



### Editors-in-Chief

Amani Ali Al-Tamimi,  
Mada Center, Qatar

Achraf Othman,  
Mada Center, Qatar

### Editors

Amira Dhouib,  
Mada Center, Qatar

### Reviewer Board

Ahlem Assila,  
CESI Reims, France.

Ahmed Tlili,  
Smart Learning Institute  
of Beijing Normal  
University China

Alia Jamal AlKathery,  
Mada Center, Qatar

Al Jazi Al Jabr,  
Mada Center, Qatar

Amnah Mohammed  
Al-Mutawaa,  
Mada Center, Qatar

Dena Al-Thani,  
Hamad Bin Khalifa  
University, Qatar.

Fahriye Altinay,  
Near East University,  
Northern part of Cyprus

Fathi Essalmi,  
University of Jeddah,  
Saudi Arabia

Haifa Ben El Hadj,  
Qatar University, Qatar

Hajer Chalghoumi,  
Canadian Centre for Diversity  
and Inclusion Consulting Inc.,  
Canada

Hana Rabbouch,  
Higher Institute of  
Management Sousse, Tunisia

Khaled Koubaa,  
Medeverse, USA

Mohamed Koutheair Khribi,  
Mada Center, Qatar

Oussama El Ghoul,  
Mada Center, Qatar

Samia Kouki,  
Higher Colleges of  
Technology, UAE

Tawfik Al-Hadhrami,  
Nottingham Trent University,  
UK

Zied Bouida,  
Carleton University, Ottawa,  
Canada

# About Mada

Mada – Assistive Technology Center Qatar, is a private institution for public benefit, which was founded in 2010 as an initiative that aims at promoting digital inclusion and building a technology-based community that meets the needs of persons with disabilities (PWDs). Mada today is the world's Center of Excellence in digital accessibility in Arabic.

The Center works through smart strategic partnerships to enable the education sector to ensure inclusive education, the community sector through ICTs to become more inclusive, and the employment sector to enhance employment opportunities, professional development and entrepreneurship for persons with disabilities.

The Center achieves its goals by building partners' capabilities and supporting the development and accreditation of digital platforms in accordance with international standards of digital accessibility. Mada also raises awareness, provides consulting services, and increases the number of assistive technology solutions in Arabic through the Mada Innovation Program to ensure equal opportunities for the participation of persons with disabilities in the digital society.

# About Nafath

Nafath aims to be a key information resource for disseminating the facts about latest trends and innovation in the field of ICT Accessibility. It is published in English and Arabic languages on a quarterly basis and intends to be a window of information to the world, highlighting the pioneering work done in our field to meet the growing demands of ICT Accessibility and Assistive Technology products and services in Qatar and the Arab region.

# Nafath

by Mada

### Issue no. 26

August 2024

ISSN (online): 2789-9152

ISSN (print): 2789-9144

### Reuse Rights and Reprint Permissions

Nafath is an open access journal. Educational or personal use of this material is permitted without fee, provided such use: 1) is not made for profit; 2) includes this notice and a full citation to the original work on the first page of the copy; and 3) does not imply Mada endorsement of any third-party products or services. Authors and their companies are permitted to post the accepted version of Nafath material on their own Web servers without permission, provided that the Mada notice and a full citation to the original work appear on the first screen of the posted copy. An accepted manuscript is a version which has been revised by the author to incorporate review suggestions, but not the published version with copyediting, proofreading, and formatting added by Mada Center. For more information, please go to: <https://nafath.mada.org.qa>. Permission to reprint/republish this material for commercial, advertising, or promotional purposes or for creating new collective works for resale or redistribution must be obtained from Mada.

Nafath © 2023 by Mada Center is licensed under CC BY-NC 4.0.



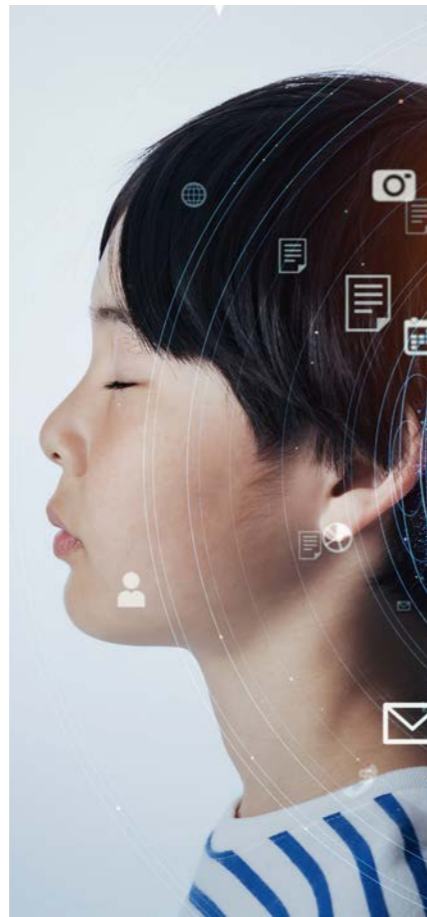
# Content Page

## Page 08

### Accessibility in Human-Computer Interaction and Human-Robot Interaction:

A Brief Review on  
Definitions, Developers  
Guidelines, Laws,  
and Regulations

Malak Qbilat



## Page 22

### Towards Next-Generation User Interfaces:

A Chinese Perspective  
of Implementing Artificial  
Intelligence to Support  
People with Disabilities

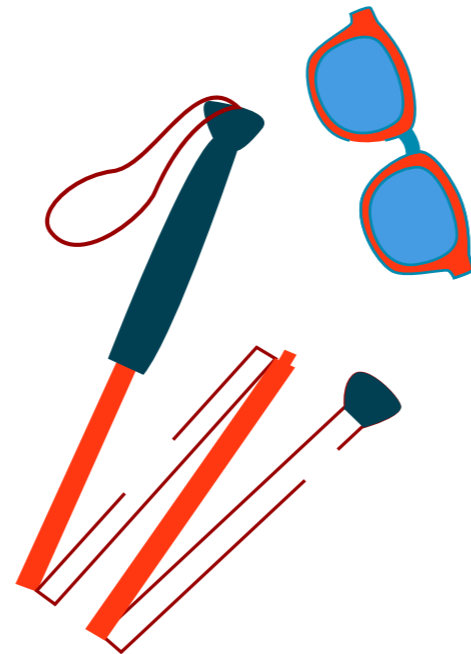
Ahmed Tlili  
Xiangling Zhang  
Ronghuai Huang

## Page 34

### Empowering Accessibility:

A Case Study on Trader  
Joe's Website Interaction  
Framework for the Visually  
Impaired

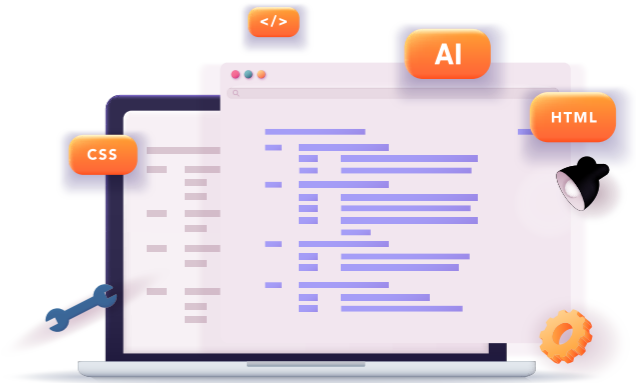
Aparna Krishnan  
Reshmy Krishnan  
Shivakumar  
Arunadevi



## Page 50

### A Review on Roles of Next Generation User Interface to Support People with Disabilities

Sheily Verma (Panwar)  
Aboubakr Aqle



## Page 70

### The Current State of Artificial Intelligence Tools for Accessibility in Product Development

Iyad Abu Doush

## Page 79

### Virtual Reality Glasses to Manage Pain Experience Among Children with Cerebral Palsy: Current State of Knowledge and Future Directions

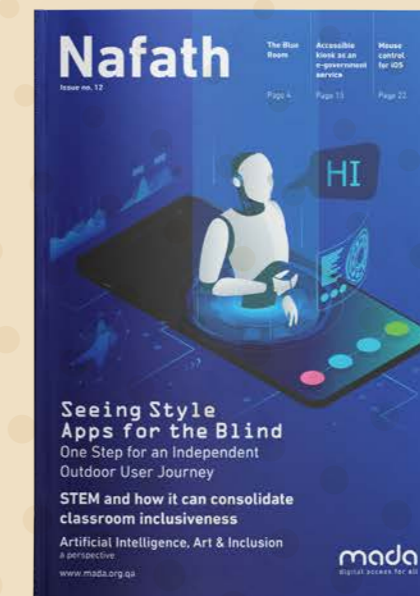
Abdullah Al Shami



## Open call for papers

Nafath is a quarterly magazine and workshop event known as Majlis Nafath.

Majlis Nafath aims to showcase the latest research, advancements, and knowledge sharing in the field of digital inclusion. In each edition, we invite innovative research and perspectives through a new call for papers, fostering a cycle of innovation and collaboration in these fields. Nafath periodical is available in both English and Arabic. Its aim is to support the growing need for accessible ICT and Assistive Technology in Qatar, the Arab region, and the world.



## Why publish with us? Submissions

All accepted and presented papers will be published in Nafath periodical, under an ISSN reference, on paper, and on digital support. Nafath is a member of CrossRef (<http://www.crossref.org/>) and every paper in our digital library is given a DOI. The proceedings will be submitted for indexation by Google Scholar.

We invite the submission of papers exclusively in English or Arabic, which have to be formatted in accordance with Nafath template guidelines (For more details about the instructions, please visit [Instruction for Authors - Nafath periodical by Mada](http://www.nafath.mada.org.qa)). Authors may submit their papers through our online submission portal available at: [nafath.mada.org.qa](http://nafath.mada.org.qa)

## Main Topics

- Interdisciplinary Synergies: Pioneering Advances in Assistive Technologies and Digital Accessibility
- The role of Next-Generation User Interfaces to support People with Disabilities
- Sign Language Processing
- The Role of Digital Accessibility in Shaping Resilient and Inclusive Smart Cities



# Accessibility in Human Computer Interaction and Human Robot Interaction:

A brief review on definitions, developers guidelines, laws and regulations

**Malak Qbilat**

INESC TEC  
Malak.m.irshed@inesctec.pt  
Porto, Portugal

## Keywords

Accessibility; Usability;  
Inclusive Design; Human  
Computer Interaction; Human  
Robot Interaction; Guidelines;  
Laws; User Experience;  
Socially Assistive Robots.



**Accessibility in Human Computer Interaction and Human Robot Interaction: A brief review on definitions, developers guidelines, laws and regulations**

**Abstract** - This paper presents an exploratory study of accessibility in both Human Computer Interaction and Human Robot Interaction focusing on its intersection with interrelated concepts such as usability and inclusive design. It underscores the overarching goal of these concepts in improving the user experience and provide equal access to all user interfaces, albeit with different targeted user groups. Furthermore, the study presents a short review on main accessibility laws and developers guidelines for both Human Computer Interaction and Human Robot Interaction. The review reveals a remarkable gap in accessibility laws and guidelines for Human Robot Interaction, hence, there is an urgent need to broader initiatives and efforts from authorities, researchers community, and industry stakeholders to formulate and create accessibility laws and developers guidelines pertaining to Human Robot Interaction products, where no such laws or guidelines were found in this study, except an individual initiative by the author, which includes a proposal dedicated to help developer in creating accessible interfaces for Socially Assistive Robots. This paper also discusses some practical challenges in implementing accessibility guidelines in HCI and HRI interfaces.

## 1. Introduction

The International Organization for Standards (ISO) defines the accessibility term for the interactive system as “the usability of a product, service, environment, or facility by people with the widest range of capabilities” [1], which means all systems’ users should have an equivalent and less discriminatory experience during their interaction with the systems. Accessibility, Inclusive Design and Usability terms are terms that are commonly and widely used regardless of the differences between them and to indicate the same purpose. The three terms vary mainly in the targeted user types.

In Human Computer Interaction (HCI), the necessity to ensure accessibility to all users with different abilities and needs has emerged and thus many countries have laws and regulations to guarantee the accessibility issue. Additionally, accessibility requirements in HCI have been extensively investigated by researchers and industry, where many guidelines and standards were introduced to help designers and developers to create accessible products [2]. In Human Robot Interaction (HRI), mainly Socially Assistive Robots (SARs), it is difficult to know the extent to which designers and developers of the currently available SARs have committed to implementing the needed accessibility requirements in their designs. It is difficult to give a confident answer comparing to the situation in HCI discipline, due to the absence of specific accessibility laws and guidelines for HRI [3]. Furthermore, none of HCI accessibility guidelines can be completely applied to robotics designing due to the differences in physical interaction components and context of use.

This paper presents a brief review of accessibility, focusing on its definition and a comparison with related concepts, that are usually used in the same context, such as usability and inclusive design. Understanding the distinctions and intersections among these three concepts is vital to enhance design practices among HCI and HRI developers, which will improve user experience consequently. Moreover, such comparisons may enrich the literature and inform policies and standards that aim to enhance digital interfaces. Additionally, this paper provides a succinct overview of existing accessibility laws and guidelines pertinent to HCI and HRI, to identify the main ones and any potential lack or gaps in this regard. The structure of this paper is as follows: Section 2 provides definitions and comparisons



of accessibility, usability, and inclusive design concepts. Section 3 presents a short review of the main accessibility guidelines and laws for HCI and HRI. Section 4 discuss some practical challenges in implementing accessibility guidelines. Finally, Section 5 outlines the conclusions of this study.

## 2. Accessibility, Usability, and Inclusive Design

In this section, we define and compare the concepts accessibility, usability, and inclusive design, which are commonly used in same context, despite their nuanced differences. The differences among these concepts primarily lie in the targeted type of users.

### 2.1 Accessibility vs. Inclusive Design

According to the International Organization for Standardization (ISO) [4], accessibility refers to the “Extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs”. Hence, accessibility focuses on users’ needs and abilities and how to guarantee equality in access to all users during their experience.

Another concept that is usually used in the same context of accessibility is Inclusive Design. Microsoft [5] terms Inclusive Design related to user centred design process (UCD) as “A methodology, born out of digital environments, that enables and draws on the full range of human diversity. Most importantly, this means including and learning from people with a range of perspectives”. John Clarkson & Coleman [6] define Inclusive Design as “a general approach to designing, in which designers ensure that their products and services address the needs of the widest possible

audience, irrespective of age or ability”. Inclusive Design considers more issues than accessibility, for instance, culture, economic situation, and geographic location. Sometimes the terms Universal Design and Design for All are used for the same contextual meaning [7]. The concept of Inclusive Design is more comprehensive than the accessibility concept, (Figure 1). In the following subsection the differences between accessibility and usability are highlighted.

