ISSN: 2634 - 8853

Journal of Engineering and Applied Sciences Technology

SCIENTIFIC Research and Community

Review Article

Open Access

Analyzing the Challenges and Opportunities for Making VR/AR Experiences Accessible to Individuals with Visual, Auditory and Mobility Impairments

Anand Sarangam

Accessibility SME, USA

ABSTRACT

This paper discusses accessibility difficulties and opportunities for virtual and augmented reality (VR/AR) for users with visual, auditory, and mobility impairments. It discusses the current major obstacles, namely reliance on visual and auditory cues and physical inputs, along with the analysis of existing assistive technologies. Emerging haptics, AI, and voice interfaces among others, are now identified as solutions that might address some of these challenges, while actual cases of successful applications show promising approaches. This concluding paper makes recommendations on good practices of inclusive design, focusing on accessibility as a moral as well as business imperative.

***Corresponding author**

Anand Sarangam, Accessibility SME, USA.

Received: April 07, 2022; **Accepted:** April 15, 2022; **Published:** April, 30, 2022

Keywords: Accessibility, AR/VR, Augmented Reality, Virtual Reality, Usability, WCAG, ADA, Section 508, Inclusion

Introduction

Background

One of the highly promising changes that would arise from integrating virtual and augmented reality technologies in both education, health, entertainment, and training sectors is that it promises more involvement from users, with better experiences for users, too. Nonetheless, accessibility remains a critical barrier to the mass adoption of such immersive technologies. Users with vision, hearing, or motor impairments often suffer limitations while using VR/AR, mainly because of design failures that fail to take into account the diversity of needs [1]. For instance, vision can make navigation through virtual environments with ample reliance on visual cues difficult, whereas users with limitations in hearing may suffer from experiences that rely on sound. Likewise, mobility impairments will more than likely serve as barriers to people's ability to engage physically with contents and applications in the VR/AR settings, leaving clients in a state of disappointment and frustration as they are denied the highest possible opportunities to make use of these new experiences [2].

Despite these issues, there is a great chance to make VR/AR-related technologies more accessible and inclusive. That is, developers can take into account universal design principles and assistive technologies so that the environments for people with disabilities are constructed to be more comfortable. This can be done by features like haptic feedback, audio descriptions, and customizable interfaces, which will make it possible for a user to adapt the experience to his particular needs. Access issues in the design of technology products are now becoming more widely known [3]. Finally, partnerships between organizations specializing in disability rights and VR/AR companies may eventually lead to new, innovative applications and standards that deliver efficiency from the outset. Ultimately, discussions around accessibility in VR/AR enhance the user experience for the disability community and further broaden a market base while creating an inclusive culture, which is useful for all [4].

Research Aim

The study's aim is to examine the opportunities and challenges in making Augmented Reality (AR) as well as Virtual Reality (VR) experiences mainly accessible to people with auditory, mobility or visual impairments, with a concentration on technology adaptations and inclusive design.

Research Objectives

- To determine the present accessibility obstacles in AR/VR experiences for people with auditory, mobility or visual impairments.
- To assess the existing accessibility solutions and assistive technology's effectiveness in VR/AR settings.
- To investigate the principles of user-centred design and their key applicability to developing comprehensive VR/AR experiences.
- To assess the emerging technologies potential like haptics, voice interfaces and AI in intensifying the VR/AR platform's accessibility.
- To evaluate successful implementation case studies related to accessible VR/AR applications in different industries.
- To present suggestions for designers and developers to incorporate accessibility features mainly into VR/AR experiences for people with distinct impairments.

Significance

This becomes an important study in respect of transforming the ways in which these technologies will be used across various sectors. With VR and AR increasingly making their presence felt in sectors such as education, health, and entertainment, inclusivity and equity should mean that all users find access to such experiences. Knowing these specific challenges and dealing with them can be helpful for developers to work out solutions that may enhance participation and inclusion in these immersive environments [5]. This is not only very important for the development of accessible standards and regulations but also for social inclusion. It makes people with disabilities enjoy the same edge of education, therapy, and playtime as any other individual. Accessibility in VR/AR development can open up great possibilities for innovation and further market penetration. An ongoing growth in the demand for immersive technologies will not only allow companies to reach a broader audience as they develop accessible experiences but also those individuals with disabilities and their families. Increased user satisfaction and loyalty could be translated into an excellent reputation for companies that actually push for accessibility [6]. Tech developers and disability advocates will push each other toward more innovative assistive technologies and design practices, leading to the overall improvement of user experience. In finality, facilitating the use of virtual and augmented reality is not just a moral along legal requirement, but also a lucrative business opportunity that may promote the expansion and long-term viability of the sector [7].

