Building Virtual and Augmented Reality Passenger Experiences

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Figure 1: We are designing multi-passenger XR experiences based on the motion of a vehicle.

ABSTRACT

Virtual and Augmented Reality (together XR) headsets enable the rendering of virtual content intermixed with reality. They have the capacity to allow passengers to break free from small physical displays in constrained environments such as cars, trains and planes, allowing them to escape to new experiences. They can allow passengers to make better use of their time by making travel more productive and enjoyable, supporting both privacy and immersion. This is of particular note given the predicted adoption of autonomous vehicles. The ViAjeRo project (www.viajero-project.org) is conducting breakthrough research in HCI and neuroscience to enable passenger usage of XR headsets, with the underlying goal of making more effective, comfortable and productive use of travel time. This paper sets out the limitations of current state-of-the-art and how ViAjeRo is opening new possibilities for passenger XR experiences.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**.

EICS '22 Companion, June 21–24, 2022, Sophia Antipolis, France

ACM ISBN 978-1-4503-9031-6/22/06.
https://doi.org/10.1145/3531706.3536450

KEYWORDS

Mixed Reality, Extended Reality, In-Car, Vehicle, Passenger

ACM Reference Format:
Stephen Brewster. 2022. Building Virtual and Augmented Reality Passenger Experiences. In *Companion of the 2022 ACM SIGCHI Symposium on Engineering Interactive Computing Systems (EICS '22 Companion), June 21–24, 2022, Sophia Antipolis, France.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3531706.3536450

1 INTRODUCTION

In Europe, we travel an average of 12,000km per year on private and public transport. These journeys are often repetitive and wasted time. This total will rise with the arrival of fully autonomous cars, which free drivers to become passengers. As part of the ViAjeRo project (www.viajero-project.org), we are investigating how best to support passengers to make the most of this expanded travel time, regardless of the mode of transportation, using Virtual and Augmented reality (together XR). To do this, three significant challenges must be overcome:

- Interaction – Confined spaces limit our interactivity and the social nature of travel settings can inhibit the types of interactions we may perform;
- Sensing – Vehicle movements cause many challenges for sensing when headset IMUs are used, making it difficult to separate vehicle and user actions;

- Motion sickness - Many people get sick when they read or play games in vehicles. Once experienced, it can take hours for symptoms to resolve.

Phones, tablets and laptops are a common sight inside planes, trains, ships, and cars. However, these devices are not well suited to travel environments, and are limited in terms of size and immersion. XR headsets could allow passengers to use their travel time in new, productive ways, but only if these fundamental challenges can be overcome. Passengers would be able to use large virtual displays for productivity; escape the physical confines of the vehicle and become immersed in virtual experiences; and communicate with distant others through new embodied forms of communication.

2 CURRENT LIMITATIONS & CHALLENGES

While XR headsets have the potential to transform the passenger experience, there are key limitations which prevent their widespread adoption and use for general media consumption.

2.1 Interaction

XR users in homes and offices will be accustomed to rich support for interacting with virtual content. Currently, it is standard for VR headsets to support either on-headset buttons and touch sensitive surfaces, or hand-based interactions using controllers. Further work is ongoing to incorporate necessary elements of reality into VR experiences, e.g. physical keyboards. However, existing interaction paradigms for XR do not take into account the physical constraints of a seated passenger or the capabilities and affordances of a potentially instrumented, connected, interactive vehicle environment (e.g. a car dashboard or plane cabin with seat-back display). The most obvious constraint is that of the physical seating. The physical environment, seat belts and the proximity of those seated nearby may dictate that more discreet gestures or interactions be performed.

Our travel context may affect our willingness to wear a headset or engage in an XR experience. Passengers might exhibit very different attitudes toward headset use when sharing a flight with collocated strangers, during a daily commute when on the train, or on a late-night bus journey. There are a multitude of contextual factors at play, from the nature of the physical environment and proximity/relationship to other passengers, the duration of travel, to perceived personal safety within the mode of transport. There will be cultural effects, with research noting that different cultures often have different attitudes and expectations when it comes to socialising in-transit. Occluding reality while in transit could even result in issues that could make headset use unsafe, such as the visibility of personal belongings or accidentally disrupting others, even physically invading their space.

2.2 Sensing Vehicle and Headset Motion

Both rotationally and positionally tracked headsets share a common problem when in motion: inertial sensing is no longer detecting head movement alone[1]. Instead, it is now detecting a combination of user head movement and vehicle accelerations/rotations, and then applying this in periodic corrections. Rotationally tracked headsets will not be able to maintain a stable forward bearing under motion, with the user's view turning with the vehicle. For positionally tracked headsets that rely on additional optical tracking, external motion will lead to the user experiencing judder as the corrective optical sensing contradicts the IMU (Inertial Measurement Unit) sensing. Future MR headsets are likely to exhibit the same problems so long as they rely on inertial sensor fusion with corrective tracking technology that has not been adapted for use in a moving vehicle.

2.3 Motion Sickness

The problem of motion sickness has remained ever-present in transportation. The prevailing theory of motion sickness is of a sensory mis-match between visual and vestibular cues. XR headsets have the potential to contribute to new forms of sensory mismatch, particularly in the case of VR headsets where reality is entirely occluded. Consider playing a VR game where the player controls their virtual movement independent of that of the vehicle. This could result in conveying no motion visually when the vehicle is moving, conveying motion visually that is entirely different to what is physically perceived (e.g. the car turns right but in the VR scene the view turns left) or even conveying motion which matches the physically perceived motion but at a different magnitude. The effects of such circumstances are largely unknown, but it would seem likely that they will create new opportunities to cause motion sickness.

In the ViAjeRo project, we are working on solutions for these problems to enable rich interactions and immersive experiences for people on the move.

3 AUTHOR BIO

Stephen Brewster is a Professor of Human-Computer Interaction in the School of Computing Science at the University of Glasgow. He got his PhD in auditory interface design at the University of York. He leads the Multimodal Interaction Group (http://mig.dcs.gla.ac.uk), focusing on multimodal HCI, or using multiple sensory modalities and control mechanisms to create a rich, natural interaction between human and computer. His work has a strong experimental focus, applying perceptual research to practical situations. A long-term focus has been on mobile interaction and how we can design better user interfaces for users who are on the move. Other areas of interest include VR/AR, wearable devices and in-car interaction. He pioneered the study of non-speech audio and haptic interaction for mobile devices with work starting in the 1990's. He was a General Chair of CHI 2019 in Glasgow, and has previously chaired MobileHCI, EuroHaptics and TEI. He is a member of the ACM SIGCHI Academy, an ACM Distinguished Speaker and a Fellow of the Royal Society of Edinburgh.

ACKNOWLEDGMENTS

This research received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (#835197, *ViAjeRo*).

[1]For an example of this, see youtube.com/watch?v=eBs8biTWuEs