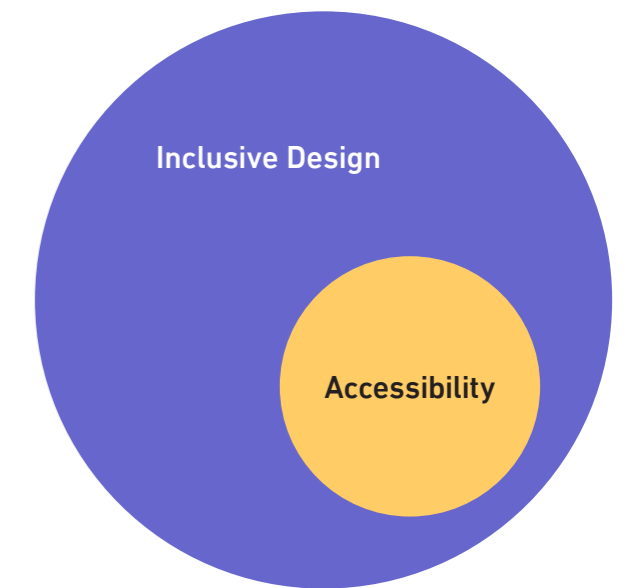
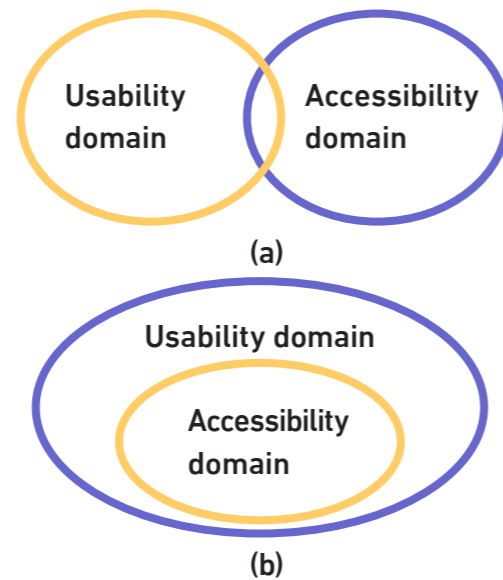


Figure 1. Accessibility compared to inclusive design [8].

### 2.2 Accessibility vs. Usability

ISO defines Usability as the “extent to which a system, product or service can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use” [9]. Another definition for usability was set by the Institute of Electrical and Electronics Engineers (IEEE), which defines usability as “The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component” [10]. Bevan & Petrie [11] have pointed out that there is lack of consensus about accessibility, where

Web Accessibility Initiative WAI [7] proposed accessibility as a subset of usability, justifying that accessibility is considered only for a subset of users who are elderly or have disabilities. ISO [9] proposed that usability as a subset of accessibility, justifying that accessibility considers issues for the largest possible range of users, including older and disabled people [11]. Aizpurua et al. [12] have explained that the scope and extent of the relationship between accessibility and usability is difficult to define, since usability and accessibility are two qualities that interact with each other. For websites, if accessibility and usability are not incorporated, then web sites can be either accessible but hardly usable, or usable but hardly accessible. The association between usability and accessibility has been presented by Casare et al. [13] from two different points of view. The first is the complementary concepts which agrees with Aizpurua et al.'s perspective [12], considering usability and accessibility as integrated concepts. The second point of view is to present accessibility as a sub-class of usability which agrees with Web Accessibility Initiative WAI perspective [7]; Figure 2 shows the association between usability and accessibility according to Casare et al. [13].



**Figure 2.** Accessibility compared to usability: (a) as complementary concepts; (b) accessibility as a sub-class [13].

The next two sections provide a short review on main accessibility laws and developers guidelines for both HCI and HRI.



### 3. Accessibility Guidelines and Laws

The scope of this short review is outlined to focus on existing accessibility guidelines and laws related to HCI and HRI, covering software and hardware interaction component. The Google search engine, as well as the databases IEEE xplora, ACM Digital Library, and Google Scholar, were utilized in this search. While numerous accessibility guidelines and laws were found for HCI, no such guidelines or laws were identified for HRI.

#### 3.1 Accessibility Laws and Regulations for HCI and HRI

Information Technology has played a major role in the daily activities of humans, therefore, the necessity to ensure accessibility to all users with different abilities and needs has emerged and many countries and organizations issued laws and decisions to guarantee the accessibility issue. In this search, main accessibility laws, regulations, and acts in different countries and international or regional organizations were reviewed. The search was limited to a maximum of two accessibility laws, regulations or acts for each country or organization. The search is also limited to the laws, regulations and acts that explicitly provide accessibility in HCI. Many laws have articles that could be explained and used implicitly for accessibility in HCI.

**At countries level.** For HCI, the United States of American (USA) has the Section 508 law [14], which is a regulation that expects all federal agencies' information and communication technology (ICT) such as computers, websites, copiers machines, printers, etc. for people with disabilities [15]. Another accessibility law in the USA is Section

255 of the Telecommunications Act, which is dedicated to the telecommunication industry, such as all types of telephones including mobile phones, faxes, computers with modems, etc. [16]. Further, In United Kingdom (UK), the Equality Act 2010 [17] requires website accessibility for people with disabilities, while The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018 [18] maintains mobile applications and websites accessibility. Likewise, UNE 139803:2012 [19] is a Spanish regulation that aims to guarantee the accessibility of web content. Additionally, the German Act on Equal Opportunities for Persons with Disabilities (BGG) [20] and Barrier-Free Information Technology (BITV) [21] are digital accessibility laws in Germany. While China has the Law on the Protection of Persons with Disabilities 1990 [22], which provides for the development and implementation of equipment that eases the difficulties facing people with disabilities.

In Portugal, Decree-Law No. 83/2018 [23] is a national directive that requires web accessibility and mobile applications for all users. As well, the 2010/2012 Jodhan decision [24] and Policy on Communications and Federal Identity [25] are policies in Canada that require web accessibility. Correspondingly, India has the National Policy on Universal Electronic Accessibility [26], which covers the accessibility issues of electronics and ICT products. France has a law for accessibility of all online public communication services in the country which is Law N° 2005-102 Article 47 [27]. At regional and international level. The European Union (EU) has the European Parliament approved directive 2016/2102 [28], which is a directive that mainly covers accessibility for websites and mobile applications. Moreover, the United Nations (UN) implemented The United Nations Convention

on the Rights of Persons with Disabilities [29]. The convention is concerned with protecting the rights of people with disabilities in several areas, including access to information. Table 1 shows the main accessibility laws, regulations, and acts for HCI found in this search.

**Table 1.**  
Main accessibility laws, regulations, and acts for HCI.

#	Accessibility laws/ regulations/ acts	Scope	Country/ owner
1	Section 508 law	ICT e.g. computers, websites, copiers machines, printers.	USA
2	Section 255 of the Telecommunications Act	Telecommunication industry, e.g. All types of telephones, faxes, computers with modems.	
3	Equality Act 2010	Websites accessibility.	UK
4	The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018	Mobile applications and websites.	
5	UNE 139803:2012	Web content.	Spain
6	German Act on Equal Opportunities for Persons with Disabilities (BGG)	Digital Accessibility	Germany
7	Barrier-Free Information Technology (BITV)	Digital Accessibility	Germany
8	Law on the Protection of Persons with Disabilities 1990, as amended in China	Development and implementation of equipment that eases the difficulties of people with disabilities.	China
9	Decree-Law No. 83/2018	Web and mobile applications.	Portugal
10	The 2010/2012 Jodhan decision	Web accessibility.	Canada
11	Policy on Communications and Federal Identity		
12	National Policy on Universal Electronic Accessibility	Electronics and ICTs products.	India
13	Law N° 2005-102 Article 47	Online public communication services in the country.	France
14	European Parliament approved directive 2016/2102	websites and mobile applications	EU
15	The United Nations Convention on the Rights of Persons with Disabilities	Access to information.	UN

In this short review, no accessibility laws, regulations or acts for HRI were found, neither at the countries level nor at the international level.

### 3.2 Accessibility Guidelines and Standards for HCI and HRI

In this section, the main accessibility guidelines and standards for HCI and HRI were reviewed. The focus was on well-known companies and accessibility organizations' guidelines or standards, where it was noticed that many countries have policies to comply with such guidelines and standards. For example, in the UK the BS 8878 [30] standards for web accessibility were replaced with ISO 30071-1 [31].

For instance, the World Wide Web Consortium (W3C) developed accessibility guidelines, such as the Web Content Accessibility Guideline (WCAG 2.2) [32] for web, non-web content and ICT; the User Agent Accessibility Guidelines (UAAG 2.0) [33] for user agents which render the web content such as browsers, media players, etc.; the Authoring Tool Accessibility Guidelines (ATAG 2.0) [34]; and the Web Accessibility Initiative-Accessible Rich Internet Applications (WAI-ARIA 1.2) [35]. These guidelines help authors specify the proper semantic meaning of web content, hence, allowing Assistive Technologies (AT) to provide user interface behaviours and structural information to the user. W3C accessibility guidelines are comprehensive as they consider several web components such as web content, user agents, authoring tools and assistive technologies. These guidelines are presented for those interested among different types of supporting documents, like success criteria which work as a quick checklist, techniques, best practices and examples that explain how to achieve accessibility. And documents for more understanding and additional

guidance for both success criteria and techniques. In addition, the guidelines have a conformance level model which starts with "A" the basic level for accessibility, "AA" the medium level for accessibility and ends with "AAA" the higher level for accessibility.

Funka Nu guidelines [36] which are accessibility guidelines for mobile interfaces by the Swedish consultancy for accessibility and user experience. The guidelines are presented in one document with a brief description for each guideline. IBM accessibility checklists [37] address accessibility issues from software and hardware perspectives such as web, non-web software, documentation and designing accessible hardware like personal computers, servers, printers, etc.

Further, Apple introduced their accessibility guidelines [38] for designing and implementing accessible applications that run on their platforms too. Apple accessibility guidelines are supported with resources and documentation which include a description for each guideline with additional learning sources, coding and graphical examples too. Correspondingly, Android developers [39] present their accessibility guidelines for android applications. The guidelines are presented along with coding and graphical examples, and additional resources (links) to provide more explanations. The European Telecommunications Standards Institute (ETSI), European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC) implemented EN 301 549 [40], which is a group of accessibility guidelines for ICT products and services. These guidelines are explained in a document along with their test procedures and evaluation methodology. Moreover, the latest version of these guidelines adopted WCAG 2.1



[41]. A few graphical examples are attached to the guidelines, besides referencing technical reports, ISO and WCAG 2.1 as support documents that could help in implementing the accessibility guidelines. Also, ISO implemented ISO/IEC 30071-1 [31] standards for establishing organizational accessibility for ICT systems, such as mobile interfaces, websites, social media, wearable applications, etc. by adopting accessibility policies, and embedding accessibility decisions in ICT systems' lifetime starting from implementing, procuring and installing processes and ending with maintenance process. Table 2 shows main accessibility guidelines or standards found in this search.

**Table 2.**  
Main accessibility guidelines and standards for HCI.

#	Accessibility laws/ regulations/ acts	Scope	Country/ owner
1	WCAG 2.2	Web content, non-web content and ICT. E.g. desktops, tablets, laptops, and mobiles.	
2	UAAG 2.0	User agents. E.g. web browsers, media players, and readers.	W3C
3	ATAG 2.0	Authoring tools for developers and users. E.g. web page and multimedia authoring tools.	
4	WAI-ARIA 1.2	Semantic meaning of web content.	
5	Funka Nu	Mobile interfaces and applications.	Swedish consultancy for accessibility and user experience.
6	IBM	<ul style="list-style-type: none"> <li>Software. E.g. web, non-web software, documentation.</li> <li>Hardware. E.g. personal computers, servers, and printers.</li> </ul>	IBM
7	Apple's accessibility guidelines for their applications	For all apple's applications (software) which run on different apple's platforms.	Apple
8	Android developers accessibility guidelines	Android applications (software).	Android developer/ Google
9	EN 301 549	ICT product and services. E.g. for web and mobile applications, hardware, etc.	ETSI, CEN and
10	ISO/IEC 30071-1:2019	ICT products and services	CENELEC



Researchers and industry have extensively explored accessibility requirements in HCI. Where many guidelines and standards were presented to support designers and developers to code and create accessible interfaces. However, the applicability of these guidelines to robotic interfaces design is limited due to the disparities in physical components and context of use. In this short review, no accessibility guidelines, standards, or recommendations for HRI were found, despite the work presented by the author herself, where she proposed accessibility guidelines for HRI, mainly focus on SARs [3]. The following section discusses several practical challenges that may obstruct the implementation of accessibility guidelines.

#### 4. Practical Challenges in Implementing Accessibility Guidelines

Implementing existing accessibility guidelines encompasses several challenges. Technically, designers and developers may face difficulty in understanding some long and extensive accessibility guidelines documents. Moreover, integrating accessibility features into existing digital systems and devices that were initially developed without considering accessibility principals can be challenging. Besides, developing accessible interfaces for users with diverse abilities and needs can increase system complexity and potentially slow down the performance.

In addition to the technical challenges, there is the cost implications. Adopting accessibility in HCI and HRI interfaces implementation requires specialised persons and tools in any team to design, develop and test these interfaces, which can increase the required time and cost for development. Accessibility evaluation tools might

be free and open sources weather it is automated tool such as WAVE [42], or for example the use of Large Language Models (LLM) as in [43].

A lack of awareness about the importance of accessibility among developers, combined with insufficient training are other challenges that can affect accessible interfaces development process. Furthermore, the absence or lack of laws and legalisations in some countries creates barriers to ensuring accessibility standards are met during development process of digital products [44], where developers or organisations may deprioritise the implementation of accessibility features.