Literature Review

VR/AR accessibility for people with disabilities is still a sensitive issue. This is mainly because most design approaches ignore multiple needs in designing the technologies. Among these barriers are visual dependency, auditory-dependent interaction, and mobility challenges in virtual environments. However, emerging solutions such as adaptive controllers and audio descriptions hold potential developments in the field.

Current Accessibility Barriers in VR/AR Experiences

In VR and AR, significant accessibility barriers are found in the interaction process with applications designed for people having a visual, auditory or mobility impairment. These applications rely heavily on visual cues and graphics to navigate, which is very hard for visually impaired individuals [8]. If there are no proper audio descriptions, there is a failure to capture vital information contained in other modalities, and confusion occurs [9]. For instance, interactive elements in the VR environment would be impossible to recognize without visual cues; thus, users cannot engage in the way they ought to. Furthermore, most VR experiences lack high contrast and text zooming, and thus the challenges of accessibility for those who have low vision are compounded [10].

Auditory impairments also add another layer of barriers as many of the experiences rely on sound in order to understand instructions or an environmental context. For example, games or simulations that invoke auditory cues in order to initiate actions or events are inaccessible to users who cannot hear these cues. Mobility impairments present unique challenges because most VR systems require users to stand, walk or use handheld controllers, which most users who have limited mobility cannot [11]. This may also discourage participation, as users with different abilities may not be able to access these virtual environments because their needs have not been taken into consideration when designing them. These barriers bring out the need for much more inclusive design practices in VR and AR development [12].

Effectiveness of Existing Accessibility Solutions and Assistive Technologies

Accessibility solutions and assistive technologies in virtual reality and augmented reality have been partial. For instance, audio descriptions might help the user with visual impairments by giving them verbal clues over the visuals. Similarly, an avatar using sign language or subtitles on a video may help a person with hearing impairment by translating the audio into visual forms. Yet, while some such solutions exist, they are in most cases not commonly used, and most VR applications are still far from fully utilizing these features [13].

In addition, especially with certain assistive technologies, like adaptive controllers and eye-tracking systems, access can truly be enhanced for people with mobility impairments, whereas availability and compatibility with mainstream VR systems are relatively less consistent. Thus, it does not necessarily mean the need continues to be critical enough to have such accessibility solutions regularly evaluated and enhanced over time in order to meet diverse user needs [14].

User-Centred Design Principles and their Applicability

Accordingly, user-centred design principles would therefore be critical for the design of accessible VR and AR experiences because they focus on users' needs and perspectives during the development process. Such practices enable developers to identify the real problem that persons with disabilities would encounter; as such, developers get insight into how these may specifically be aided by features or functionality. Flexibility, feedback, and simplicity are principles that should be adopted to make interfaces intuitive and easy to navigate for users with different abilities [15]. In addition, the acceptance of an iterative design process allows for continuous improvements following the patterns of response by the user to a solution, which therefore leads to better and more inclusive solutions. Not only does this make VR and AR accessible for users but also gives an ownership feeling and a sense of agency to the user with a disability, encouraging them to connect more fully with the same technologies [16].

Potential of Emerging Technologies in Enhancing Accessibility

Haptics, AI, and voice interfaces have enormous potential to make access in VR and AR both better and "more the person". Haptic feedback may provide sensations that are nearer to real sensations, such as being told some things about a virtual object or space-and would certainly enhance navigation and interaction with visually impaired people [17]. Personalization created by AI would measure the behaviour and preferences of users in order to create thoroughly optimized experiences that are tailored to every person's needs, where consequently, interactions will be more intuitive and accessible. Voice interfaces can also enhance accessibility by offering mobility-impaired users the possibility of accessing and controlling VR/AR experiences solely through voice commands, without any requirement for physical inputs [18]. The more these technologies develop, the more integrations are probably going to happen in VR and AR applications. More inclusive experiences in user diversity will likely be better engaging and, thus, move forward [19].

