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A Study on the Accessibility of Technology for Users with Disabilities

Shrina Tyarla
Department of Computer Engineering and Technology,
Chaitanya Bharathi Institute of Technology (A)

ABSTRACT
The accessibility of technology for people with disabilities is a critical topic that addresses the need for inclusive design and the development of assistive technologies. As society increasingly relies on digital platforms, ensuring that individuals with disabilities can access and utilize these technologies is essential for promoting digital equity. Approximately 466 million people worldwide have hearing loss, and this number is expected to rise to 900 million by 2050. This paper illustrates the need for more inclusive technologies as well as designing digital content and experiences that are accessible to users with diverse abilities. By doing so, we can create a more inclusive and equitable digital landscape that empowers individuals with disabilities to fully participate in the online world.

General Words
Accessibility, Technology, Visual Impairment, Deafness, Intellectual Disability, Human Computer Interaction.

Keywords
Web Standards, Assistive Technology, WCAG 2.2

1. INTRODUCTION
According to the National Institute of Health India (National Institute of Health [NIH], 2023), 4.95% of citizens have some sort of disability across all age groups and 2.2% percent of this group have a severe form of disability [23]. The accessibility of technology for people with disabilities is a critical topic that addresses the need for inclusive design and the development of assistive technologies. As society increasingly relies on digital platforms, ensuring that individuals with disabilities can access and utilize these technologies is paramount for promoting equity and independence. Assistive technology (AT) encompasses a wide range of devices and software designed to enhance the functional capabilities of individuals with disabilities. The landscape of assistive technology is rapidly evolving, with advancements in both high-tech and low-tech solutions. For instance, navigation apps like NaviLens (NaviLens, 2018) use QR codes to assist visually impaired users in finding their way, while smart devices offer various functionalities to enhance daily living.

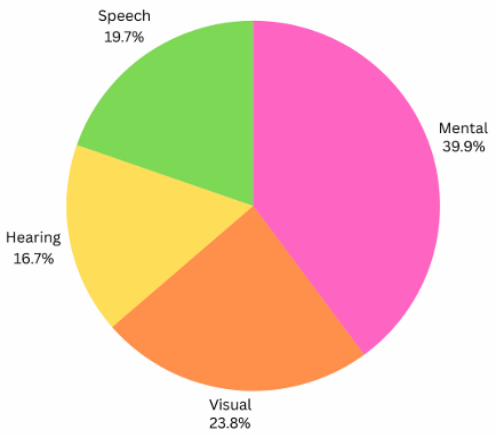

Figure 1: Graph depicting number of Indian residents with disabilities

Assistive technology (AT) encompasses a wide range of devices and software designed to enhance the functional capabilities of individuals with disabilities. The landscape of assistive technology is rapidly evolving, with advancements in both high-tech and low-tech solutions. For instance, navigation apps like NaviLens (NaviLens, 2018) use QR codes to assist visually impaired users in finding their way, while smart devices offer various functionalities to enhance daily living.

However, challenges persist, including the need for better integration of assistive technologies into mainstream applications and the importance of user-centered design that considers the diverse needs of disabled individuals from the outset of technology development. This paper serves as a systematic review of all guidelines and technologies implemented in digital network technologies, especially for students and professional users with disabilities.

