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May AR-Navigation pose a Safety Issue? Exploring the Usage Behaviour of an Augmented Reality Human-Machine Interface for Virtual Stops

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Introduction, including research aim and objectives

In demand responsive transportation (DRT), the use of flexible pick-up locations can be advantageous to mobility service providers and customers alike. However, in order to achieve high user acceptance of DRT services, providing information along the user journey and fostering high rates of user experience (UX) is essential. After booking a trip on the smartphone, customers need to get to the initiated flexible pick-up location in time to board the booked shuttle. Because to the flexibility, the pick-up locations are virtual stops (vStop) and have no real-world cues. Thus, especially in those situations of getting to the vStop, customers need clear and efficient information on their smartphones regarding the vStop location.

The novel vStop HMI fills the information gap in this user journey scenario and supports users finding the pick-up location effectively. By using means of Augmented Reality (AR), it presents guiding information about the vStop and the rout towards it in reference to the real traffic environment. Yet, while navigating, the vStop HMI might also claim a lot of user's attention, which could bar him/her from observing the surrounding sufficiently and may lead to safety critical situations. So, restricting AR information access while walking might mitigate safety critical side effects of AR navigation with smartphones. Goal of this explorative user study was to gain insights about the effect of restricting AR navigation information while walking.

Research methodology

Therefore, the present study applied a between subject design and exploratively compared the usage behaviour of two different vStop HMI variants (A/B-testing). The user study was conducted in a virtual reality (VR) environment and participants wore a head-mounted-display. The vStop HMI was presented as AR-within-VR prototype as a simulated smartphone. Participants had to follow an approximately 300m long route in a simulated VR roadside environment to get to a pick-up location. Along the way, the crossing of a minor road was required. Other road users were part of the simulated VR scene, but only for reasons of immersion. To get to the vStop, participants either used a vStop HMI that blocked the AR information display while walking, or a baseline vStop HMI without information restrictions. Participants had to navigate to a vStop, solely relying on a simulated mobile AR device. To evaluate and compare the both vStop HMI variants, user experience metrics (UX, workload, and acceptance), as well as information access and the locations of information retrieval during the experiment were captured.

Results

The user study showed significantly positive results in terms of pragmatic quality for both vStop HMI variants. Using the vStop HMI with information restriction while walking received significantly higher workload ratings. However, differences in the results for UX and acceptance were not significant between the two groups. Investigation of usage behaviour showed remarkable differences. On the one hand, restricting information access while walking led to stop and go behaviour and more deliberate information retrieval. On the other hand, the baseline vStop HMI encouraged permanent information consumption, even when crossing the road.

Discussion and conclusions

This study gained insights about how users behave when using AR navigation on a smartphone. Both vStop HMI variants provided information efficiently and helped to solve the given task. Restricting the information access on the vStop HMI while walking did not affect UX metrics negatively. Although workload was relatively low for both groups, it was significantly higher for the HMI that blocked the AR information during walking. The results manifested the assumption that careless AR navigation might pose a threat to users, especially when crossing a road. Hence, limiting information access could be beneficial for user's safety while not compromising overall UX and tolerating slightly higher workload during use. The results give practical implications for the design and use of AR-HMIs in DRT in roadside use cases. Furthermore, insights for scenarios of potentially decreased traffic safety for vulnerable road users using AR were drawn.