Case Studies of Successful Implementation

Many case studies demonstrate the effectiveness of accessible VR and AR applications for different sectors, emphasizing the fact that accessible solutions may be made which will satisfy any needs of people with any type of disability. In the gaming industry, for instance, a game like "Beat Saber" came to centre attention due to its numerous configurable hardness levels that allow the user

to ease up or raise the difficulty level depending on their abilities [20]. For instance, some games previously introduced alternative control schemes and greyscale modes. Such features increase the availability of the games to the broad population and can make games accessible to a more varied player base. Indeed, such innovation not only makes gaming more enjoyable for a user with disabilities but also creates bigger audiences; it shows that being inclusive is also commercially viable [21].

Applications such as "Immersive VR Education" in the education sector have been successful in incorporating audio descriptions and sign language interpretation into their VR simulations so that immersive learning may be enjoyed by students with hearing impairments [22]. In the health sector, VR therapies for mobility-impaired persons are now widely used because they offer virtual physical therapy sessions to accommodate the limitations of users' movement, but still result in effective rehabilitation [23]. The case studies prove these findings, where careful designing and implementation are allowed to lead to effective and accessible VR and AR applications for the betterment of users with varying needs and overall engagement with the application.

Recommendations for Integrating Accessibility Features

To fully integrate accessibility features into VR and AR experiences for people of different impairments, the developers and designers ought to embrace the following recommendations: First, developers and designers must include users with disabilities in the design process to be in a position to determine particular needs and testing the efficiency of accessibility features [24]. The adaptive user interfaces that could support different settings, such as text size, color contrast, and control schemes, would make the system much more usable for a wider range of users. Thirdly, multiple input forms, including voice commands and gesture-based controls, would support mobility-impaired users. Developing accessibility features from user experience must be a continuous process of collecting user feedback and testing in an iterative manner [25]. Lastly, the promotion of awareness and education on best practices of accessibility within the VR/AR development community will inspire a culture of inclusiveness that encourages more developers to give priority to accessible design in their work.

Theoretical Framework

Social Model of Disability

The Social Model of Disability states that impairment itself does not lead to disability but rather the exclusion or restriction of participation from society. This theory finds that the obstacles visually, hearing, or mobility-impaired people face come simply from design based on tool perspective rather than from impairment in itself [26]. The disability social model then follows through with the creation of VR/AR environments that are inclusive of all kinds of disabilities for users to participate fully. Inclusive design and assistive technologies will make the platforms ensure this in reducing barriers [27].

Conclusion

It is concluded that accessibility is a universal necessity in VR/AR design, bringing inclusive, immersive experiences to people of all backgrounds and skill levels. Combining universal design principles with current and emerging technologies creates greater access to a wider market for developers and leads to better experiences for people with disabilities, making VR/AR more inclusive for all users.

