How can emerging technologies help disadvantaged people through inclusive design?

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Abstract

This article explores the impact of advanced technologies on inclusive design. It focuses on Smart home appliances, Virtual Reality (VR), Artificial Intelligence (AI), Brain-Computer Interface, and Elon Musk's Neuralink. With the global demographic shift, including an aging population and people with disabilities, it is crucial to consider inclusive design principles in technology development. As income disparities may hinder access to technology for the elderly it becomes an important aspect to consider. Technologies that discussed this article and its use by the elderly and disabled individuals and its potential to promote independence for these people are discussed in the article. The most important issue we deal with within the scope of Inclusive design is the provision of equal access and opportunities. And the most important of these opportunities is education. The easy accessibility of Artificial Intelligence and language models has been considered to play a role in creating an inclusive education environment by personalizing these learning experiences and providing cost-effective resources. Brain-Computer Interfaces, such as Neuralink, offer opportunities for those with physical limitations or neurological disorders. By embracing diverse perspectives and skills, inclusive design not only promotes social equality but also fosters innovation and creativity.

Keywords: *Inclusive Design, Virtual Reality, Augmented Reality, Artificial Intelligence, Brain Computer Interface.*

Introduction

As the world of technology advances with lightning speed, it is crucial to evaluate the potential effects these innovations might have on inclusive design. This article aims to delve into the implications of these advancements, focusing specifically on technologies such as smart home appliances, virtual reality (VR), artificial intelligence and language models, Brain Computer Interface (BCI), and Elon Musk's Neuralink. The evolution in our societal demographics has been equally astounding, with increased longevity and a subsequent rise in the elderly population being noteworthy aspects. Based on the The United Nations reports (2019) that one in six people in the world will be over age 65 by 2050. These changes have created an expanding market that has provoked a re-evaluation of the design strategies in technology to accommodate this demographic transition.

Approximately 15% of the world's population experiences some form of disability according to World Bank data statistics. Again, based on this data, the 5-15% of all disabled individuals having access to higher education. These statistics highlight the importance of incorporating inclusive design principles into new technologies to ensure accessibility and usability for all, irrespective of age or physical ability (World Bank, 2021).

Consider virtual reality (VR), a burgeoning field that has demonstrated significant potential in creating more inclusive environments. The virtual reality technology`s immersive nature has been leveraged for various applications ranging from education and training to gaming and entertainment (IDC, 2018). Developing inclusive technologies isn't just about incorporating advanced features; it's equally crucial to be mindful of affordability. A 2019 European Commission report showed that the median equivalised net income for elderly people was €20,604 in 2017, lower than the total population median of €21,953 (European Commission, 2019). This statistic reveals a potential barrier to technology access amongst the elderly demographic, making it imperative for designers and technologists to consider the economic aspects of inclusive design. Looking into educational settings, the inclusion of students with disabilities is another area where technology can make a significant impact. According to a 2021 report by the National Center for Education Statistics in the United States, about 14% of all public-school students – ages 3 to 21 – received special education services in the 2018-2019 school year (NCES, 2021). Inclusive technologies can provide these students with innovative learning tools and opportunities to participate in regular classroom activities, inclusive technologies may provide an inclusive and productive learning environment.

The discourse around smart home technologies, as defined by the Housing Learning & Improvement Network (Intertek, 2003) and Aldrich (2003), underscores their potential to enhance comfort, convenience, security, and entertainment within the home. Particular attention is paid to their utility for elderly individuals and those with disabilities, enabling these individuals to lead independent lives by leveraging technology such as smart plugs, cameras, power strips, and digital assistants (Mtshali & Khubisa, 2019). Virtual and augmented reality technologies have substantial potential in terms of improving the lives of individuals with disabilities and the elderly. These technologies facilitate immersive experiences, with applications ranging from therapeutic activities to communication and social interaction aids (Gigante, 1993; Peterson, 2023). Artificial intelligence (AI), as described by Lo (2023) and Salas-Pilco et al. (2022), demonstrates significant promise in fostering an inclusive educational environment. The technology's ability to individualize learning experiences and offer cost-effective educational resources could notably contribute to a more equitable education system. Lastly, the sphere of brain-computer interfaces is assessed, primarily focusing on the advancements made by Elon Musk's Neuralink company. This technology, which serves as a direct communication pathway between brain activity and external devices, may offer a multitude of opportunities for those with physical limitations or neurological disorders (Krucoff et al., 2016). By utilizing the various

