Challenges in designing inclusive immersive technologies

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Published in:
Proceedings of the 20th International Conference on Mobile and Ubiquitous Multimedia, MUM 2021

DOI:
10.1145/3490632.3497751

Publication date:
2022

Challenges in Designing Inclusive Immersive Technologies

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ABSTRACT

Immersive experiences – enabled by technologies such as VR, AR, 360° video and other highly immersive multimedia applications – have the potential to make interacting with various activities more inclusive for many people. This can be achieved by applying the principles of inclusive design. This panel will discuss the current challenges in designing inclusive immersive technologies, and how they should be addressed.

CCS CONCEPTS

• **Virtual reality**; • **Mixed / augmented reality**; • **HCI design and evaluation methods**;

KEYWORDS

Immersive technologies, AR, VR, 360° video, Inclusive Design

ACM Reference Format:
David Geerts, Radu-Daniel Vatavu, Alisa Burova, Vinoba Vinayagamoorthy, Martez Mott, Michael Crabb, and Kathrin Gerling. 2021. Challenges in Designing Inclusive Immersive Technologies. In *20th International Conference on Mobile and Ubiquitous Multimedia (MUM 2021), December 05–08, 2021, Leuven, Belgium.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3490632.3497751

1 INTRODUCTION

Immersive experiences – enabled through the use of technologies such as Virtual Reality (VR), Augmented Reality (AR), 360° video and other highly immersive multimedia applications – have the potential to make interacting with various activities more inclusive for many people, e.g. by supporting learning activities, connecting healthcare providers with patients or enabling remote museum participation. In order to achieve this potential, it is necessary to apply the principles of inclusive design, defined by the British Standard Association as "*design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design*" [2]. Defined as such, inclusivity goes beyond adapting designs to people with disabilities, and also relates to situational or temporal disabilities. According to [5], visual, cognitive, and communication access are the most common aspects of inclusivity to be addressed in immersive spaces. Visual access concerns both users with vision issues, as well as with temporary or situational vision accessibility. Cognitive access is related to how people understand and manipulate information, which can involve issues of memory, fluid intelligence, attention and emotiveness. Finally, communication access deals with how users communicate with the surrounding world through language, hearing and speech. All of these aspects have a different impact on the design of an immersive experience, depending on its purpose. This panel will discuss the current challenges in designing inclusive immersive technologies, and how they should be addressed.

MUM 2021, December 05–08, 2021, Leuven, Belgium

ACM ISBN 978-1-4503-8643-2/21/12.
https://doi.org/10.1145/3490632.3497751

2 PANELISTS' STATEMENTS

2.1 Radu-Daniel Vatavu

We live in a time where the physical world can be left behind to explore alternative world designs that feature new stimuli, different laws of physics, and increased opportunities for enriched perception, interaction, and immersive experiences. As eXtended Reality (XR) becomes mainstream, our perception of the world we live in changes and adapts accordingly, so does our dependence on the interplay between the physical and the virtual. However, computer-based, supported, augmented, or mediated worlds can be as inclusive or exclusive just like physical environments are, as they are equally affected by physical challenges (e.g., difficulty to manipulate or wear devices), psychological challenges (e.g., social acceptability of immersive technology), and experiential challenges (e.g., experiences that are refused when immersive technology is not usable or accessible), among others. Thus, making XR more inclusive has become as important as making the physical world more accessible to people with various abilities. For instance, XR devices and interactions little matched to users' specific abilities lead to user experiences that are poor, inadequate, or not accessible at all, while the lack of appropriate concepts, terminology, and design paradigms centered on abilities in the (still under development) theoretical landscape of XR restricts fundamental discoveries and advances in this direction. In this context, by focusing on understanding the diversity of human sensorimotor abilities, new world designs can capitalize on those abilities to make immersive technology more accessible and usable and, ultimately, inclusive for all. Acknowledging the diversity of and capitalizing on users' sensorimotor abilities must be design imperatives for the community involved in computer-generated, supported, augmented, and mediated realities that is, in a sense, blueprinting the actual physical reality of the generations to come.

