are even strategies on how to enable collaboration of HMD users and people without such a device in a mixed-presence scenario [12]. If required, all passengers can be connected, which is particularly easy due to the very controllable environment of the vehicle on network level. Additionally, the vehicle offers the advantage that people sit permanently in one place. Through the consistent design of the interior, the interaction in VR can be clearly supported in terms of efficiency and entertainment. Physical surfaces could support interaction through tactile feedback. Redirected touch enables an infinite amount of touchable elements through a few physical elements. Such physical elements only have to correspond slightly to the virtual ones to create the illusion of interacting with the virtual object.

EXEMPLARY SCENARIOS

To support our argumentation, we present two examples on how to include the benefits of integrated HMDs in automated vehicles interior design.



Figure 4: Examples of HMDs in automated vehicles. I [1], J [18], K [7]

Example 1: Relaxation and Take Over Request

The usage of level 4 automation is restricted to certain environments, e.g. a highway. During this period, drivers are likely to relax in the vehicle [14], which could be supported by using a VR HMD. The passenger could be virtually floating on an air mattress in the ocean. The interior will provide stimuli like air flow or changing the seating position as proposed by Rober et al. [17]. The car will hand over control to the driver before leaving the highway. The driver therefore will need to take off the HMD. The interior now needs to provide a space for that. If the device is brought by the user there might be a storage in the center stack that also charges the HMD. If the HMD is part of the interior it might be attached to the headrest of the seat. The car recognizes the removal of the headset and places the HMD mechanically in the headrest. It is safely stored there, disinfected and cleaned and can be folded back over the user's head at the push of a button. While the HMD is not in use, the user follows the vehicle's status via the traditional interface around the steering wheel.

Example 2: Virtual Office

In level 5 automation, the vehicle could become a driving office. Recreating a desktop work space via virtual reality only requires a bluetooth keyboard [9]. When wearing an HMD the virtual environment would recreate a private office adjustable to the users preferences. Cheng et al. [5] present how sparse touch feedback can be implemented to improve the experience, comfort and performance. Their findings could be transferred to built a convincing work space within a vehicle, as we showcase in Figure 1. The interior could support immersion by providing a small table for the keyboard and, for example small handles to mimic drawers.

CONCLUSION

In this position paper we argue that a consequent car interior design for HMDs enable novel interaction possibilities and helps to overcome current limitations of these HMD. Advances in the development of AR and VR HMDs provide a strong alternative to displays and the potential of applications is recognized in related work. However, in contrast to screens and handheld devices, there are hardly any investigations regarding interior design specifically built for the use of HMDs. Hence, we want to provoke a discussion on how consequent interior design could support the usage of HMDs in future autonomous vehicles. Exemplary questions to be considered for consequent interior design are: How will we integrate HMDs in the interface concept of a car? Do people favor personal devices or should the HMD be an integral part of the car? Where is information about the vehicle presented and should the information presentation be supported by the interior design? Are there particular needs for the interior design in critical situations like a take-over request when wearing an HMD? Can safety and well-being while wearing an HMD be supported by the interior design?

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