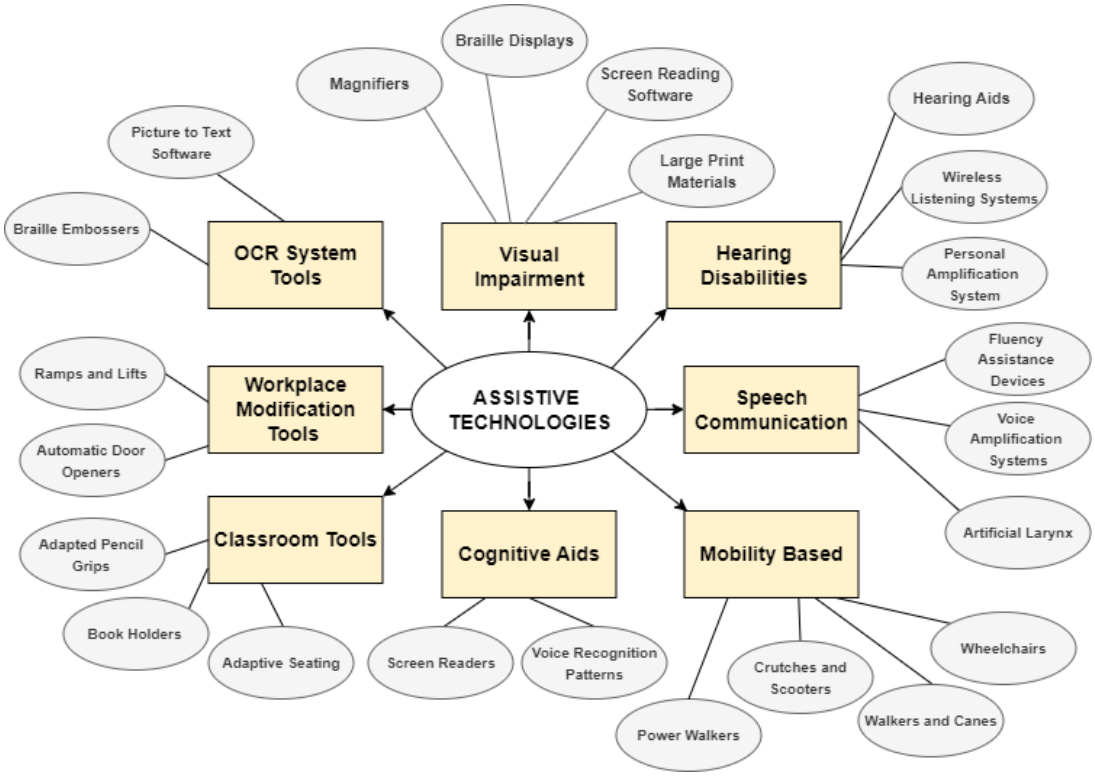

Figure 2: Categories of Assistive Technologies

2. LITERATURE REVIEW

2.1 Related Works

Vollenwyder, Beat et al, 2023, studied the impacts of web accessibility standards on user experiences of both handicapped and non-handicapped users [1]. It highlights how crucial web accessibility is to advancing inclusivity and raising the standard of digital technology in general. This was a controlled, randomized trial where 66 people with a visual impairment and 65 people without such impairment performed tasks on an online store which followed web accessibility guidelines at a low (NA) or high (AA) level. The Handicapped users received some kind of assistive technologies, whereas non-handicapped users received no kind of assistive means. The outcomes were encouraging both for the non-handicapped users and for the handicapped ones. However, the authors were advocating integration of user-centered design approaches in addition to compliance to enhance the general effectiveness of web accessibility efforts There are many non-accessible websites present on the Internet, as studied by Sardella, Nayara, and Manuela Quaresma in 2020 [2].

Despite the prominence of the Web Accessibility initiative in introducing compliances for creating web-friendly products, most websites remain not fully accessible (Schmutz et al., 2016; Kleynhans & Fourie, 2014). There are several factors that lead to a non-accessible interface, among them is the difficulty of contacting users with disabilities to participate in the design process and a number that is representative of this diversity. The authors performed simulations against real world situations amongst a defined set of factors and found a set of difficulties. These difficulties occur because the simulations have limitations concerning the results delivered due to the small variety of disabilities to emulate. performed tasks on an online store which followed web accessibility guidelines at a low (NA) or high (AA) level. The Handicapped users received some kind of assistive technologies, whereas non-handicapped users received no kind of assistive means. The outcomes were encouraging both for the non-handicapped users and for the handicapped ones. However, the authors were advocating integration of user-centered design approaches in addition to compliance to enhance the general effectiveness of web accessibility efforts