2.2 Alisa Burova

Immersive technologies of eXtended Reality (XR), due to the richness of sensory information [13] and the possibility to blur the border between virtual and real [9], are becoming more prominent and attractive for people from various backgrounds. While the list of application cases is rapidly expanding, promising a great value for societal, industrial, and business needs [1],[6],[7],[10],[14], there is still no clear understanding of how to make these technologies inclusive for everyone [12]. The interaction with immersive technologies reassembles real-world experiences and may happen over multiple senses, which is the major design factor to consider. In some cases, it offers flexibility to cover the needs of many user groups, alternating from one modality to another to represent the same information, while in other cases it may cause inequality. There is no unique set of rules to make immersive technologies inclusive; on the contrary, the inclusion is dynamic and would directly depend on *the purpose*, *context of use* and *target users*. In the field of *Industrial Maintenance*, where XR technologies are applied to aid complex operations in dangerous contexts [4],[8],[11], inclusion may and should be reviewed from a different perspective. Industries strive to optimize their operations with XR, meanwhile minimizing the costs and resources [3]. The primary challenge is not how to design immersive systems to support the diversity of users, but how to include diverse groups and enable access *despite the users' location, cultural background, and technology adoption levels*. Therefore, the first step towards truly inclusive industrial XR would be to enable *asymmetric access practices*. To achieve it, the technologies should be designed considering the participation of non-immersive user groups instead of leaving them out. This way, industries may advance the scalability of immersive technologies, include wider circles of users to the innovation and development processes, raise awareness of the value of XR and prepare communities with lower technology adoption to utilize XR in the future.

2.3 Vinoba Vinayagamoorthy

One of the most exciting opportunities presented through immersive technologies is the '*Social*' factor - being able to interact, collaborate and communicate effectively with people across the globe from the comfort of your home-base. Imagine a scenario where you are a part of a team tasked with making recommendations for commissioning the build design of your next office space. You go to a virtual showroom with your colleagues to get a presentation from an upcoming architect about the new sustainable designs she has come up with, complete with three-dimensional interactive models of 'sample workspaces' that you can explore and request customisations on the go. You must make your decision at the end of the presentation after some discussion. Your team is distributed - you are in the London office with access to an HMD and the shiniest screens known to mankind, one colleague is temporarily working remotely from their parents' home in south Asia with patchy internet, one is stuck in quarantine at home in Seattle on a 2-year-old laptop, and your team leader in the New York office is visually impaired. How do you enable all five of you to have an equitable experience? An experience that has personalised accessibility features, allows folks to join in the conversation using the technology and internet capabilities available to them, enables each of you to express yourself seamlessly, take cues from your team leader, and makes you all feel like you contributed to the decision-making process? In a physical room, these sorts of interactions are easy enough to visualise. In a virtual space, the challenges range from things as simple as providing diverse personalised avatars all the way to making the technology accessible to the individual user needs and context.

2.4 Martez Mott

Virtual and augmented reality offers new and compelling ways for people to interact with digital content. These systems provide users with immersive experiences that can be beneficial in various applications, such as gaming, design, training simulations, and communication and collaboration. Over the years, researchers have proposed, developed, and evaluated numerous input techniques that allow users to successfully interact with these systems. Although many of these techniques have been shown to improve users' ability to manipulate digital objects, these techniques often presume users possess certain abilities. For example, these techniques presume users can: perform mid-air gestures; use two-hands for bimanual tasks; rotate their heads or torso; or accurately point to objects in a scene. However, many people with limited mobility as the result of injury, advanced age, or physical disability, might experience difficulties when using these techniques to interact with digital objects. As a result, their experiences in augmented or virtual reality might be severely limited or less enjoyable than it could be if more accessible interaction methods were available. An opportunity exists to create accessible input methods and interaction techniques that will enable people with limited mobility to have enjoyable immersive experiences. However, we are woefully behind in: (1) understanding the needs of people with limited mobility as it relates to the various applications that exists on these platforms and the contexts in which they are used; (2) co-designing with people with limited mobility to envision a range of solutions—from the feasible to the improbable—to reimagine the capabilities of immersive technologies; and (3) developing and evaluating novel input methods and interaction techniques that meet the diverse needs of people with limited mobility. By addressing these limitations—and many others—we can make significant progress in improving the accessibility of current and future immersive technologies.

2.5 Michael Crabb

When designing accessible services, we traditionally think of the challenges that are created because of the technology that is being used or how different environments may alter the overall experience. We consider how visual, physical, cognitive, auditory, and communication accessibility can impact on the overall way that a person uses an application, and our design practice takes these areas into consideration.

Within the immersive technology space, challenges relating to technology, person, and place are combined. This creates an additional set of design constraints due to the interaction between these very different areas. The combination of these factors creates additional difficulties in the development of immersive experiences as we must consider the impact that restrictions in one area will have in the overall immersive experience that we wish to develop.

We need to understand the interaction that these elements have with each other, and the challenges that arise when all three are combined. Two of the more pressing challenges in this area are:

- How do we determine the digital constraints created by the physical limitations of an environment that an immersive experience is taking place in?
- How do we facilitate movement between virtual and physical spaces in a way that considers the accessibility challenges that are faced by individuals?