References

1. Teófilo M, Lourenço A, Postal J, Lucena VF (2018) Exploring virtual reality to enable deaf or hard of hearing accessibility in live theaters: A case study. In Universal Access in Human-Computer Interaction. Virtual, Augmented, and Intelligent Environments: 12th International Conference, UAHCI 2018, Held as Part of HCI International, Las Vegas, NV, USA. Springer International Publishing 12: 132-148.
2. Ivanova AV (2018) VR & AR technologies: opportunities and application obstacles. Strategic decisions and risk management 88-107.
3. Epuran G, Tecau AS, Constantin CP, Tescasiu B, Chitu IB (2020) Opportunities of Using New Technologies (VR/AR) in Order to Facilitate the Access of Persons with Disabilities to Tourism Products. Bulletin of the Transilvania University of Brasov. Series V: Economic Sciences 55-64.
4. Ahmed T, Kapadia A, Potluri V, Swaminathan M (2018) Up to a limit? privacy concerns of bystanders and their willingness to share additional information with visually impaired users of assistive technologies. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 2: 1-27.
5. Hayhurst J (2018) How augmented reality and virtual reality is being used to support people living with dementia—design challenges and future directions. Augmented reality and virtual reality: Empowering human, place and business 295-305.
6. Zanwar P, Heyn PC, McGrew G, Raji M (2018) Assistive technology megatrends to support persons with Alzheimer's disease and related dementias age in habitat: challenges for usability, engineering and public policy. In Proceedings of the Workshop on Human-Habitat for Health (H3): Human-Habitat Multimodal Interaction for Promoting Health and Well-Being in the Internet of Things Era 1-9.
7. Pavlik J (2017) Experiential Media and Disabilities in Education: Enabling Learning through Immersive, Interactive, and Customizable Digital Platforms. Ubiquitous Learning 10: 15.
8. Grussenmeyer W, Folmer E (2017) Accessible touchscreen technology for people with visual impairments: a survey. ACM Transactions on Accessible Computing (TACCESS) 9: 1-31.
9. da Cunha RD, Neiva FW, da Silva RLDS (2018) Virtual reality as a support tool for the treatment of people with intellectual and multiple disabilities: a systematic literature review. Revista de Informática Teórica e Aplicada 25: 67-81.
10. Thevin L, Briant C, Brock AM (2020) X-road: virtual reality glasses for orientation and mobility training of people with visual impairments. ACM Transactions on Accessible Computing (TACCESS) 13: 1-47.
11. Perfect E, Jaiswal A, Davies TC (2019) Systematic review: Investigating the effectiveness of assistive technology to enable internet access for individuals with deafblindness. Assistive Technology 276-285.
12. Boot FH, Owuor J, Dinsmore J, MacLachlan M (2018) Access to assistive technology for people with intellectual disabilities: a systematic review to identify barriers and facilitators. Journal of Intellectual Disability Research 62: 900-921.
13. Jie LJ, Jamin G, Smit K, Beurskens A, Braun S (2020) Design of the user interface for "Stappy", a sensor-feedback system to facilitate walking in people after stroke: a user-centred approach. Disability and Rehabilitation: Assistive Technology 15: 959-967.
14. Cacho-Elizondo S, Lázaro Álvarez JD, Garcia VE (2017)

Assessing the opportunities for virtual, augmented, and diminished reality in the healthcare sector. The Digitization of Healthcare: New Challenges and Opportunities 323-344.

15. Khan A, Khusro S (2021) An insight into smartphone-based assistive solutions for visually impaired and blind people: issues, challenges and opportunities. Universal Access in the Information Society 20: 265-298.
16. Sable C, Alison G (2020) Analysis of emerging technologies for improving social inclusion of people with disabilities https://repositorio.ipsantarem.pt/handle/10400.15/3096?locale=en.
17. Chuah SHW (2018) Why and who will adopt extended reality technology? Literature review, synthesis, and future research agenda. Literature Review, Synthesis, and Future Research Agenda DOI: https://dx.doi.org/10.2139/ssrn.3300469.
18. Hadjinicolaou Y ed (2020) Visual Engagements: Image Practices and Falconry. Walter de Gruyter GmbH & Co KG https://www.journals.uchicago.edu/doi/10.1086/728510.
19. Eldin SS, El Naggar HF (2018) Potential of Virtual reality in special needs higher education. In Eurasia International Conference file:///C:/Users/PC/Downloads/FullPaper.pdf.
20. Moon NW, Baker PM, Goughnour K (2019) Designing wearable technologies for users with disabilities: Accessibility, usability, and connectivity factors. Journal of Rehabilitation and Assistive Technologies Engineering 6: 2055668319862137.
21. Zhao Y, Cutrell E, Holz C, Morris MR, Ofek E, et al. (2019) Seeing VR: A set of tools to make virtual reality more accessible to people with low vision. In Proceedings of the 2019 CHI conference on human factors in computing systems 1-14.
22. Franks MA (2017) The desert of the unreal: Inequality in virtual and augmented reality. UCDL Rev 51: 499.
23. Hudson J, Waters T, Holmes M, Agris S, Seymour D, et al. (2018) Using virtual experiences of older age: exploring pedagogical and psychological experiences of students. In Proceedings of the Virtual and Augmented Reality to Enhance Learning and Teaching in Higher Education Conference. IM Publications Open 61-72.
24. Series BT (2018) Collection of usage scenarios and current statuses of advanced immersive audio-visual systems.
25. Torelli E (2018) HoloLearn: mixed reality experiences for persons with neurodevelopmental disorders https://www.politesi.polimi.it/handle/10589/148547.
26. Berghs M, Atkin K, Hatton C, Thomas C (2019) Do disabled people need a stronger social model: a social model of human rights?. Disability & Society 34: 1034-1039.
27. Woods R (2017) Exploring how the social model of disability can be re-invigorated for autism: In response to Jonathan Levitt. Disability & society 32: 1090-1095.