#### 5. Conclusion

The brief review presented in this paper explore accessibility in HCI and HRI regarding, comparative analysis of related concepts, existing designers and developers guidelines and laws. Accessibility, usability, and inclusive design are interrelated concepts, which usually used to refer to the same context. It is true that these concepts share the overarching goal of improving user experience in general in addition to provide equal access to user interfaces, however the differences among these concepts primarily lie in the targeted type of users. Accessibility laws, regulations and acts at countries level and international levels were briefly reviewed in this study. Fifteen accessibility laws, regulations and acts were identified, in addition to the scope of

**each one. The laws varied in terms of the aspects they considered, both software and hardware interaction component. No accessibility laws, regulations or acts pertaining to HRI were identified during this brief review. Ten HCI accessibility guidelines and standards were identified along with the scope and owner of each one. While No accessibility guidelines, standards, or recommendations for HRI were found, despite the work proposed by the author.**

**This situation highlights the urgent need to broader efforts and initiatives from authorities, academia, and industry to establish more comprehensive accessibility laws and guidelines, especially for HRI. Additionally, it is crucial to raise awareness among all stakeholders about the significant impact of accessibility and provide training to designers and developers and allocate the needed resources to encourage accessibility practices in any project.**

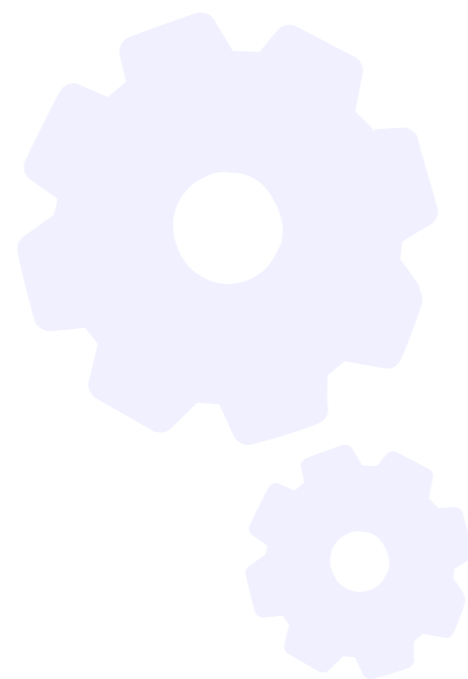
**Acknowledgments.** Some sections of this work are derived from the author's doctoral thesis, which is available on the following website: (<https://e-archivo.uc3m.es/rest/api/core/bitstreams/be521cfd-7ed4-43ec-ab01-ab82b6eb5c84/content>).

#### References

1. ISO. (2008). Ergonomics of human-system interaction — Part 171 : Guidance on software accessibility. International Organization. <https://www.iso.org/obp/ui/#iso:std:iso:9241:-171:ed-1:v1:en>.
2. Qbilat, M., & Iglesias, A. (2018). Accessibility guidelines for tactile displays in human-robot interaction. A comparative study and proposal. In *Computers Helping People with Special Needs: 16th International Conference, ICCHP 2018, Linz, Austria, July 11-13, 2018, Proceedings, Part II 16* (pp. 217-220). Springer International Publishing.
3. Qbilat, M., Iglesias, A., & Belpaeme, T. (2021). A proposal of accessibility guidelines for human-robot interaction. *Electronics*, 10(5), 561.
4. ISO. (2019). ISO/IEC 30071-1:2019(en), Information technology — Development of user interface accessibility — Part 1: Code of practice for creating accessible ICT products and services. <https://www.iso.org/obp/ui/#iso:std:iso-iec:30071:-1:ed-1:v1:en>.
5. Microsoft. (2021). Microsoft Design. Microsoft. <https://www.microsoft.com/design/inclusive/>.
6. John Clarkson, P., & Coleman, R. (2015). History of inclusive design in the UK. *Applied Ergonomics*, 46(PB), 235–247. <https://doi.org/10.1016/j.apergo.2013.03.002>.
7. Rush, S., & EOWG. (2016). Accessibility, Usability, and Inclusion | Web Accessibility Initiative (WAI) | W3C. W3C Wai. <https://www.w3.org/WAI/fundamentals/accessibility-usability-inclusion/>.
8. Al-Qbilat, M. M. I. (2022). Accessibility requirements for human-robot interaction for socially assistive robots. [https://doi.org/10.1007/978-3-319-94274-2\\_29](https://doi.org/10.1007/978-3-319-94274-2_29).

9. ISO/IEC. (2018). ISO 9241-11:2018(en), Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts. Iso. <https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en>.
10. IEEE. (1990). IEEE Standard Glossary of Software Engineering Terminology. In *Office* (Vol. 121990, Issue 1). <https://doi.org/10.1109/IEEESTD.1990.101064>.
11. Petrie, H., & Bevan, N. (2009). The evaluation of accessibility, usability, and user experience. In *The Universal Access Handbook* (pp. 20-1-20-16). <https://doi.org/10.1201/9781420064995-c20>.
12. Aizpurua, A., Harper, S., & Vigo, M. (2016). Exploring the relationship between web accessibility and user experience. *International Journal of Human Computer Studies*, 91, 13–23. <https://doi.org/10.1016/j.ijhcs.2016.03.008>.
13. Casare, A. R., Da Silva, C. G., Martins, P. S., & Moraes, R. L. O. (2016). Usability heuristics and accessibility guidelines: A comparison of heuristic evaluation and WCAG. *Proceedings of the ACM Symposium on Applied Computing*, 04-08-April, 213–215. <https://doi.org/10.1145/2851613.2851913>.
14. IT Accessibility Laws and Policies | Section508.gov. (n.d.). Retrieved July 30, 2020, from <https://www.section508.gov/manage/laws-and-policies>.
15. U.S. Access Board. (2021). Revised 508 Standards and 255 Guidelines. <https://www.access-board.gov/ict/>.
16. Govoni, N. A. (2012). Telecommunications Act. In *Dictionary of Marketing Communications*. <https://doi.org/10.4135/9781452229669.n3639>.
17. HM Government. (2010). Equality Act 2010. In *The Stationery Office Crown Copyright. Statute Law Database*. <https://doi.org/10.1007/978-0-10-541510-7>.
18. UK Statutory Instruments. (2018). The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations. *Legislation.Gov.Uk*, 2, 2021.
19. UNE 139803: 2012. (2012). <https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma?c=N0049614>.
20. BGG. (2002). <http://www.gesetze-im-internet.de/bgg/BJNR146800002.html>.
21. BITV 2.0. (2011). [https://www.gesetze-im-internet.de/bitv\\_2\\_0/BJNR184300011.html](https://www.gesetze-im-internet.de/bitv_2_0/BJNR184300011.html).
22. NATLEX database. (1990). CHINA. LAW ON THE PROTECTION OF DISABLED PERSONS, 1990. <https://www.ilo.org/dyn/natlex/docs/WBTEXT/31906/64869/E90CHN01.htm>.
23. Decreto-Lei 83/2018, 2018-10-19 - DRE. (2018). <https://dre.pt/web/guest/pesquisa/-/search/116734769/details/maximized>.
24. Home | Canadian Internet Policy and Public Interest Clinic (CIPPIC) - Canadian Internet Policy and Public Interest Clinic (CIPPIC). (n.d.). Retrieved November 4, 2011, from <http://www.cippic.ca/>.
25. Canada. (2016). Policy on Communications and Federal Identity and Directive on the Management of Communications. Treasury Board of Canada Secretariat. [http://news.gc.ca/web/article-en.do?nid=1064269&\\_ga=1.128207116.1668809937.1476978133](http://news.gc.ca/web/article-en.do?nid=1064269&_ga=1.128207116.1668809937.1476978133).
26. PIB. (2013). National Policy on Universal Electronic Accessibility: PIB. <https://pib.gov.in/newsite/printrelease.aspx?reid=99845>.
27. Leplège, A., & Welniarz, B. (2015). La loi du 11 février 2005 pour l'égalité des droits et des chances, la participation et la citoyenneté des personnes handicapées... dix ans après. *Perspectives Psy*. <https://doi.org/10.1051/ppspsy/2015544293>.

28. European Parliament. (2016). EUR-Lex - 32016L2102 - EN - EUR-Lex. Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the Accessibility of the Websites and Mobile Applications of Public Sector Bodies. <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1596098310471&uri=CELEX:32016L2102>.
29. United Nations. (2020). Convention on the Rights of Persons with Disabilities (CRPD) | United Nations Enable. Department of Economic and Social Affairs Division for Inclusive Social Development. <https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html>.
30. Bsi. (2012). BS 8878 is a code of practice to ensure your websites are accessible for all web users. <https://shop.bsigroup.com/products/web-accessibility-code-of-practice?pid=000000000030180388>.
31. ISO/IEC 30071-1. (2019). ISO/IEC 30071-1:2019 Information technology - Development of user interface accessibility - Part 1: Code of practice for creating accessible ICT products and services. Geneva, Switzerland: International Organization for Standardization. <https://www.iso.org/obp/ui/#iso:std:iso-iec:30071:-1:ed-1:v1:en>.
32. Web Content Accessibility Guidelines (WCAG) 2.2. (n.d.). Retrieved May 21, 2024, from <https://www.w3.org/TR/WCAG22/>.
33. User Agent Accessibility Guidelines (UAAG) Overview | Web Accessibility Initiative (WAI) | W3C. (n.d.). Retrieved May 21, 2024, from <https://www.w3.org/WAI/standards-guidelines/uaag/#user-agent-accessibility-guidelines-uaag>.
34. Authoring Tool Accessibility Guidelines (ATAG) Overview | Web Accessibility Initiative (WAI) | W3C. (n.d.). Retrieved May 21, 2024, from <https://www.w3.org/WAI/standards-guidelines/atag/>.
35. WAI-ARIA Overview | Web Accessibility Initiative (WAI) | W3C. (n.d.). Retrieved May 21, 2024, from <https://www.w3.org/WAI/standards-guidelines/aria/>.
36. Mobile guidelines - Funka. (n.d.). Retrieved February 26, 2020, from <https://www.funka.com/en/our-assignments/research-and-innovation/archive---research-projects/mobile-guidelines/>.



37. IBM. (2014). IBM Human Ability and Human Ability and Accessibility Center | Developer guidelines | Documentation checklist. <https://www.ibm.com/able/guidelines/hardware/accesshardware.html>.
38. Apple. (n.d.). Accessibility on iOS - Apple Developer. Accessibility on IOS - Apple Developer. Retrieved October 30, 2021, from <https://developer.apple.com/accessibility/ios/>.
39. Google. (2020). Build more accessible apps - Android Developers. <https://developer.android.com/guide/topics/ui/accessibility>.
40. ETSI org. (2018). ETSI - Welcome to the World of Standards! Etsi.Org. <https://www.etsi.org/>.
41. Web Content Accessibility Guidelines (WCAG) 2.1. (n.d.). Retrieved April 30, 2024, from <https://www.w3.org/TR/WCAG21/>.
42. WAVE Web Accessibility Evaluation Tools. (n.d.). Retrieved May 21, 2024, from <https://wave.webaim.org/>.
43. Othman, A., Dhouib, A., & Nasser Al Jabor, A. (2023, July). Fostering websites accessibility: A case study on the use of the Large Language Models ChatGPT for automatic remediation. In Proceedings of the 16th International Conference on Pervasive Technologies Related to Assistive Environments (pp. 707-713).
44. Al-Jabir, M. (2023). The Importance of Digital Accessibility Policies in Promoting Inclusivity and Diversity. Nafath, 8



# Towards next-generation user interfaces

## Chinese perspective of implementing Artificial Intelligence (AI) to support people with disabilities

### Ahmed Tlili

Smart Learning Institute  
of Beijing Normal University  
ahmed.tlili23@yahoo.com  
Beijing, China

### Xiangling Zhang

Beijing Institute of Education  
zhangxiangling@bjie.ac.cn  
Beijing, China

### Ronghuai Huang

Smart Learning Institute  
of Beijing Normal University  
huangrh@bnu.edu.cn  
Beijing, China

### Abstract

While several studies have investigated how artificial intelligence (AI) has shaped next-generation user interfaces, most of the literature is Western-based and scant information exists on the technological advancement for people with disabilities. To address this research gap, this study conducts an integrative review to show how AI in China has facilitated the development of next-generation interfaces, allowing more realistic and personalized interactions based on the different needs of people with disabilities. Specifically, it reports various cases adopted and implemented in various Chinese real-scenarios, beyond lab experiments or small tests. This study contributes to the Sustainable Development Goals (SDGs) by depicting different scenarios, techniques and interaction levels that could be adopted in various contexts to facilitate the life of people with disabilities in different fields.

### Keywords

Artificial intelligence, next-generation, user interface, disability, special needs, accessibility, sustainable development goals



## 1. Introduction

The UNESCO Asia Pacific Education Bureau in 2019 and some of the World Health Organization (WHO) data stated that there are more than 1 billion people worldwide having a disability, of which 93 million are children under the age of 14 [1]. China, particularly, has 85 million people with disabilities, making it the country with the largest disabled population in the world, accounting for 6.34% of the total population. It is expected that the total number of people with disabilities in China will reach 65.3% by 2050, which will be twice that of the current total number of people with disabilities in China [2].

Meanwhile, with rapid evolution of technology, several research studies and projects have started relying on assistive technology to help people with disabilities achieve several tasks. Artificial Intelligence (AI) as a technology, particularly, has allowed developing next-generation user interfaces where various human-machine interactions are now made possible to cater to the different needs of various disability features. Human-machine interfaces are smart interfaces that provide more realistic interactions to achieve personalized human-machine interaction according to users' abilities and pre-existing knowledge [3]. Wigdor [4] highlighted the need to investigate how emerging technologies will develop next-generation user interfaces that provide a high quality, easy to use interfaces for experts and novices alike.

The rapid technological advancement in China, especially in terms of Artificial Intelligence (AI), has attracted international attention from different fields, including economists [5], US-based political analysts [6] and security experts [7]. In 2017, the Chinese government promulgated the "Development Plan for the New Generation of Artificial Intelligence," which proposed the guiding ideology, strategic goals, key tasks, and guarantee measures for the development of the new generation of artificial intelligence in China by 2030, deploying to build China's leading advantage in artificial intelligence development, accelerating the construction of an innovative country and a world-leading technological power. This AI advancement has catalyzed developing next-generation interfaces generally and for people with disabilities specifically.

However, most of the literature is Western-based, and little is known on how next-generation interfaces are developed for people with disabilities in non-Western countries like China. Therefore, this study provides an integrative review on the Chinese perspective of developing next-generation interfaces. Specifically, it reports various cases adopted and implemented in various real-scenarios, beyond lab experiments or small tests. This study contributes to the Sustainable Development Goals (SDGs) by depicting different scenarios, techniques and interaction levels that could be adopted in various contexts to facilitate the life of people with disabilities in different fields.