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With the rise of Artificial Intelligence (AI) in everyday activities, incorporating multimedia services with AI technologies paves way for such developments in the field of accessibility and assistive technologies [4]. Krishnan, Reshmy, and Sivakumar Manickam in 2024 illustrated the various ways AI has transformed assistive technologies. The study emphasized the role of AI in various assistive devices and applications, detailing how these technologies are breaking down barriers and fostering inclusivity. The authors suggest that continued research and development in AI-driven assistive technologies will further enhance their effectiveness and accessibility, promoting a more inclusive society.

Children with Special Educational Needs and Disabilities (SEND) need to focus on assessing the suitability and adaptability of a more inclusive and personalized learning environment [5]. Layachi, Aida, and Nicola J. Pitchford (2024) conducted a study of the formative measures of a more inclusive environment for all kinds of students irrespective of whether they have special needs or not. The findings stress the importance of involving educators in the implementation process and suggest that thoughtful instructional design is crucial to maximizing the effectiveness of such technologies for SEND children.

In Human Computer Interaction, cognitive workload is the amount of mental effort and resources required to complete a task or activity [12]. Research done by Kosch, Thomas, et al. (2023) tackles the issue of inconsistent and repeatable HCI research due to the absence of a common technique to assess cognitive workload [6]. In order to improve the incorporation of cognitive workload considerations into HCI design, the authors highlight research gaps, offer a literature overview of cognitive workload metrics used in HCI by using the NASA-TX Survey mechanism, and suggest a classification of these metrics.

Integration of physical technologies for enhancing the quality of assistive technologies is another crucial mechanism in improving accessibility for all kinds of users. 3D Printing rose to fame when it was able to create compact and sustainable devices to integrate with existing systems. Benham, Sara, et al. (2024) focused their studies on the impact of 3D printing in ensuring mobile device accessibility. They studied the user experience of a mobile device using a set of 10 individuals [7]. Findings suggested that 3D printing is feasible with a potential increase in user satisfaction through a customization process that is client centered.

In addition to creating more accessible and assistive technologies, Santórum, Marco, et al. (20230 created an Accessible game-based application called LudoMinga [8]. This platform uses serious games to facilitate the learning process for individuals with intellectual disabilities. The research emphasizes the importance of creating an inclusive and accessible learning environment that enhances cognitive abilities and promotes active participation. The study outlines the design and implementation of the platform, utilizing the iPlus methodology, and evaluates its usability and accessibility. The research suggests that continued development in this area could further enhance educational opportunities for people with intellectual disabilities, contributing to their personal and cognitive development.

2.2 Consolidation of Related Works

Analyzing the results and the research opportunities from the related works, we can see that accessibility is a necessity in this new digital era. Though measures and initiatives have been made to ensure that web accessibility standards are being followed, there are more measures to ensure that the website is compliant with the currently defined set of web accessibility standards (WCAG 2.2). Systematic reviews can be conducted using various metrics such as WAVE, AXE and HTML_CodeSniffer. With the help of continuous research and developments in website development, there is a possibility of producing high quality [3].

3. DISCUSSION

3.1 Accessibility in India

In 2015, the Department of Empowerment of Persons with Disabilities, Ministry of Social Justice and Empowerment came up with the Accessible India Campaign (Sugamya Bharat Abhiyan). This campaign aimed at providing universal accessibility for people with disabilities across various sectors, including the built environment, transportation, and information communication technology. [16][25].