viewpoints and skills of people from all backgrounds, this inclusive approach not only encourages social equality but also innovation and creativity.

Smart Home Technologies

The definition of smart home concept was made by Housing Learning & Improvement Network offered by Intertek in September 2003 which realized the project called DTI Smart Homes Project. "A dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored or accessed." is the definition according to Intertek. Another definition of smart homemade as "a residence equipped with computing and information technology, which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond" by Aldrich (2003). Since Intertek`s definition is mostly made on technological connections, Alrich's definition is mostly on the relationship of the user with the system and the possibilities provided by this system. Based on this, it can be concluded that the main purpose of developing smart home technologies is to increase the comfort of their users at home and their quality of life.

Since the goal of smart home technologies is to improve quality of life, these technologies represent a promising response to the requirements of the elderly and those with disabilities who want to live more independently (Mtshali & Khubisa, 2019; Farber et al., 2011). These technologies encompass a range of devices and systems, such as smart plugs, smart cameras, smart power strips, and digital assistants like Amazon Alexa, Google Home, Google Assistant, Apple Siri, or Microsoft Cortana (Mtshali & Khubisa, 2019). By leveraging voice commands or gestures, individuals with physical disabilities can control various home electrical appliances effortlessly, reducing the need for physical exertion (Mtshali & Khubisa, 2019). Additionally, smartphones can act as a convenient interface for controlling appliances connected to smart plugs (Mtshali & Khubisa, 2019).

Smart home technologies provide advantages such as remote monitoring of health status, assistance with communication and social connectivity, and the ability to perform everyday tasks with minimal effort (Mtshali & Khubisa, 2019). These advancements align with the increasing desire for inclusive design products tailored to the needs of aging populations and individuals with disabilities (Farber et al., 2011). The adoption of smart home technologies can support the desire of older adults to age in place and retain their sense of self within their home environments (Farber et al., 2011; Swenson, 1998). Future research and development efforts should focus on expanding the capabilities of smart home systems to further cater to the unique requirements of these populations (Mtshali & Khubisa, 2019).

Virtual and Augmented Reality Technology

According to Gigante (1993) virtual reality is an experience based on three-dimensional (3D) stereoscopic head-tracking screens, hand/body tracking and binaural sound, which is computer-generated instead of just watching from the outside, giving the impression of participating in a synthetic environment, creating an immersive and emotions. On the other hand, augmented reality (AR) is the experience that lets your brain get its normal sensory input from its surroundings in other words from the real world, while overlaying the computer rendered image or data. Another variant of virtual reality is Mixed Reality. This experience simulates physical presence with a mixture of 3D elements and partially photographed real environments (Peterson, 2023).

Virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies have demonstrated their potential in improving the lives of individuals with disabilities and elderly

populations. These immersive technologies offer inclusive design solutions that address various challenges faced by these groups (Gigante, 1993; Peterson, 2023).

By creating simulated environments, VR and MR allow individuals to engage in therapeutic activities, aiding in rehabilitation for motor impairments (Kuhlen & Dohle, 1995). Moreover, exergaming platforms utilizing VR have been found to increase physical activity among individuals with intellectual or developmental disabilities, providing an additional tool for enhancing their overall well-being (McMahon et al., 2020). These findings highlight the positive impact of immersive technologies on individuals' physical health and rehabilitation progress.