## 2. Chinese policies to support people with disabilities

According to the State Council Information Office of the People's Republic of China [2], the Chinese government has taken several major measures to champion the programs of persons with disabilities and improve their lives, including founding of the China Foundation for Disabled Persons in 1984, the first national sample survey on disability in 1987, founding of the China Disabled Persons' Federation (CDPF) in 1988, and promulgation of the Law of the People's Republic of China on the Protection of Persons with Disabilities and the first five-year program for China's cause of these people in 1991. The State Council has released seven five-year development plans for persons with disabilities, making overall arrangements for the protection of their rights and interests. To further define the tasks and responsibility list for the protection of persons with disabilities, China has issued "Instructions of the State Council on Accelerating the Process Toward Prosperity for Persons with Disabilities", "Outline for Accelerating the Process Toward Prosperity for Persons with Disabilities in the 13th Five-year Plan Period", "Plan for Promoting Equal Access to Basic Public Services in the 13th Five-year Plan Period", "The National Disability Prevention Program (2016-2020)", and two documents of "Special Education Promotion Plan", for 2014-2016 and 2017-2020 respectively. Launched in 2009, the three documents of the "National Human Rights Action Plan" for 2009-2010, 2011-2015, and 2016-2020 specified the tasks and goals of this mission. By April 2018, more than 80 laws and 50 administrative regulations had been passed concerning the protection of the rights and interests of persons with disabilities. In terms of assistive technologies, during the "13th Five-Year Plan" (2016-

2020) period, China formulated the vision that "over 80 percent of the disabled adults (with disability certificate) and children can receive basic adaptive assistive technology products and services by 2020." Additionally, the Ministry of Education and six other ministries jointly issued the "14th Five-Year Plan for the Development and Enhancement of Special Education" in 2021. The document states: "Strengthen the construction of digital education resources. Actively promote the digital and intelligent transformation and development of special education, explore the application of new technologies such as the internet, cloud computing, big data, virtual reality, and artificial intelligence."

All those efforts and initiatives to support people with disabilities in line with the rapid technological advancements in China have raised the attention of people about the latest developed next-generation interfaces and how they used to cater to the different needs of disabilities, as discussed in this study.

### 3. Method

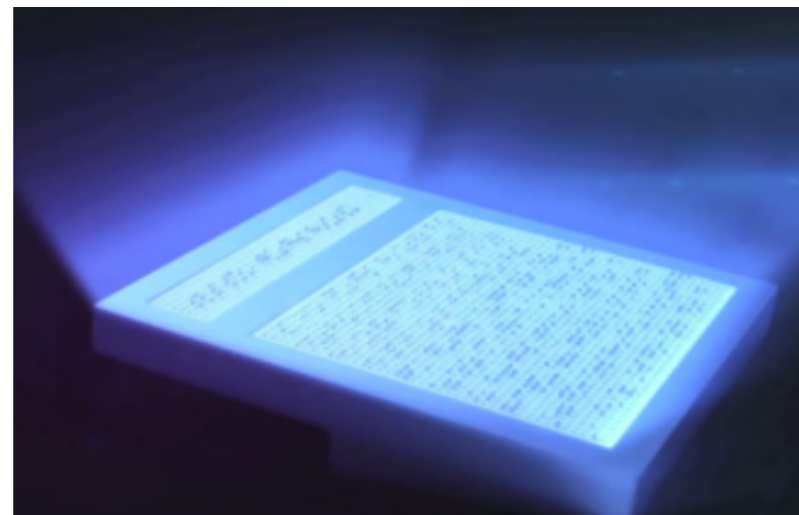
This present study was framed through an integrative literature review [8, 9]. Integrative reviews are a type of non-systematic reviews [10] aiming to cover “new or emerging topics that would benefit from a holistic conceptualization and synthesis.” While systematic reviews might inadvertently amplify knowledge inequalities by focusing on specific databases or article types [11], the integrative approach on the other hand overcomes this issue by covering knowledge in different types from different sources, regions and languages [12, 13]. This is important in this present study as the goal is to exemplify case studies of implementing AI to support people with disabilities in real contexts beyond the lab experiment context, which is usually the common practice reported in research papers [14, 15]. Our approach distinctly adopts the methodology proposed by Raffo et al. [16], known as “conceptual synthesis,” which goes beyond synthesizing substantive research findings. Instead, it aims to identify the conceptual foundations from which these findings emerge. Particularly, this present study focuses on how AI has shaped user interfaces, referred to as “next-generation interfaces”, and the different types of interaction made possible for people with disabilities and special needs to achieve various objectives (education, information access, etc.).

### 4. AI-based next-generation interfaces and interactions for people with disabilities in China

This section provides several case studies illustrating next-generation interfaces that have been implemented in various contexts to support people with disabilities.

#### 4.1 Accessible information search and retrieval

China's leading search engine provider Baidu has announced the Blind Search device (see Figure 1), a tool to assist blind and vision impaired people access “massive amounts of information online through touch” using a combination of tactile and voice-activated commands. The Blind Search tool provides a dedicated area for typing commands using finger gestures, which are converted to Braille output via a display at the top of the device so that the users can check if there are any typing errors. Once search terms have been entered, a button at the back of the device can be pressed to display a list of text-based search results. These results are displayed in Braille output to be read by users or they are



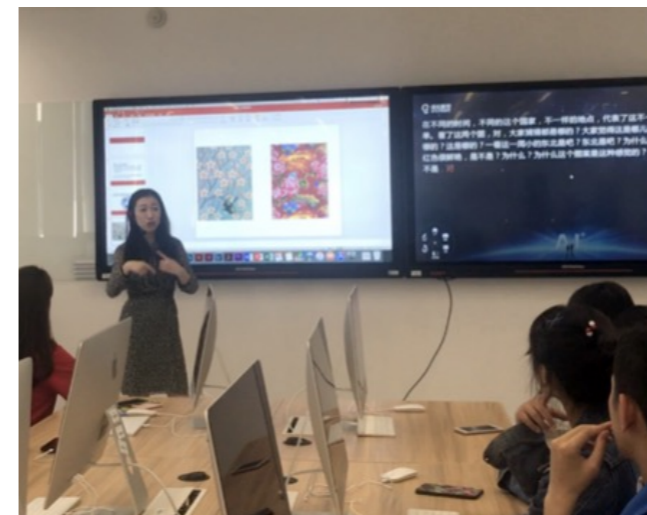
**Figure 1.**  
Blind Search device [17]

also converted to audio through text-to-speech functionality. Voice input is also supported, allowing users to press a button at the side of the device to speak search terms aloud, which are then converted into text or image-based results via the tactile display.

Images can also be searched and displayed using a “tangible image made from dot positions arranged in rectangles” which the user can interact with via touch, providing audio description as users navigate across different sections of the picture. As Baidu states, the combination of providing tactile imagery with audio description is intended to “help blind people understand [the] search results in a comprehensive stereoscopic way”.

#### 4.2 Easy communication and interaction

Special Education College of Beijing Union University is the only college in Beijing that focuses on higher education for persons with disabilities. At present, 70% of the students in the college are students with disabilities, and 70% of the students with disabilities are hearing-impaired. The school uses an AI-based smart classroom, where teachers' speeches in classrooms are automatically translated into subtitles and sign-languages and then displayed on a large screen in classes (see Figure 2).



**Figure 2.**  
Art and Design Professional Teacher is teaching to Disabled Students [18]

For blind people, the school has also developed and equipped students with reading pens which are used to scan the letters and these letters are then read out loud (see Figure 3). This tool allows self-studying and avoids issues, including having only four or five books for Braille, which is very inconvenient to check; the second obstacle is that the information they master through touch is sometimes incomplete, and they need to turn over the books to form a connection with the things they touch. This pen can also be used to read images which are converted into 2D convex images.



**Figure 3.**  
Diagram of the Voice QR Code Reading pen on the medicine cabinet [18]

#### 4.3 Cognitive Development in immersive virtual reality (VR) environments

Shunde District Qizhi School is a comprehensive boarding special education school for children with moderate to severe intellectual disabilities. There are VR labs to develop students' cognition, overcome limitations and monotonous methods in safety education, as well as issues related to the difficulty and high cost of setting up training scenarios (see Figure 4). For instance, abstract concepts like 'up-down' and 'left-right' are traditionally taught using a point of reference. However, for children with intellectual disabilities, they might struggle to understand these concepts when the environment changes, yet real-life teaching cannot provide a variety of scenarios. VR can simulate numerous scenarios for intensive student training, enhancing their understanding of abstract concepts through continuous stimulation and fostering the ability to generalize these concepts.



**Figure 4.** Special education students learn through VR [19]

Take safety education as another example, real-life teaching cannot allow students to touch fire or experience the pain of drowning by jumping into water. VR simulates such scenarios, and when students enter those virtual environments, the system triggers alarms or produces smoke signals to indicate danger. Through repeated reinforcement, students become aware of potential hazards, achieving the goal of training their safety awareness. Teachers can also monitor the virtual scenarios experienced by students in real-time on a pad device, providing timely instructional guidance and intervention. Students also receive feedback within the VR environment; for instance, if they perform well, the computer may emit an encouraging sound saying, "You did great!"

#### 4.4 Early diagnosis and intervention for children with Autism

In March 2024, the "China Autism Education and Rehabilitation Industry Development Status Report" was officially released. The report estimates that the prevalence of autism among children aged 6-12 is 0.7%. Conservatively estimated, there are about 2 million children with autism aged 0-14 nationwide, with an annual increase of approximately 160,000. Professor Xu Peng from the University of Electronic Science and Technology of China has combined artificial intelligence techniques such as deep learning, transfer learning, and manifold learning to establish an early diagnostic recognition system for children with ASD (Autism Spectrum Disorder), focusing on the abnormal interaction information between brain networks and other source signal networks [20]. This system improves the accuracy of diagnosis and helps patients with autism receive early intervention, achieving better outcomes in lifelong rehabilitation. Currently, intervention technologies for autism face issues such as a lack of personalized intervention and insufficient levels of intelligence. Over the past decade, Professor Chen LiangYing's team at Central China Normal University has been continuously

tackling these challenges, focusing on refined assessment and personalized intelligent intervention for children with autism. Her research has explored intelligent recognition methods for children with autism that integrate multimodal data. By analyzing behavioral and cognitive data, significant differences were found between children with autism and typically developing children in eye movements, facial expressions, cognitive scores, and cognitive response time data. Furthermore, feature selection was performed using these data differences, and an autism recognition model integrating multimodal data was constructed. Figure 5 shows the data from a child with autism are being collected through a head-mounted device while he is playing games.



**Figure 5.** A child with autism is being assessed [21].

#### 4.5 Intelligent sports equipment aids in enhancing the physical fitness of special-needs children

Since most children with disabilities are unable to express their adverse physical reactions normally using smart teaching devices such as jump ropes and wristbands to monitor their heart rate and other physical indicators can effectively prevent the occurrence of safety accidents. These intelligent devices provide teachers with a better understanding of students' physical conditions and offer precise exercise data to physical education teachers, allowing them to develop personalized teaching plans for students with different physical disabilities.

Xiangyang Special Education School has a total of 14 teaching classes with 180 students enrolled. In 2022, the school launched a smart physical education project, including a smart physical education platform and intelligent devices, which have now been fully implemented in each class. The school also conducted a comparative experiment on the one-minute rope skipping event, showing that the overall average score of students in the experimental group (using the smart physical system) improved by 20.3%. At the same time, the teachers stated that "the smart physical system has made the physical education teaching process quantifiable and visual, promoting classroom communication between teachers and deaf students or students with intellectual disabilities, effectively enhancing the quality of physical education teaching." Figure 6 shows the data on a student's psychological baseline indicators, average heart rate curve, and exercise intensity index after exercising.

Since most children with disabilities are unable to express their adverse physical reactions normally using smart teaching devices such as jump ropes and wristbands to monitor their heart rate and other physical indicators can effectively prevent the occurrence of safety accidents. These intelligent devices provide teachers with a better understanding of students' physical conditions and offer precise exercise data to physical education teachers, allowing them to develop personalized teaching plans for students with different physical disabilities. Xiangyang Special Education School has a total of 14 teaching classes with 180 students enrolled. In 2022, the school launched a smart physical education project, including a smart physical education platform and intelligent devices, which have now been fully implemented in each class. The school also conducted a comparative experiment on the one-minute rope skipping event, showing that the overall average score of students in the experimental group (using the smart physical system) improved by 20.3%. At the same time, the teachers stated that "the smart physical

system has made the physical education teaching process quantifiable and visual, promoting classroom communication between teachers and deaf students or students with intellectual disabilities, effectively enhancing the quality of physical education teaching.” Figure 6 shows the data on a student’s psychological baseline indicators, average heart rate curve, and exercise intensity index after exercising.



Figure 6. Student’s psychological data [22]

#### 4.6 Empower special education teachers through generative AI

On November 9, 2023, the Tianhe District Education Bureau in Guangzhou held a seminar on the exploration and practice of AI+ Special Education Practice Community. A teacher from Qihui School in Tianhe District presented an open class demonstration titled “Carmen Overture Music Appreciation - Rhythm.” Before the class, the teacher used generative artificial intelligence to create personalized learning objectives and strategies for eight children with varying degrees of intellectual disabilities. Figure 7 shows the generative AI system, iFLYTEK Spark, responds to the following prompt:

“You are an esteemed professor specializing in special education. I have eight children with various disabilities, including three with intellectual disabilities, two with Down syndrome, two with autism, and one with

cerebral palsy. Classified by the degree of impairment: one mild, two moderate, three severe, and two profound. Please provide an analysis of their learning situations when teaching ‘Carmen Overture,’ focusing on three aspects: musical perception ability, rhythmic expression ability, and social adaptation skills. The analysis should be presented in a tabular form for each type of child.”

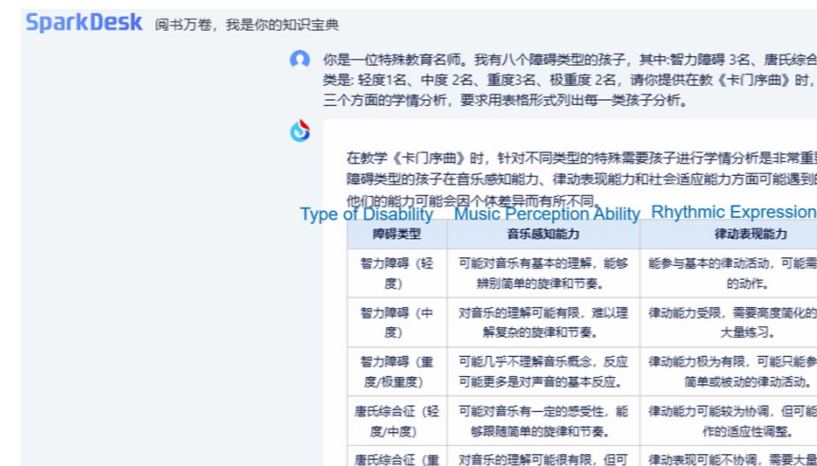


Figure 7. Response of the generative AI tool

It should be noted that iFLYTEK Spark is a general-purpose large language model and is not specifically designed for the field of special education. In China, there are also GAI that specifically serve special education teachers, such as the one shown in Figure 8, namely QiWei special education AI partner. It can provide teachers with functions like lesson plan writing, rehabilitation training activity design, special education encyclopedias, and special education event planning assistants and so on.