Table 1: Data of people in India with Disabilities categorized based on age collected by National Family Health Survey [NFHS-5] 2019-2021 (in percent) [16]

Age (in years)	Hearing Disability	Speech Disability	Visual Disability	Mental Disability	Locomotor Disability	Other	Number
0-4	0.1	0.1	0.0	0.1	0.1	0.0	224,226
5-14	0.1	0.2	0.1	0.2	0.2	0.1	508,218
15-24	0.1	0.2	0.1	0.3	0.3	0.1	487,927
25-34	0.1	0.2	0.1	0.3	0.4	0.1	432,764
35-49	0.2	0.2	0.1	0.2	0.5	0.2	531,882
50-69	0.2	0.1	0.2	0.1	0.5	0.2	475,849
70 +	0.5	0.1	0.3	0.1	0.7	0.2	119,507
Unknown	0.5	0.0	0.0	0.0	0.2	0.2	351
Total	0.2	0.2	0.1	0.2	0.4	0.1	2,780,724

Assistive technology (AT) in India is crucial for enhancing the quality of life for people with disabilities. However, there is a significant gap in the availability and awareness of AT services. Many individuals still face challenges accessing these technologies due to cultural stigmas, lack of data on disabilities, and insufficient production of assistive devices. The World Health Organisation (World Health Organization Newsroom [WHO], 2024) has initiated efforts to improve access to AT,

but much work remains to align with global standards and ensure that all individuals can benefit from these technologies. [15][25]

The campaign aims to make at least 50% of all government buildings accessible to PwDs in each state capital and central capital by 2018. It also targets to make 25% of public transport vehicles under the government disabled-friendly by mid-2017. As of August 2016, 400 out of nearly 1,800 government websites were made accessible. By July 2016, all international airports and railway stations under categories A1, A, and B were made fully disabled-friendly. [25]

While the Accessible India Campaign has made some progress, challenges remain in terms of enforcement and consistent implementation across the country. Continuous efforts are needed to ensure that all public spaces, transportation, and digital platforms are accessible and inclusive for PwDs. [16][25]

3.2 Compliance with Accessibility Guidelines

The current version of the Web Content Accessibility Guidelines (WCAG) is WCAG 2.2, which was published in October 2023. This version builds upon its predecessors,

WCAG 2.0 and 2.1, and introduces several new success criteria aimed at improving accessibility for users with disabilities. [22] WCAG 2.2 (Web Content Accessibility Guidelines [WCAG], 2022) includes a total of 86 success criteria across three levels of conformance: A, AA, and AAA. This includes 77 criteria from WCAG 2.1 and 9 new criteria specifically designed to enhance accessibility for users with low vision, cognitive and learning disabilities, and motor disabilities, particularly in touch-screen environments. [13][15]

The guidelines are structured into four parts:

1. Perceivable: Information and user interface components must be presented in ways that users can perceive.
2. Operable: User interface components and navigation must be operable by all users.
3. Understandable: Information and operation of the user interface must be understandable.
4. Robust: Content must be robust enough to be interpreted reliably by a wide variety of user agents, including assistive technologies.

The new criteria address specific needs, such as ensuring that focus indicators are visible and that content remains accessible when resized, which is particularly beneficial for users with low vision [13][22]. The WCAG 3.0 guidelines are currently in draft form and are intended to expand the scope of accessibility standards beyond web content to include apps, tools, and emerging technologies [16]. However, WCAG 2.2 will remain a relevant standard for the foreseeable future, as WCAG 3.0 is not expected to be finalized for several years

3.3 Maintaining accessibility in Technology for Students and Professionals

Maintaining accessibility compliances in organizational technology is essential to ensure that all students and professionals, irrespective of their abilities, can effectively access materials and education media without any hurdles.

One way of ensuring accessibility is evaluating websites against the WCAG 2.2 guidelines. Some of the ways the accessibility standards could be maintained are [22]:

1. Providing text alternatives for non-text content.
2. Ensuring that all functionality is available from a keyboard.
3. Giving users enough time to read and use content.
4. Minimizing potential triggers for seizures and physical reactions.
5. Making it easier for users to see and hear content by separating foreground from background.