In addition to rehabilitation, VR, AR, and MR can also improve communication and social interaction for individuals with disabilities. VR data gloves enable individuals with speech disabilities to communicate through hand gestures, facilitating effective expression and interaction (Kuhlen & Dohle, 1995). For instance, newly developed MR glass of Apple (2023) that name is Apple Vision Pro makes it possible to navigate between applications by just looking and promises to run many applications actively with its virtual screen, which is moved by pinching hand gestures. The fact that this high-functioning glasses also provides a computer experience makes it suitable for use by people with physical disabilities or even paralysis, so that a computer experience can be enjoyed without using any controller.

Furthermore, AR-based systems provide visual cues and prompts to support independent living and navigation for individuals with visual impairments, enhancing their mobility and fostering social inclusion (Hoe et al., 2019). These applications demonstrate the potential of immersive technologies in empowering individuals with disabilities to communicate and engage with the world around them. Elderly individuals can also benefit from VR, AR, and MR technologies, particularly in terms of cognitive stimulation and mental well-being. VR-based training systems have been successful in enhancing spatial visualization ability among the elderly, leading to improvements in mental rotation skills and daily functioning (Hoe et al., 2019). These technologies promote active observation, imagination, and mental engagement, contributing to enhanced cognitive abilities and overall mental well-being.

In conclusion, the integration of VR, AR, and MR technologies into inclusive design strategies has proven beneficial for individuals with disabilities and the elderly. These immersive technologies offer simulated environments for rehabilitation and therapeutic activities, increasing physical activity levels and supporting motor rehabilitation progress. They also enhance communication and social interaction by providing innovative means of expression and interaction for individuals with disabilities. Moreover, for the elderly, VR, AR, and MR technologies contribute to cognitive stimulation and mental well-being by improving spatial visualization and promoting mental engagement. As these technologies continue to advance, their potential to positively impact the lives of individuals with disabilities and the elderly will expand further.

Artificial Intelligence and Language Models

AI technologies can contribute to inclusive design in several ways. First, AI enables individualized learning experiences that are tailored to the needs of specific learners, enabling students to advance at their own learning rate (Lo, 2023). This approach lets us develop a model of individual education, accommodating a variety of learning styles and abilities. Secondly, AI can provide additional support for students with disabilities, creating special environments that motivate them for active participation (Salas-Pilco et al., 2022).

Another key advantage of incorporating AI in education is its potential to reduce costs associated with traditional learning methods. Traditional educational resources such as textbooks, reference materials, and tuition fees can pose significant financial burdens, limiting access to quality education for individuals with limited income. However, AI-driven solutions have the capacity to provide cost-effective alternatives. For instance, AI-powered chatbots, like ChatGPT developed by OpenAI, can serve as virtual tutors, offering personalized learning experiences and support at a fraction of the cost associated with human instructors (Lo, 2023).

According to Salas-Pilco, Xiao, and Oshima (2022), the literature on AI technologies and inclusive education has placed a strong emphasis on the potential of cutting-edge technology to promote students' multimodal engagement, establish low-risk learning environments, and scaffold their learning goals. However, it is important to consider the socioeconomic inequalities that exist in access to education. Fahimirad and Kotamjani (2018) highlight the significance factors like creativity, imagination, innovation, and skills that cannot be easily replicated by machines. This suggests that while AI can improve the learning experience, human educators still play a crucial role in promoting students' complete development.

Brain Computer Interface Technology

A brain–computer interface is an external device which is mostly implanted to the human brain in terms of making a direct communication pathway between the electrical activities of the brain. It is mostly referred to as a computer or robotic limb. Repairing human cognitive or sensory-motor functions are its main aim as well as assisting, mapping and augmenting these functions (Krucoff et al., 2016).

One of the companies doing current studies on this subject is Elon Musk's neuralink company. The American neurotechnology company which consists of seven scientists and engineers is aiming to develop an implantable brain–computer interfaces (BCIs). Restoring autonomy with unmet medical needs and unlocking human potential are the company's main goals for today and the future. Scientists working on the technology to bring it to people's homes from the lab. Controlling computer or smart devices and cosmetical invisibility are one of the main objectives, with the aim of making fully implantable brain-computer interfaces (Neuralink, 2023).