2.6 Kathrin Gerling

Immersive technologies such as Virtual Reality are set to transform our lives: they seek to immerse users' senses by directly connecting with their bodies, transposing them into virtual worlds, and opening up enriching experiences that would otherwise remain inaccessible. However, the majority of VR platforms and applications are designed for non-disabled, remarkably average human bodies, leaving those who do not fall within this narrowly defined norm with inaccessible or diminished virtual experiences. Hence, we risk a further reinforcement of a divide that exists between those people who happen to have bodies that were accounted for in the design process of immersive technologies, and those who have not. In the case of VR, this results in the inaccessibility of a platform which promises to give access to immersive experiences, which is a threat to equal access to education, work, and leisure as the integration of the technology progresses. Therefore, researchers and developers need to return to the drawing board, re-think immersive technology in a way that accepts diversity of bodies as a starting point for design, actively working with relevant communities to disentangle implications at the level of hardware design, interaction paradigms, and user representation. Building on resulting novel systems that provide adequate physical access, this would enable our research community to push forward and focus on experiential access to VR, answering questions about the experiences that different user groups have when immersed in virtual worlds, and how to design content that is truly meaningful, returning to the idea of leveraging VR as a means of facilitating enriching experiences.

3 PANELISTS' BIOGRAPHIES

Radu-Daniel Vatavu is a Professor of Computer Science at the Stefan cel Mare University of Suceava, where he directs the Machine Intelligence and Information Visualization Research Laboratory (MintViz). He conducts research in Human-Computer Interaction, Ambient Intelligence, Accessible Computing, Augmented and Mixed Reality, and Entertainment Computing. At the intersection of these areas, he is interested in designing useful and usable interactions between humans and computers supported by artificial intelligence and information visualization techniques informed by understanding users' behavior, needs, preferences, and expectations of interactive technology.

Alisa Burova is a Doctoral Student of the Humans and Technology Programme at Tampere University. Her major research topic is Industrial Collaboration in VR, which she carries in joint work with KONE Corporation, investigating the application scenarios and value of XR technologies for the field of Industrial Maintenance. Her thesis work is supervised by Prof. Markku Turunen (Tampere University) and Dr. Sanni Siltanen (KONE). Apart from the main research direction, Alisa is actively participating in various research projects of her research group (investigating, for instance, Immersive Media, Technology-based Education and Remote Operations) and other academic activities (e.g., Proceedings Chair for MindTrek 2021 and Discussion Panel for "Blow Your Mind event" on Synthetic Media).

Dr. Vinoba Vinayagamoorthy is a Project Research & Development Engineer with the BBC working on how broadcasters (and content makers) could have more personal 'conversations' with audiences on interactive and immersive platforms. She is interested in using insights in audience behaviour to inform the design of novel experiences on emerging platforms. Her research interests cover (social) VR/AR, connected TVs/devices and interaction design. Before joining the BBC, she was a research fellow in virtual environments and computer graphics at University College London (UCL). She has a PhD from UCL in Computer Science and a BEng in Information Systems Engineering from the University of Surrey. She is passionate about improving equity, diversity and inclusion in STEM - from outreach events for kids to encouraging more diverse participation in conferences.

Martez Mott is a Senior Researcher in the Ability Group at Microsoft Research. His research is focused on designing, implementing, and evaluating intelligent interaction techniques that improve the accessibility of computing devices for people with disabilities. His current research focuses on identifying and overcoming accessibility barriers embedded in the design of virtual and augmented reality systems. Martez is passionate about improving diversity in the CS and HCI communities. He co-chaired the 2020 and 2021 CHI Mentoring Workshops (CHIMe) and co-founded the Black Researchers @ MSR group. Martez received his Ph.D. in Information Science from the Information School at the University of Washington. Prior to attending UW, he received his B.S. and M.S. in Computer Science from Bowling Green State University.

Dr Michael Crabb is Head of Computing Learning & Teaching at the University of Dundee. His research interests are focused in immersive technology interface design and the accessibility of digital media. In addition to his local work, Michael is the ACM SIGCHI Vice-Chair for Accessibility and works with a team of academics from across the globe on creating methods to enable inclusive participation at ACM SIGCHI sponsored events.

Kathrin Gerling is an Assistant Professor in Computer Science at KU Leuven, Belgium. Her research focuses on technology in sensitive settings, including accessibility of body-based technology for people with disabilities in the context of playful and interactive technology, and has received awards in recognition of research excellence and contributions to diversity and inclusion. Most recently, she engaged in theoretical and technical explorations of the accessibility of VR for people with limited mobility. Kathrin previously held an appointment as Senior Lecturer (Assistant Professor) at the University of Lincoln, UK. She received a PhD in Computer Science from the University of Saskatchewan, Canada, and completed an MSc in Cognitive Science at the University of Duisburg-Essen, Germany.

ACKNOWLEDGMENTS

R.D. Vatavu acknowledges support from a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI-UEFISCDI, project number PN-III-P4-ID-PCE-2020-0434 (PCE29/2021), within PNCDI III. The base for Alisa Burova's statement was gained within the HUMOR project (HUMan Optimized xR), funded by Business Finland (# 3913/31/2019). She wishes to sincerely thank the members of PIRG research group and KONE employees for efficient academia-industry collaboration practices and valuable input to the research activities.

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