Figure 8. The webpage of QiWei special education AI partner [23]

## 5. Conclusion and future directions

This study conducted a review to highlight how emerging technologies like AI in China have sharpened next-generation interfaces. The obtained results revealed that Internet of Things (IoT) and immersive technologies like AR have helped to provide more natural interactions, where multimodal data are collected and analyzed in immersiveness environments stimulating real-world scenarios. This reveals that such technologies can provide new types of interaction beyond the traditional ones which usually relies on clicking (through mouse) and typing (through keyboard). It is also seen that China has relied on portable and open source technologies to cater to the different needs of people with disabilities. In this context, several studies highlighted the importance of harnessing the power of “openness” to promote accessibility and inclusivity [24, 25].

Additionally, it is seen that several case studies have relied on large language models (LLM) and generative AI (Gen AI) to generate different solutions (content, teaching strategies, etc.) for people with disabilities based on their needs. While Gen AI is a great technology to support inclusivity and accessibility, Tlili et al. [26] also pointed out the need to keep a close eye on the ethical issues of such technology as it might harm users instead of helping them.

This study also revealed the close relationship between research and development (R&D) in China which facilitated the rapid development of next-generation interfaces for people with disabilities. This was seen where various leading industries and companies have closely worked with special education schools to develop low-cost and portable assistive technologies.



**References**

1. UNESCO Asia Pacific Bureau of education. (2019). Focusing on “hidden disabled” children, world education information, 2019, 11.
2. State Council Information Office of the People’s Republic of China. (2019). Equality, Participation and Sharing: 70 Years of Protecting the Rights and Interests of Persons with Disabilities in the PRC. Available on: [http://www.scio.gov.cn/zfbps/ndhf/2019n/202207/t20220704\\_130618.html](http://www.scio.gov.cn/zfbps/ndhf/2019n/202207/t20220704_130618.html)
3. Jacob, R. J. (2006). What is the next generation of human-computer interaction?. In CHI’06 Extended Abstracts on Human Factors in Computing Systems (pp. 1707-1710).
4. Wigdor, D. (2010). Architecting next-generation user interfaces. In Proceedings of the International Conference on Advanced Visual Interfaces (pp. 16-22).
5. Barton, D., Woetzel, J., Seong, J., Tian, Q. (2017) Artificial intelligence: implications for China. McKinsey Global Institute, San Francisco Beijing AI Principles (2019) Beijing Academy of Artificial Intelligence. <https://www.baai.ac.cn/blog/beijing-ai-principles>
6. Kempe, F. (2019). The US is falling behind China in crucial race for AI dominance. CNBC. Accessed April 02 2024. <https://www.cnbc.com/2019/01/25/chinas-upper-hand-in-ai-race-could-be-a-devastating-blow-to-the-west.html>
7. Allen, G. C. (2019). Understanding China’s AI Strategy: Clues to Chinese Strategic Thinking on Artificial Intelligence and National Security. Center for a New American Security. <http://www.jstor.org/stable/resrep20446>
8. Salha, S., Tlili, A., Shehata, B., Zhang, X., Endris, A., Arar, K., Mishra, S., & Jemni, M. (2024). How to Maintain Education During Wars? An Integrative Approach to Ensure the Right to Education. *Open Praxis*, 16(2), 160–179. DOI: <https://doi.org/10.55982/openpraxis.16.2.668>
9. Torraco, R. J. (2005). Writing Integrative Literature Reviews: Guidelines and Examples. *Human Resource Development Review*, 4(3), 356–667. DOI: <https://doi.org/10.1177/1534484305278283>
10. Souza, M. T. D., Silva, M. D. D., & Carvalho, R. D. (2010). Integrative review: what is it? How to do it?. *Einstein*, 8, 102–206. DOI: <https://doi.org/10.1590/s1679-45082010rw1134>
11. Atenas, J., Nerantzi, C., & Bussu, A. (2023). A conceptual approach to transform and enhance academic mentorship: Through open educational practices. *Open Praxis*, 15(4), 271–287. DOI: <https://doi.org/10.55982/openpraxis.15.4.595>
12. Almeida, C. P. B. D., & Goulart, B. N. G. D. (2017). How to avoid bias in systematic reviews of observational studies. *Revista CEFAC*, 19, 551–155. DOI: <https://doi.org/10.1590/1982-021620171941117>
13. Kordzadeh, N., & Ghasemaghaei, M. (2022). Algorithmic bias: Review, synthesis, and future research directions. *European Journal of Information Systems*, 31(3), 388–809. DOI: <https://doi.org/10.1080/0960085X.2021.1927212>
14. Tlili, A., Denden, M., Duan, A., Padilla-Zea, N., Huang, R., Sun, T., & Burgos, D. (2022). Game-based learning for learners with disabilities—What is next? A systematic literature review from the activity theory perspective. *Frontiers in Psychology*, 12, 814691. <https://doi.org/10.3389/fpsyg.2021.814691>

15. Tlili, A., Lin, V., Chen, N. S., & Huang, R. (2020). A systematic review on robot-assisted special education from the activity theory perspective. *Educational Technology & Society*, 23(3), 95-109.
16. Raffo, C., Dyson, A., Gunter, H., Hall, D., Jones, L., & Kalambouka, A. (2007). Education and poverty: A critical review of theory, policy and practice. York: Joseph Rowntree Foundation.
17. Media Access Australia. (2015). Chinese Tech Giant BAIDU Announces Blind Search Device. Retrieved from [https://mediaaccess.org.au/latest\\_news/web/chinese-tech-giant-baidu-announces-blind-search-device](https://mediaaccess.org.au/latest_news/web/chinese-tech-giant-baidu-announces-blind-search-device).
18. Guo, Y. (2019). AI Empowers Special Education: Enabling Deaf Students to “Hear” and Blind Students to “See”. Retrieved from <https://baijiahao.baidu.com/s?id=1633649241615557222&wfr=spider&for=pc>.
19. Mo, S. (2023). When Special Education Meets VR Technology, a Group of Special Children in Shunde Entered a New World. Retrieved from <https://content.foshanplus.com/newsDetails.html?newsId=768765>
20. Tian, Y. (2024). How Can AI Help Children with Autism? An Exclusive Interview with the Director of Chengdu Frontier Brain-like Artificial Intelligence Innovation Center. Retrieved from <https://baijiahao.baidu.com/s?id=1795192308285836396&wfr=spider&for=pc>
21. China Education News Network. (2023). 2023 New Era Teacher Style | Chen Liangying: Because of AI, So Love. Available on: [http://www.jyb.cn/rmtzcg/xwy/wzxw/202309/t20230906\\_2111088881.html](http://www.jyb.cn/rmtzcg/xwy/wzxw/202309/t20230906_2111088881.html)
22. Liu, H., & Gong, Y. (2023). Intelligent Physical Education Classes Support the Development of Sports Specialties in Special Education Schools. Retrieved from <https://news.hbtv.com.cn/p/2436020.html>
23. Shanghai Qiwei Information Technology Co., Ltd. (2023). Welcome to QiWei special education AI partner. Retrieved from <https://www.tejiao123.com/#/>
24. Tlili, A., Altinay, F., Huang, R., Altinay, Z., Olivier, J., Mishra, S., Jemni, M., & Burgos, D. (2022). Are we there yet? A systematic literature review of Open Educational Resources in Africa: A combined content and bibliometric analysis. *Plos one*, 17(1), e0262615. <https://doi.org/10.1371/journal.pone.0262615>
25. Zhang, X., Tlili, A., Nascimbeni, F., Burgos, D., Huang, R., Chang, T. W., Jemni, M., & Khribi, M. K. (2020). Accessibility within open educational resources and practices for disabled learners: A systematic literature review. *Smart Learning Environments*, 7, 1-19. <https://doi.org/10.1186/s40561-019-0113-2>
26. Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learning Environments*, 10(1), 15. <https://doi.org/10.1186/s40561-023-00237-x>

# Empowering Accessibility

## A Case Study on Trader Joe's Website Interaction Framework for the Visually Impaired



## Empowering Accessibility A Case Study on Trader Joe's Website Interaction Framework for the Visually Impaired

### Aparna Krishnan

Parsons School of Design,  
The New School  
krisa304@newschool.edu  
New York, USA

### Reshmy Krishnan

Muscat College  
reshmy@muscatcollege.edu.om  
Sultanate of Oman

### Shivakumar

Oman Dental College  
skumar@staff.odc.edu.om  
Sultanate of Oman

### Arunadevi

Gulf College  
arunadevi@gulfcollege.edu.om  
Sultanate of Oman

### Abstract

Individuals with visual impairments have significant challenges in obtaining the essential knowledge necessary for making dietary choices in today's consumer market. Assistive technology is a vital tool for enhancing the daily lives of individuals with disabilities. An important area of research related to expected restrictions on diets, such as "kosher," "gluten-free," "vegan", etc., should be explored. Like many grocery stores, Trader Joe's aims to make their in-person experience accessible to all customers, including those with disabilities. Their efforts might include store layout designs that are navigable for people with visual impairments, training staff to aid, and possibly incorporating technology or tools that enhance shopping accessibility. Our study designed and implemented an automated packaging system for Braille users to assist them in the data visualisation by using a set of pre-determined parameters that are both definite and sensory on a collection of macro-level products. Here, we design a tool that generates the visual/label for each item based on its input data. The design will give an at-a-glance visual or user journey of the entire collection, which can be interactive and printed.

### Keywords

Braille users; data visualisation; Assistive Technology; disabilities; macro shopping accessibility.



## 1. Introduction

The World Health Organization (WHO) reports that over 2.2 billion individuals experience vision issues, with approximately 1 billion having correctable vision impairments. Moreover, WHO estimates that 36% of long-distance vision difficulties stem from refractive errors, which occur when the eye's shape affects the proper focusing of light on the retina [1].

An individual uses vision as a sensory mechanism to gather information about the surrounding environment [2]. Food labels commonly appear on food packaging to help customers choose products that meet their diets or tastes. However, a significant difference exists in the representation of those characters in Braille, the writing system used by visually impaired people [3]. Organisations may develop their symbols for internal use in food packaging. However, these mostly never include an inclusive option such as a standard Braille code, and they would need to be understood by the visually impaired users, who make up many grocery store shoppers. Hence, for accessible packaging labelling, sticking to the standard Braille alphabet to spell out essential terms is the most accessible and universally understood approach to cater towards visually impaired customers.

Trader Joe's also takes extensive measures to make its web-shopping experience accessible to its customers, such as ensuring its website meets WCAG compliance standards, partnering with Manucode to aid neurodivergent customers, etc.

Yet, for a company that prides itself on its unique packaging and design strategy, Trader Joe's currently does not have any product in their stores with accessible packaging to its visually impaired customers.

### 1.1 Assistive Technology

According to the International Agency for the Prevention of Blindness (IAPB), children experiencing vision impairments often achieve lower educational success than their peers without visual impairments [1]. Assistive technologies are utilised during rehabilitation to enhance the functionality of limbs affected by disabilities, thus improving the quality of life for those individuals [4]. Assistive technology for individuals with visual impairments encompasses devices designed to aid them in determining their location and orientation and provide support during indoor and outdoor activities [2]. Assistive smartphone technologies offer feedback for various activities through multiple mediums, such as voice, sonification, and vibration. Researchers have suggested diverse approaches to communicate feedback messages to individuals with visual impairments utilising these mediums [5].

Previous research has focused on assistive technology for visually impaired individuals. A survey has been conducted on various assistive technologies for visually impaired individuals [10]. This article discusses technologies and approaches used in the development of devices, including sensors, image processing techniques, app-based solutions and deep learning models [10]. Innovations in mobile assistive technologies are particularly significant,

as they help visually impaired people lead more independent lives. These technologies play a crucial role in compensating for lost capabilities. [9]. Mobile phones and other mobile technologies can provide portable solutions that assist users in a discreet and omnipresent manner. Their unobtrusive nature and lack of stigma make them particularly effective [9]. A survey article indicates that assistive technology for visually impaired individuals is expected to grow rapidly, significantly impacting the lives of both visually impaired individuals and the elderly in unprecedented ways. [11]. Applications of AI in assistive technologies were discussed in the article [12]. Various devices like Speechnote and voice access are discussed in the article. It has been observed that research and innovation are still needed for enabling direct and online shopping of specialized items for visually impaired individuals. This article primarily focuses on the design of labels, packaging, and user interfaces of web pages to assist visually impaired individuals.

#### 1.1.1. Braille

Blind and visually impaired individuals face numerous obstacles while engaging in many everyday activities that non-disabled individuals perform effortlessly [6]. Prior research has delved into novel technological prospects by examining patents within the realm of assistive technology for individuals who are blind or visually impaired. Research also offers invaluable insights to guide researchers and developers in formulating strategic R&D plans concerning emerging technologies. Furthermore, this study is a rich resource for decision-makers and

policymakers to anticipate and plan for new developments [7]. There is a scarcity of research investigating the effects of visual impairment (VI) on older adults within the context of ageing complexities, resulting in gaps in our comprehension of how to mitigate the health ramifications of VI [8].

Braille is a tactile writing system used by visually impaired people. It consists of raised dots arranged in cells of up to six dots in a 3x2 configuration, each configuration representing a letter, numeral, or punctuation mark. Braille enables people with visual impairments to read and write through touch rather than sight. Braille is read by moving one's fingers over the raised dots. Skilled readers can read Braille quickly and efficiently [3].

Braille is composed of raised dots arranged in cells. Each cell contains up to six dots in a 3x2 grid.