The development of advanced mathematical methods for extracting and classifying neuronal activity features, as highlighted by Pisarchik, Maksimenko, and Hramov (2019), paves the way for the future integration of BCIs into everyday life.

It is possible for people with disabilities to regain or develop their sensory and motor abilities by establishing a direct and clean connection between the human brain and BCIs. This has significant implications for inclusive design, as it enables the developing new technologies and interfaces that can be accessed and operated by a wide range of people, regardless of their physical limitations.

BCIs can help in the research of neurological disorders like Parkinson's, Alzheimer's, and dementia by directly interacting with neurons and gathering data at a higher bandwidth (Alex, S. A.). These new understandings might fundamentally alter how these diseases are treated and managed, making healthcare more accessible. Additionally, a greater comprehension of the brain could make it easier to create methods for increasing remembering and preserving treasured memories, improving people's general wellbeing and inclusion.

In order to determine the safety and effectiveness of Neuralink's neuroprostheses, human studies are essential, according to Fiani, Reardon, Ayres, Cline, and Sitto (2021). For those with spinal cord injuries, neurodegenerative diseases, and other neurobiological deficiencies, Neuralink's implant's potential for neuro amplification and therapy modalities offers hope. The authors do warn that more research and investigations are required due to the safety concerns connected with the implantation method, which calls for the employment of neurosurgical robots. Despite these reservations, it is impossible to ignore the potential advantages of Neuralink's technology in enhancing the lives of people with disabilities, and the incorporation of BCIs into inclusive design strategies might have transformational effects.

In conclusion, Neuralink's ground-breaking work in the field of BCIs offers tremendous prospects for improving inclusive design and the quality of life for people with impairments. Neuralink intends to bring BCIs into daily life by evaluating neural activity using sophisticated mathematical techniques, creating new opportunities for accessible technology. Although further studies and human trials are required to assure safety and efficacy, BCIs have the potential to improve sensory and motor abilities, progress healthcare, and encourage inclusion. As BCIs develop, their incorporation into inclusive design methodologies has the potential to revolutionize how we engage with technology and empower people with a variety of abilities.

Discussion

The increasing proportion of the elderly population to the young population, the prolongation of the human life span with the advancing type especially increases the interest in this concept and emphasizes the need for inclusive design in technology. Intelligent home technology, first discussed in this context, means a house with a communication network that connects main electrical devices and services and allows them to be remotely controlled, monitored, or accessed. Increasing the comfort and quality of life of users at home was one of the main objectives of the development of smart home technologies. Given that the goal of smart home technologies is to improve the quality of life, these technologies have significant potential to meet the needs of the elderly and disabled who want to live more independently. Recent developments in the field of artificial intelligence will also have a positive effect on these home technologies in the future.

Virtual reality technology is advancing with increasing momentum in creating more inclusive environments and providing equal opportunities for education, training, gaming, and entertainment. In particular, the newly introduced Apple Vision Pro goggles, such as face scanning and creating a 3D model of the user with this face data and mirroring it to the other person during a video call with this model, detecting the user's facial gestures only from the state of the eyes, are a valuable asset for the healthy communication of disabled users.

The rapid development of artificial intelligence and language models has led to consideration of the possibilities of their use in the field of education. Language models, which enable rapid access to information on many subjects, will soon reach maximum efficiency in terms of consistency of information. This can become an inclusive technology by providing cheap and easy learning for private teachers, students with special needs. AI can foster an inclusive education environment by personalizing learning experiences and providing cost-effective resources. Brain-computer interfaces like Neuralink show promise in providing direct communication between the brain and external devices, benefiting individuals with physical limitations or neurological disorders. In addition, thanks

to this technology, which allows the transmission of information without voice communication, the language barrier between people can be removed in the future.

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