Another method is making the technology adaptable to assistive technologies in different ways such as:

1. Screen readers for users with visual impairments
2. Speech recognition software for users with mobility impairments
3. Refreshable braille displays
4. Alternative input devices like head pointers and eye gaze systems [4]

Personalisation or customizations of settings based on the user can also serve as a way for providing accessibility means for a broad range of users. Features like adjustable text size, color contrast, and cursor size benefit users with low vision. The ability to turn off animations and set timing preferences helps those with cognitive or motor disabilities. Enabling keyboard shortcuts for common actions also improves efficiency for keyboard-only users [14].

3.4 Integration of Emerging Technologies for Accessibility

Artificial Intelligence, Augmented Reality, Internet of Things, Human Computer Interaction and Blockchain are some of the emerging technologies that can be integrated with devices for enabling accessibility compliances. Artificial Intelligence (Artificial Intelligence [AI], 2024) can be integrated into tools such as voice recognition systems for speech impairment users or automatic sign language recognition systems to ensure real time translation for users with hearing impairments [4].

Augmented Reality (Augmented Reality [AR], 2024) [23] and Internet of Things can be combined together. Smart systems for homes and organizations using Internet of

Things (Internet of Things [IoT], 2024) can have voice or gesture detection software for enabling the devices to be used based on custom commands [24]. Virtual Reality or augmented reality technology can be used for including accessibility by creating social environments for empowering better experiences for mobility based disability users.

Other innovations such as Brain-Computer Interaction and 3D printing offer new ways for developing assistive technologies. Brain-Computer Interaction allows for users with a severe form of disability to be able to easily use technologies such as creating software that takes brain thoughts, converts it into text and takes that text and turns it into speech. Blockchain Technology (Blockchain Technology, 2024) can also be used to ensure secure and personalized experiences as well as streamline access to content in a brisk manner [23].

Table 2: Data of the estimated usages of different industrial emerging technologies for accessibility

Emerging Technologies	Estimated Usages (in %)
Artificial Intelligent (AI) Driven Assistive Technologies	40
Augmented Reality for Virtual Assistance	15
Internet of Things Smart Home Accessibility	20
Virtual Reality for Simulations	10
Brain-Computer Interaction	5
Blockchain for Accessibility Records	5
3D Printing of Assistive devices	15

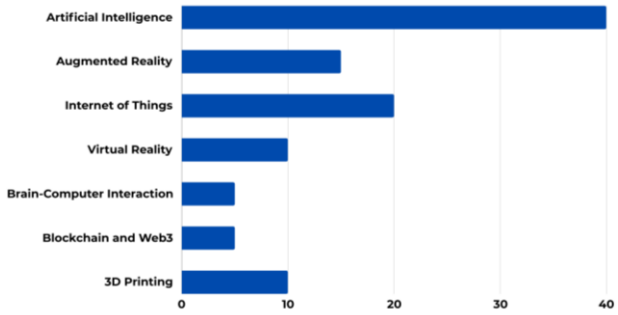

Figure 3: Chart depicting the estimated values of emerging technologies for accessibility [13][23][24].

4. CONCLUSION

The focus should be on the various progressions made to accessibility in modern technology, as this is an essential aspect regarding the society we live in currently. By stressing accessibility, the barriers that disabled individuals from fully participating across different areas of life, including personal, professional, and even educational spheres 6 are removed. Now, thanks to available technology, these people are able to participate fully in society and not be limited by challenges that have in the past held back their potential. [20] The purchase of such accessible technologies also makes business sense because they enhance innovation, promote growth and expand the market. Creating and promoting products and services that are easily accessible to the users allows businesses to improve customer satisfaction and get more customers. Investing in accessible technology not only aligns with ethical and moral imperatives but also promotes innovation and market growth. By creating products and services that are usable by a broader audience, businesses can expand their customer base and enhance user satisfaction.

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