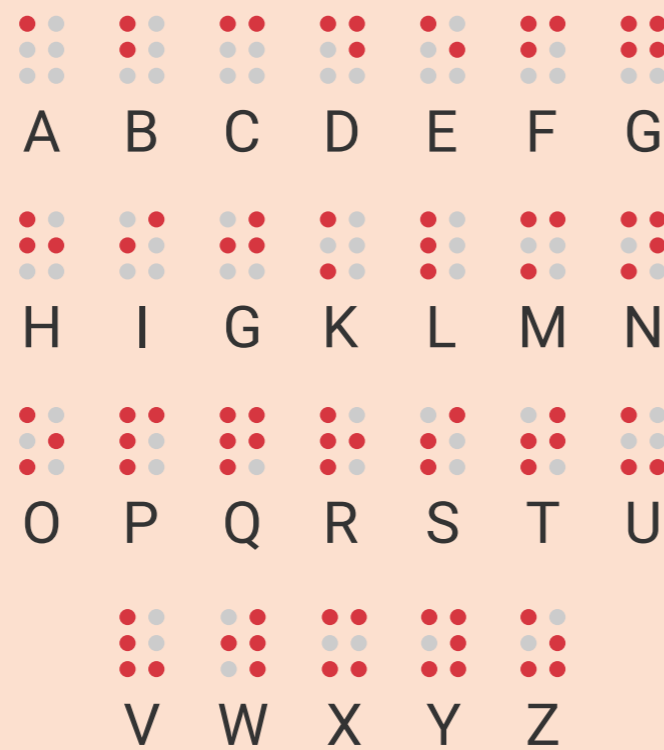
- **The Grid:** The grid of dots in each Braille cell is called a Braille cell. Each position in the cell is numbered, with the top left dot being position one and the bottom right dot being position 6.
- **Characters:** Different combinations of these raised dots represent different characters, including letters, numbers, punctuation marks, and even specific formatting indications like capitalisation or italics.

**Understanding Braille:** To understand how to use Braille, a deep dive is done into several guides explaining the official English (Braille) alphabets, numbers, signs, symbols and even computer notations used as a standard practice today (Figure1,2). Understanding Braille and its usage nuances is essential to

ensure that my design choices comply with visual impairment standards when integrating it with the rest of the product packaging.

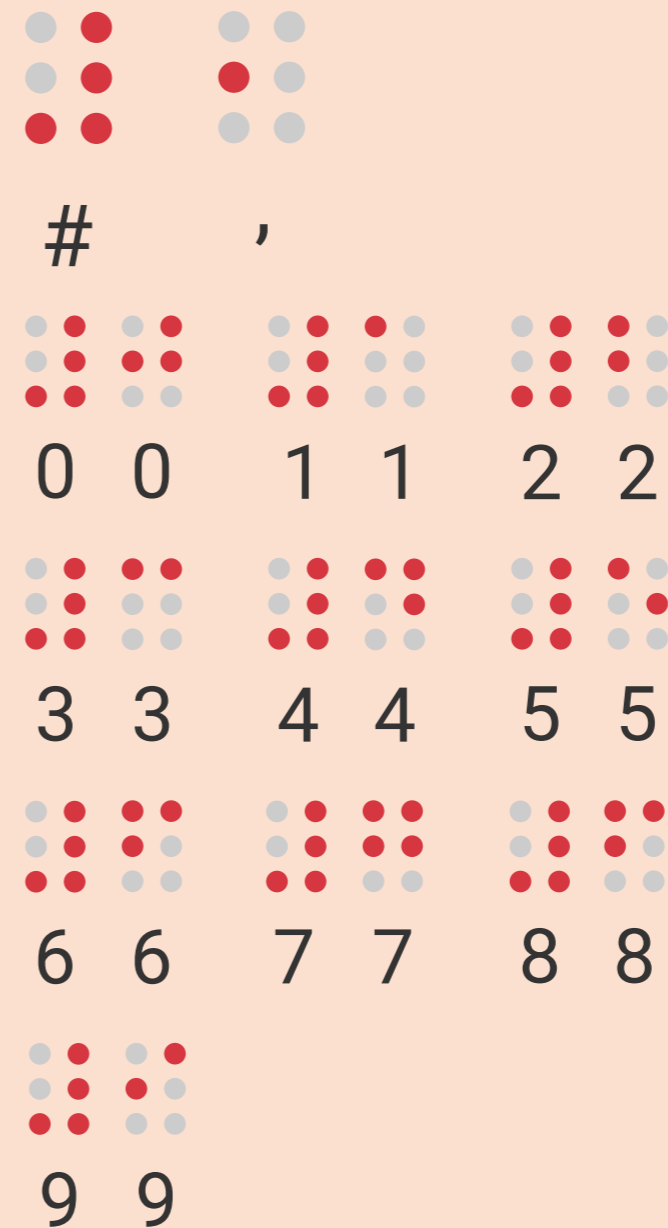


**Figure 1.**  
3x2 Braille Grid.



**Figure 2.**  
Understanding Braille: Alphabets (English)

Braille numbers are made using the first ten letters of the alphabet, "a" through "j", and a unique number sign, # (represented by dots 3, 4, 5, and 6) Figure 3). More significant numbers only need one number sign (#). Commas are used to separate the multiples of 10 and 100s. The comma in Braille is dot 2, which is used in numbers and words, too.



**Figure 3.**  
Understanding Braille: Numbers

## 2. Problem Statement & Objectives

**Although Braille is used to identify letters and serves a basic purpose, there is a growing need for special category foods. Innovations in assistive technology are necessary to support visually impaired individuals in direct and online shopping. Here, we propose a technique in the design of labels, packaging, and user interfaces to help users recognize special category foods.**

**Trader Joe's, a distinguished grocery store chain in the United States, is renowned for its distinctive, laid-back vibe and a significant selection of private-label sweets and snacks. Emphasizing a unique branding strategy, nearly 80% of its offerings are Trader Joe's-branded products sourced from reputable manufacturers, repackaged, and sold under the store's name. This approach is complemented using playful and engaging product names, incorporating puns, cultural references, and humorous twists to enrich the shopping experience and make the products memorable. The packaging of these products features a nostalgic and whimsical design adorned with hand-drawn illustrations, vintage fonts, and captivating stories**

# 40

about the product on the label, ensuring they stand out on the shelves.

As they put it, the company's ethos focuses on providing "a store full of unique and interesting products, along with everyday basics, in the Trader Joe's label," eschewing many branded items to enhance the customer experience. This experience is crafted to be "rewarding, eventful, and fun," supported by the efforts of helpful and friendly crew members who ensure safe and inviting store environments, create informative and creative signage, and foster a sense of adventure, humour, and community.

In the context of our study, Trader Joe's serves as an ideal "candidate" or "user persona" due to their meticulous attention to customer experience and innovative branding and packaging strategies. However, it's crucial to note that while Trader Joe's exemplifies the focus of our testing, the insights and strategies discussed can be universally applied across the board to any grocery store, food store, whole foods supplier, or food packaging company, underscoring the broader applicability and potential impact of our project beyond just one brand or retailer.

## 2.1. Objectives

1. To explore product packaging design that caters explicitly towards visually impaired customers; this entails explorations of Integrating tactile Braille labels and intuitive signs and symbols to enable individuals with visual impairments to shop independently but also makes it easier to identify products that meet various dietary restrictions.
2. Integrate this design system into a web-shopping experience while exploring accessibility for web products.
3. To create functional packaging for the visually impaired that is aesthetically pleasing and practical for all consumers, thereby fostering an inclusive shopping environment.

# 41

## 3. Methodology

The main aim of the study is to develop a novel approach to data visualisation that uses Braille and other tactile languages to show dietary limitations, such as "Kosher," "Gluten Free," and "Vegan," on food packaging. It helps the visually impaired people to enhance their grocery store shopping experience. The proposed approach can be divided into essential phases: Developing tactic symbols, Incorporating the Braille symbols with the Packaging system and Developing a website.

This symbol must also translate into a web interface for a web-shopping experience by using understanding coding for assistive technologies. This includes incorporating a CMS(content management system) with specific data points (based on the importance of data visualisation) into the code.

This code can also help create a design system for the generative packaging to produce packaging for Trader Joe's (or any grocery store) products from their product database to prove that it can be applied across all their product packaging. Figure 4 shows how the theoretical part of the proposed system is converted to the implementation of this case study.

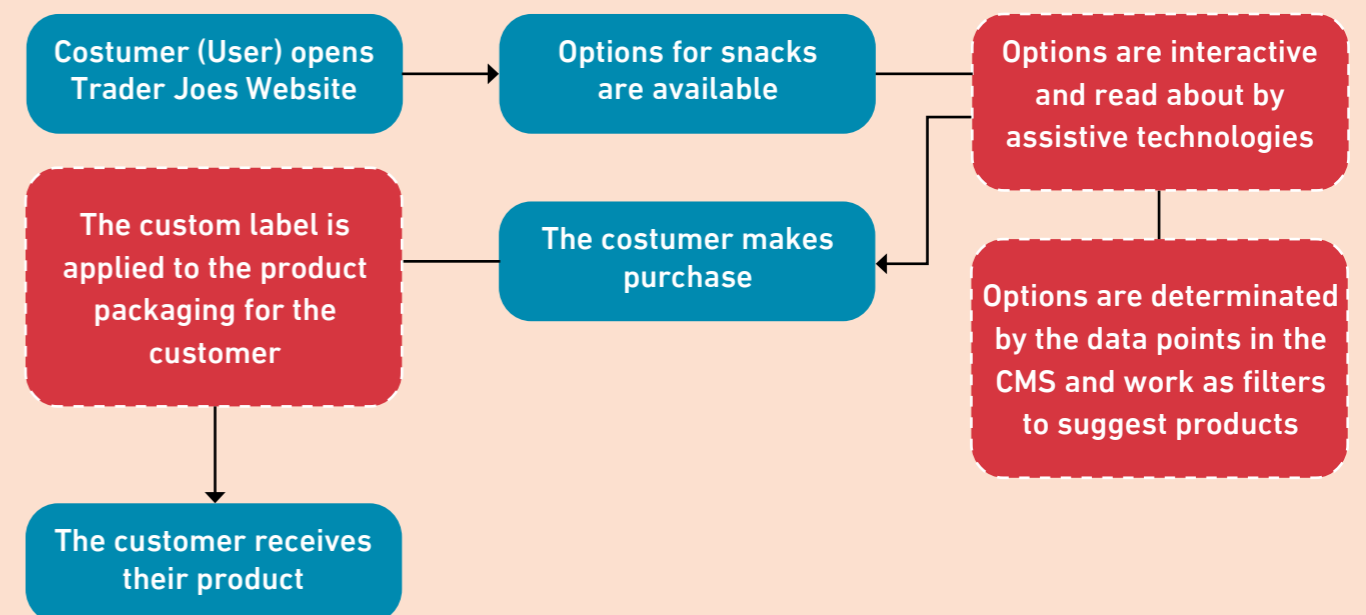


Figure 4.  
User Flow / Journey from Digital to Physical

### 3.1 Characteristics of the proposed BRAILLE (the name of proposed) system

- **Braille Inclusion:** The most significant feature is the incorporation of Braille on packaging. Braille allows people who are blind or have severe visual impairments to read information through touch. This would include essential details like the product name, expiration date, and instructions for use.
- **Tactile Symbols:** For those who do not read Braille, raised symbols could provide information about the product type and dietary restrictions. For instance, a series of raised dots in a specific shape could indicate "gluten-free," while another shape might denote "vegan."
- **High-Contrast Visuals:** For those with partial sight, using high-contrast colours and large, bold fonts can make the visual elements of packaging more discernible.
- **Shape Coding:** The physical shape of packaging could also help. For example, the packaging of dairy alternatives might have one corner squared off, while dairy products have rounded edges.
- **QR Codes:** Including QR codes that can be scanned with a smartphone to provide auditory product descriptions and additional information can further enhance accessibility.

## 4. Results & Analysis

### 4.1 Designing a Website for Braille Food Packaging

#### Initial Design Process

**Font:** When choosing the right font to use for the coding aspect of this project, I stumbled across the "Braille Collection" [3] created by Cal Henderson[4], CTO of Slack. Henderson is interested in creating pixel fonts and has created a library of free fonts available for anyone to download and use.

**Indicators:** There are several indicators in Braille, such as "shape indicator", "filled-in shape", "shaded shape", "interior shape modification indicator", and "termination indicator", and some for font styles, all of which can be used to make further the Braille appropriate for Braille-readers.

### Developing a new Universal system

Main limitations/challenges when designing the system:

- You cannot use any indicators other than the initial capitalisation of letters. Let's say we were to use existing alternatives for specific indicators, but they still would have to be manually entered into the system.
- Cannot capitalise an entire word correctly; the font seems to be applying the capitalisation to each letter individually--which is not the right way.

### Main takeaways

- Use the full word, but capitalise the first letter of the word so that seasoned readers can immediately identify the symbol using the capital letter (first letter). In contrast, newer readers can read the entire word.
- If there is a single universal Capital Letter Abbreviation, use that Capital letter as the symbol instead of the entire word. If there are two, they can be separated by hyphens, periods, or commas. [Figure 5]

#### "Kosher"

Style 1: "Kosher"  
Capital K + osher



First letter is capital K

Style 1: "Kosher"  
Capital K + osher



#### "Vegan"

Style 1: "Vegan"  
Capital V + egan



Style 2: "V"  
Capital V



Figure 5.  
Sample of new design

• **Designing the Label Format**

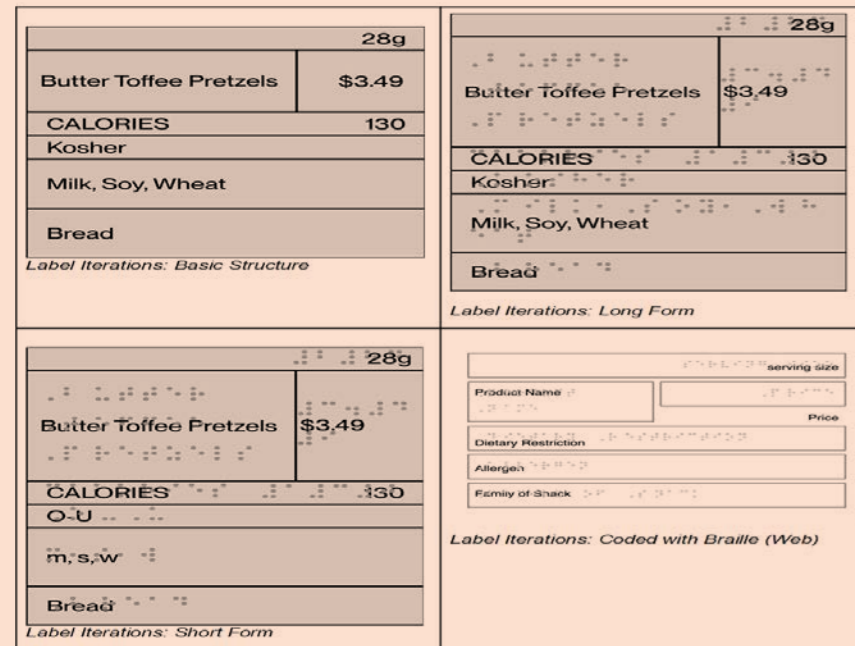


Figure 6.  
Sample of Label design

Keeping in mind that there is a spectrum of visual impairments, the first step in choosing colours for the label was to select combinations that have high contrast to appeal to users who are colour-blind.

Using the Venngage Accessible Colours Generator[5], here are some colours that follow WCAG (Web Content Accessibility Guidelines) standards [Figure 7]



Figure 7.  
Colors as per WCAG

To incorporate the design of the labels, there are some foundational accessibility principles to be followed when choosing fonts and colours for visually impaired users/customers.

**Font Size:** The larger text is generally more accessible for people with visual impairments to read. The text should be of a size that can be easily read from a reasonable distance.

**Font Style:** Sans-serif fonts, with straightforward letterforms, are usually more legible than serif or decorative fonts, especially for people with specific visual impairments.

**Font Weight:** Bold text can stand out better and be more accessible to read for some visually impaired individuals, provided the letters do not bleed into each other.

**Capitalisation:** Unicase or all-caps text can sometimes be more challenging to read for those with visual impairments because it may reduce

the distinctiveness of word shapes. Several iterations were created with varying fonts, colours and layouts to test out which label would be the most effective in legibility. In order to make my design decisions, I interviewed an individual who identifies as a visually impaired web user. This step helped me eliminate several of my iterations for technical and legibility reasons.

**Label Iterations that did not work**  
Preferred fonts: Helvetica

Helvetica has a high degree of uniformity in its character design. This consistency can make it easier for visually impaired users to recognise words and letters, especially when reading on digital screens. Helvetica is designed with adequate spacing between characters and words, which helps in reducing visual clutter. Helvetica has a relatively high x-height (the height of lowercase letters), which can improve readability. A higher x-height makes the lowercase letters more prominent and easier to distinguish.



- Label Iteration 1:
- The text is not always visible despite the contrast
  - The serif-font is difficult to read

- Label Iteration 2:
- Sufficient contrast but Unicase/mixed-capitalisation fonts are not encouraged

- Label Iteration 3:
- The White text is not legible against the background color.
  - Unicase/mixed-capitalisation fonts are not encouraged.

Figure 8.  
Colors as per WCAG Label Iterations that did not work

# 46

## 4.2 Web Design Process

To put these coded labels to use, the experience must begin with the user selecting the product they wish to purchase, then proceeding to checkout and having the label present on the product they bought (physically).

Some of the existing challenges of this journey that make it different for the visually impaired:

- We cannot shop digitally without assistive technologies.
- They cannot choose dietary restrictions for products that they wish to consume.
- **Assistive Technology**  
A screen reader is a technology that helps people who have difficulties seeing, accessing, and interacting with digital content via audio or touch, like websites or applications. The primary users of screen readers are blind or have minimal vision.

Outside of people with disabilities, screen readers are also used by people with low literacy levels, non-native speakers, and people who prefer to listen to content instead of reading (roughly 12% of screen reader users don't have a disability).

- **Things to keep in mind when coding for a Screen Reader:**
  - **Provide alternate text for every image:** a descriptive alternate text is necessary for visual elements like images and videos.
  - **Use ARIA Attributes:** Accessible Rich Internet Applications (ARIA) attributes give visually impaired users more information about specific elements on a web page.
  - **Declare a page's language in HTML:** This is important for users who navigate in a different language than yours.
  - **Keep your links short, but not too short:** If you use too many words, since the link will get read out loud, it may confuse the user. If the link is too short, those users who rely on screen readers but still use their mice to navigate websites might miss the link altogether.
  - **Use semantic tags:** They're valuable "stage directions" on how it should be read to enhance the users' understanding.
  - **Structure your web pages with accessibility in mind:** making sure the hierarchy of content and navigation from one web page to the next is not confusing to visually impaired users.

# 47

- **Non-Visual Labelling:**
  - Hierarchy in headings should be structured not according to style but in order of importance.
  - Alternative text for Links and images must be particular to be descriptive of their function, even when taken out of context (say, when navigated through a rotor/combined menu)
  - Using the ARIA attribute in HTML can help users differentiate between input types (say, to specify a toggle-down menu).
  - Do not try to change the pronunciation of words using the ARIA attribute unless necessary, as most users have adjusted to the nuances of voice-over screen readers, and changing them may cause more confusion.
- **Focus, Tab Order, Navigation, Labelling, Alt-text:**
  - **Focus/ Tab-Index**  
When using a screen reader on a browser, a "focus" bar will highlight certain sections of the webpage. Setting a tab index will help control the order of this focus even when using implicit attributes. Using a tab index of -1 and then calling it JS will help manage focus onto elements directly when navigating through the page.
  - **Tab Order**  
Visual users can spot differences in the visual appearance of interactive elements on a screen. However, visually impaired users who use screen readers cannot tell the difference in order unless specified in the code by changing the tab order of the DOM.

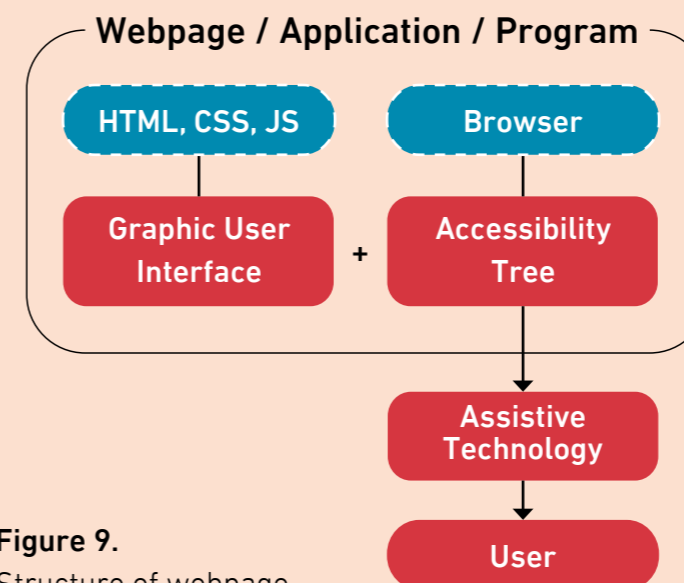


Figure 9.  
Structure of webpage



- **Navigation**  
Using a rotor and native attributes such as header, footer, navigation, etc., will help a user who uses a screen reader navigate through the page faster.
- **Labelling**  
Semantically, a screen reader would classify a div as a "group"; therefore, it is essential to specify your buttons and elements.
- **Alt-text**  
Although one can use either (or both) aria-labels and alt-text for images, most screen readers prioritise alt-text over aria-label. The aria-label is generally more helpful for interactive elements like buttons or links.

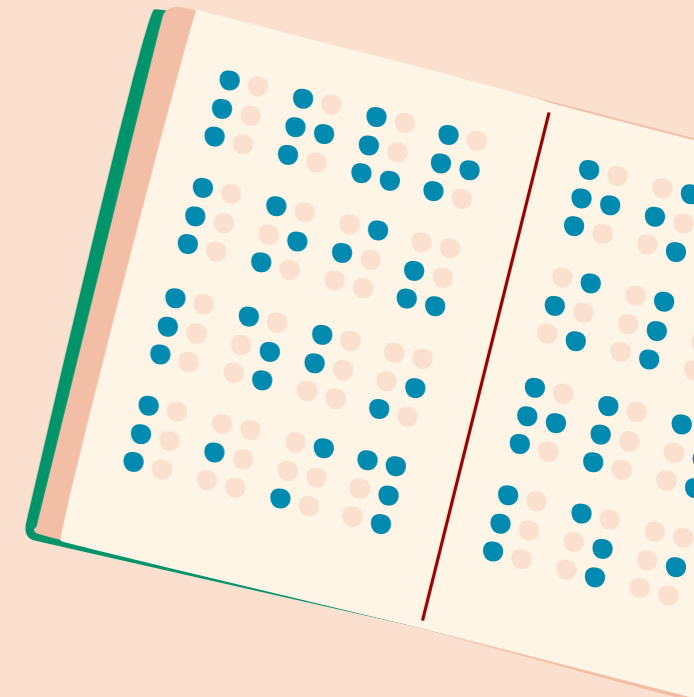
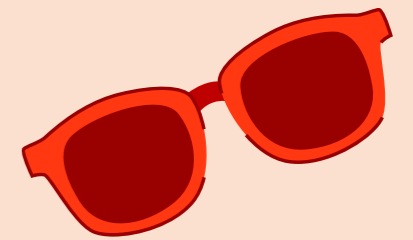


## 5. Conclusion

**The grocery shopping experience for visually impaired individuals can be revolutionized through the development of a new system of data visualization. This system has integrated the tactile languages of Braille and universally recognized symbols for dietary restrictions and provides vital information directly on food packaging. This promising application of assistive technology in the web interface guarantees the accessibility of the digital sphere for visually impaired shoppers. The adaptability and scalability of the system are improved through the cooperation of a content management system and ensure the diverse needs of users. Moreover, the prospect of a generative design system for packaging opens avenues for widespread implementation across various products and brands, exemplified by its application to Trader Joe's extensive product database. Ultimately, this innovative approach addresses the immediate challenges faced by visually impaired consumers and sets a precedent for inclusive design practices in the retail industry.**

## References

1. Manirajee, L., Shariff, S. Q. H., Meeze, S., & Rashid, M. Assistive Technology for Visually Impaired Individuals: A Systematic Literature Review (SLR).
2. Madake, J., Bhatlawande, S., Solanke, A., & Shilaskar, S. (2023). A Qualitative and Quantitative Analysis of Research in Mobility Technologies for Visually Impaired People. IEEE Access.
3. Majid, M. N. A., Alias, A., & Mazlan, M. R. (2022). Isu serta Cabaran Pengajaran dan Pembelajaran Murid Berpenglihatan Terhad dalam kalangan Guru di Sekolah Rendah. Malaysian Journal of Social Sciences and Humanities (MJSSH), 7(7), e001614-e001614.
4. Texeira, C. H. M., Rodrigues, A. A., de Azevedo Costa, A. L. F., & dos Santos, V. R. Wearable Haptic Device as Mobility Aid for Blind People: Electronic Cane.
5. Khusro, S., Shah, B., Khan, I., & Rahman, S. (2022). Haptic feedback to assist blind people in an indoor environment using vibration patterns. Sensors, 22(1), 361.
6. Elmannai, W. M., & Elleithy, K. M. (2018). A highly accurate and reliable data fusion framework for guiding the visually impaired. IEEE Access, 6, 33029-33054.
7. Hwang, J., Kim, K. H., Hwang, J. G., Jun, S., Yu, J., & Lee, C. (2020). Technological opportunity analysis: Assistive technology for blind and visually impaired people. Sustainability, 12(20), 8689.
8. Swenor, B. K., Lee, M. J., Varadaraj, V., Whitson, H. E., & Ramulu, P. Y. (2020). Ageing with vision loss: a framework for assessing the impact of visual impairment on older adults. The Gerontologist, 60(6), 989-995.
9. Hakobyan, L., Lumsden, J., O'Sullivan, D., & Bartlett, H. (2013). Mobile assistive technologies for the visually impaired. Survey of ophthalmology, 58(6), 513-528.
10. Manjari, K., Verma, M., & Singal, G. (2020). A survey on assistive technology for visually impaired. Internet of Things, 11, 100188.
11. Bhowmick, A., & Hazarika, S. M. (2017). An insight into assistive technology for the visually impaired and blind people: state-of-the-art and future trends. Journal on Multimodal User Interfaces, 11, 149-172.
12. Krishnan, R., & Manickam, S. (2024). Enhancing Accessibility: Exploring the Impact of AI in Assistive Technologies for Disabled Persons. Nafath, 9(25).



# A Review on Roles of Next Generation User Interface to Support People with Disabilities



## Sheily Verma (Panwar)

Assistan professor  
(Department of computer  
science/Cyber Securit),  
CUC-Ulster University  
sheily.verma@cuc-ulster.edu.qa  
Doha, Qatar

## Aboubakr Aqle

Assistant professor  
(Department of computer  
Engineering),  
CUC-Ulster University,  
aboubakr.aqle@cuc-ulster.edu.qa  
Doha, Qatar

**Abstract** - User interfaces of the next generation are a significant step forward in technological development. They bring potential that have never been seen before for boosting accessibility and inclusivity, particularly for people who have disabilities. These interfaces, driven by state-of-the-art technology like AI, NLP, and gesture detection, enable users to overcome limitations in their physical abilities. These interfaces provide individualized solutions to several requirements. They empower those with visual impairments by providing them with superior screen readers, and they empower individuals with motor disabilities by providing them with intuitive gesture-based interactions. This can be accomplished by democratising access to information and communication. The principles of inclusive design that are included into these interfaces give accessibility the highest priority from the very beginning, thereby creating environments in which dignity and autonomy are prioritised. The influence extends beyond the realm of convenience, permeating social inclusion and empowerment through the provision of tools for communication, cooperation, and engagement. The revolutionary potential of next-generation user interfaces promises a future in which disability is associated with infinite potential. This is because innovation is continuing to meet unmet requirements, such as brain-computer interfaces and devices that use augmented reality. The purpose of this abstract is to investigate the substantial consequences of next-generation user interfaces in the process of making society more accessible and inclusive. This will ensure that everyone, regardless of their ability, has the opportunity to flourish and make meaningful contributions.

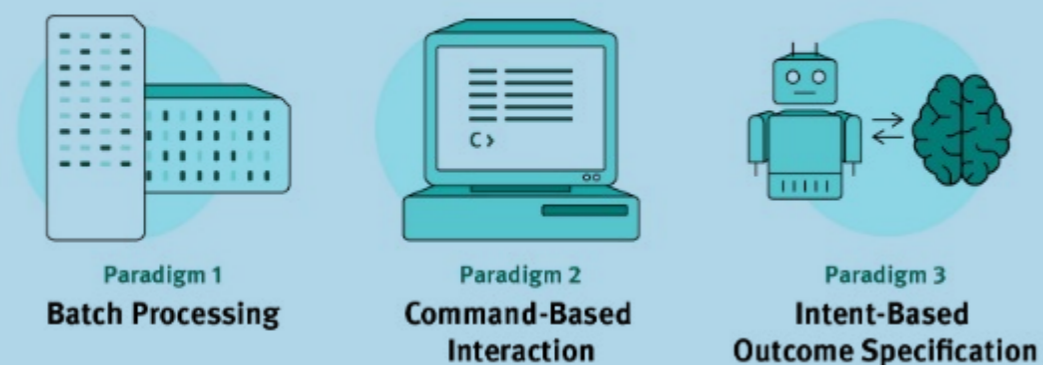
## Keywords

Disabilities, Generation, Interface, Environments and Empowerment.

## 1. Introduction

In the ever-evolving landscape of technology, the advent of next-generation user interfaces heralds a transformative era, promising not only heightened user experiences but also revolutionary opportunities for inclusivity and accessibility. Amidst this progression, the pivotal question arises: How can these advancements empower and support individuals grappling with disabilities? This introduction delves into the profound impact of next-generation user interfaces on enhancing the lives of people with disabilities, elucidating how technology can serve as a beacon of hope and change. Living with a disability presents multifaceted challenges, ranging from physical limitations to barriers in communication and access. On the other hand, cutting-edge user interfaces have opened up a world of possibilities by connecting people's abilities with their limitations. By leveraging cutting-edge technologies such as artificial intelligence, natural language processing, and gesture recognition, next-generation user interfaces offer tailored solutions that cater to the diverse needs of individuals with disabilities. One of the most compelling aspects of these advancements lies in their ability to democratize access to information and communication. For individuals with visual impairments, screen readers powered by advanced algorithms now render digital content into speech or Braille, unlocking a wealth of knowledge and opportunities that were previously inaccessible. Those with motor impairments find newfound independence through intuitive gesture-based interfaces, enabling seamless interaction with digital devices and the virtual world. The significance of inclusive design cannot be overstated in the realm of next-generation user interfaces[1].

### User-Interface Paradigms of Computing



**Figure 1.**  
UI Paradigms of computing

By prioritizing accessibility from the inception of product development, designers and engineers can create solutions that cater to a diverse range of abilities, fostering an environment where no one is left behind. Whether it's through customizable interfaces, voice commands, or haptic feedback, these inclusive designs empower individuals to navigate the digital landscape with dignity and autonomy. Beyond mere convenience, the impact of next-generation user interfaces transcends into the realm of social inclusion and empowerment[2]–[6]. By providing individuals with disabilities the tools to communicate, collaborate, and engage with their surroundings, technology becomes a catalyst for breaking down societal barriers and fostering a more inclusive society. From facilitating employment opportunities to enabling active participation in social activities, these interfaces pave the way for a future where disability is not synonymous with limitation but rather with endless potential, the roles of next-generation user interfaces in supporting people with disabilities are multifaceted and profound. Through innovation, inclusivity, and empowerment, technology has the power to make a tangible difference in the lives of millions worldwide. As we embark on this journey towards a more accessible future, let us harness the transformative potential of next-generation user interfaces to create a world where everyone, regardless of ability, can thrive and contribute to society. In the ever-evolving realm of technology, the emergence of next-generation user interfaces stands as a beacon of hope and change, particularly for individuals navigating life with disabilities. By democratizing access to information and communication, they bridge the chasm between ability and limitation, offering

tailored solutions to cater to diverse needs. For those with visual impairments, advanced screen readers transform digital content into speech or Braille, unlocking previously inaccessible realms of knowledge and opportunity. Similarly, individuals with motor impairments find newfound independence through intuitive gesture-based interfaces, enabling seamless interaction with digital devices and the virtual world. Moreover, inclusive design principles embedded within these interfaces ensure that accessibility is prioritized from inception, fostering environments where dignity and autonomy reign supreme. Customizable interfaces, voice commands, and haptic feedback mechanisms empower individuals to navigate the digital landscape with ease and confidence. Yet, the impact extends far beyond convenience, permeating the fabric of social inclusion and empowerment. By equipping individuals with disabilities with tools to communicate, collaborate, and engage, technology becomes a powerful catalyst for dismantling societal barriers and fostering a more inclusive society. From enhancing employment opportunities to facilitating active participation in social activities, these interfaces pave the way for a future where disability is synonymous not with limitation, but with boundless potential. Moreover, the relentless march of innovation continues to address previously unmet needs, with advancements such as brain-computer interfaces offering unprecedented control over digital devices through neural signals. Technologies like virtual reality (VR) and augmented reality (AR) help people with sensory impairments navigate more effectively and have a better sense of space [6]. As we journey towards a more accessible future, the transformative potential of next-generation user interfaces holds

the key to unlocking a world where everyone, regardless of ability, can thrive and contribute meaningfully to society, ensuring that no one is left behind in the march of progress [7]–[13].

## 2. Literature Review

Vanpuymbrouck 2024 et al. This study aimed to qualitatively examine healthcare access barriers' impact on Persons With Mobility Disabilities (PWMD), focusing on self-advocacy experiences and accommodation request decision-making factors. Qualitative semistructured interviews were conducted with 6 purposively sampled PWMD. Interpretative phenomenological analysis revealed a shared process of recognizing and combating disability discrimination normalization, fostering self-advocacy agency. Results underscore the importance of supporting individual advocacy and combating disability discrimination in healthcare systems[14].

Xie 2023 et al. This retrospective study evaluated the clinical utility of metagenomic next-generation sequencing (mNGS) in bronchoalveolar lavage fluid (BALF) for HIV-infected patients with suspected multi-pathogenic pneumonia. Among 57 patients who underwent bronchoscopy, mNGS demonstrated higher accuracy in fungal detection compared to conventional microbiological tests (CMTs). Sensitivity of mNGS for pneumonia diagnosis was significantly higher than CMTs (79.6% vs. 61.1%). Patients with mixed infections had lower CD4 T-cell counts and longer symptom duration. mNGS detected more co-pathogens, with fungi-virus being the most common mixed infection pattern. Early bronchoscopy and mNGS are recommended for HIV-infected patients with low CD4 T-cell counts and prolonged symptoms [15].

Namoun 2023 et al. Integrating diverse technologies for new functionalities is highly researched, yet overlooked for individuals with special needs. This study reviews recent advancements in service-oriented composition techniques for disabled individuals, identifying key challenges. A systematic literature review identified 38 relevant articles from major databases. Findings reveal gaps in datasets, accessibility specifications, design practices, testing with disabled users, and techniques. The study concludes with guidelines to enhance assistive service composition, highlighting AI/ML utilization and addressing research gaps [1].

Li 2023 et al. Uterine adenocarcinoma (UA) is a rare tumor characterized by benign epithelial and sarcoma-like stromal components, often low-grade. Its etiology remains unclear. Next-generation sequencing (NGS) analysis was conducted to explore gene mutations in UA. Two low-grade UAs with heterologous components exhibited ATRX gene frameshift mutations, one had a MED12 missense mutation. Copy number amplifications were observed on chromosome 12q13-15. PIK3/AKT/PTEN pathway mutations were common, alongside a rare BCORL1-PRR14L fusion mutation. These findings shed light on UA molecular changes for future targeted therapy research [16].

Park 2022 et al. This study investigates the impact of parental stress on depression among 164 mothers of children with disabilities in Gwangju and Jeollanamdo, South Korea. Parental stress predicts depression, with social support buffering this relationship. High social support levels correlate with lower depression likelihood. Findings underscore the critical role of social support in mitigating

depression risk among mothers facing parental stress. Implementing supportive techniques, such as counseling and support groups, could enhance mental well-being in this demographic [17].

Aqle 2022 et al. Experiment conducted to explore whether search result summaries can enhance web search efficiency and experiences for visually impaired (VI) users. Their research introduces an interactive search engine interface called InteractSE, which utilizes unsupervised machine learning to organize search results into a hierarchical tree structure.

This approach aims to improve the efficiency and interaction experience of VI users by enabling easier navigation through clustered concepts summarizing relevant information. The evaluation, involving 16 legally blind users comparing InteractSE with traditional Google search methods, indicates that providing search result summaries significantly enhances search efficiency and user experience by reducing cognitive load, suggesting potential improvements for search engine interfaces to better support VI users [45, 46].

Authors/ year	Methodology	Advantages	Future intentions
[18] 2023	Conducted research on the experiences of unpaid careers, using phenomenological investigation, and presented significant findings.	Gaining understanding of the requirements of careers to develop impactful assistance initiatives for individuals with dementia.	Improve assistance programmers by incorporating insights and expectations from careers.
[9] 2021	Implemented Device-to-Device (D2D) communication into the IEEE 802.11ax standard, enhancing resource allocation for improved efficiency.	Enhanced spectrum efficiency, improved resource allocation, minimized interference, and optimized performance.	Further refine D2D integration for enhanced WLAN spectrum efficiency.
[10] 2021	Introduced efficient decoding algorithm for LDPC codes in IoT networks.	Improved hardware efficiency, reduced complexity, and enhanced error-correction performance for LDPC.	Enhance LDPC decoding efficiency and error correction for IoT networks.
[19] 2020	Compilation of Nano fluid research: preparation, performance, limitations, for transformer insulation.	Compilation elucidates Nano fluid advantages, aiding transformer insulation development.	Address concerns, resolve inconsistencies, and advance high heat dissipation insulation.
[20] 2019	Reviewed clinical trials to assess ECLS effectiveness in ARDS management.	Highlighted limitations prompt cautious consideration of ECLS in ARDS.	Improve ECLS efficacy through high-quality evidence and focused studies.

**Table 1.** Summary of Research Studies with Methodologies, Advantages, and Future Intentions

### 3. Research Methodology

This research undertakes a comprehensive review of the roles of next-generation user interfaces (UIs) in supporting individuals with disabilities. Through systematic searches of databases including PubMed, IEEE Xplore, ACM Digital Library, Scopus, and Google Scholar, employing keywords such as "next generation user interface," "disabilities," "accessibility," and "usability," peer-reviewed articles, conference papers, and relevant reports published in English from 2010 onwards were selected based on strict inclusion criteria. Thematic analysis of the selected literature was conducted to identify recurring themes related to UI technologies, disability types, usability challenges, technological innovations, and user experiences. Critical appraisal of the literature ensured the reliability and validity of findings. The synthesis of results provides insights into the implications of next-generation UIs for individuals with disabilities, addressing both opportunities and challenges, thereby contributing to the academic discourse and guiding future research and development efforts in this field[19], [21]–[24].

#### 3.1 Database on Next-Generation User Interfaces for Disability Support

This review on the roles of next-generation user interfaces (UIs) in supporting individuals with disabilities encompasses a systematic examination of literature sourced from databases including PubMed, IEEE Xplore, ACM Digital Library, Scopus, and Google Scholar. Utilizing keywords such as "next generation user interface," "disabilities," "accessibility," and "usability," the search was restricted to peer-reviewed articles, conference papers, and relevant reports

published in English from 2010 onwards. A stringent inclusion criteria ensured selection of studies primarily focusing on UI technologies and their implications for disability support. Thematic analysis of the literature enabled the identification of recurring themes, encompassing UI technologies, disability types, usability challenges, technological innovations, and user experiences. Through critical appraisal, the reliability and validity of findings were ensured. The synthesis of results provides comprehensive insights into the impact of next-generation UIs on individuals with disabilities, addressing both opportunities and challenges. This database serves as a valuable resource for researchers, developers, and practitioners in the field, facilitating informed decision-making and guiding future endeavors aimed at enhancing accessibility and usability for people with disabilities through innovative UI solutions[25]–[29].

#### 3.2 Analysis Methods

Analysis methods encompassed thematic analysis to identify recurring themes, critical appraisal to assess study quality, comparative analysis to evaluate UI technologies, quantitative synthesis for statistical aggregation, user experience evaluation for subjective feedback, and emergent theme identification for comprehensive exploration. These methods ensured rigorous examination of next-generation UI roles in disability support[20], [30], [31].

**1. Thematic Analysis:** Thematic analysis was employed to identify recurring themes across the selected literature, including UI technologies, disability types, usability challenges, technological innovations, and user experiences. This method involved

systematically coding and categorizing data to extract meaningful patterns and insights related to the roles of next-generation UIs in supporting people with disabilities.

- 2. Critical Appraisal:** A critical appraisal of the literature was conducted to evaluate the quality of evidence and potential biases. This involved assessing the methodological rigor of included studies, considering factors such as sample size, study design, and data analysis techniques. By critically appraising the literature, the reliability and validity of the review findings were ensured, enhancing the credibility of the synthesized results.
- 3. Comparative Analysis:** Comparative analysis was utilized to examine the similarities and differences between various UI technologies in terms of their effectiveness in supporting individuals with disabilities. This involved comparing features, functionalities, and performance metrics across different UI platforms to identify strengths, weaknesses, and areas for improvement.
- 4. Quantitative Synthesis:** Quantitative synthesis methods, such as meta-analysis or statistical aggregation, were employed where applicable to quantitatively summarize findings from multiple studies. This involved pooling data from individual studies to calculate effect sizes, confidence intervals, or other statistical measures, providing a more robust and precise estimate of the overall impact of next-generation UIs on disability support.
- 5. User Experience Evaluation:** User experience evaluation methods, including surveys, interviews, or usability testing, were utilized to

gather insights into the subjective experiences and preferences of individuals with disabilities using next-generation UIs. This involved collecting qualitative feedback on factors such as ease of use, satisfaction, and perceived accessibility barriers, informing recommendations for improving UI design and implementation.

- 6. Emergent Theme Identification:** In addition to predefined themes, emergent themes were identified through iterative analysis of the literature. This involved remaining open to new ideas and concepts that may not have been initially anticipated, allowing for a more comprehensive exploration of the roles of next-generation UIs in supporting people with disabilities.

### 4. Empowering Accessibility: Next Gen UI Impact

In the realm of technology, the emergence of next-generation user interfaces (UIs) stands as a beacon of hope and change, particularly for individuals navigating life with disabilities. This article delves into the profound impact of next-generation UIs on enhancing accessibility and empowering individuals with disabilities, elucidating how technology can serve as a transformative force in their lives. Traditional user interfaces often posed significant challenges for individuals with disabilities, ranging from physical barriers to limitations in communication and access. However, the advent of next-generation UIs heralds a new era of possibilities, offering tailored solutions that cater to diverse needs. Utilising state-of-the-art technology like

AI, NLP, and gesture recognition, these interfaces bridge the gap between ability and limitation, empowering users to interact with digital devices and the virtual world with greater ease and independence. One of the key advantages of next-generation UIs lies in their ability to enhance interaction for individuals with disabilities. Intuitive gesture-based interfaces allow people with motor impairments to easily browse digital devices by simply moving their hands. This eliminates the need for traditional input techniques. Similarly, voice recognition technology enables hands-free interaction, allowing individuals with mobility issues to control devices and access information effortlessly. These advancements not only promote independence but also foster a sense of empowerment and inclusion in the digital realm. Communication barriers are often a significant challenge for individuals with disabilities, but next-generation UIs are changing the landscape by providing innovative solutions. Speech-to-text and text-to-speech technologies enable seamless communication for individuals with hearing or speech impairments, allowing them to engage in conversations, access information, and participate in social interactions with greater ease. Real-time translation features break down language barriers, facilitating communication across diverse linguistic backgrounds and promoting inclusivity on a global scale. Inclusive design principles are at the core of next-generation UIs, ensuring that accessibility is prioritized from the inception of product development. Customizable interfaces allow users to adapt settings and features to suit their specific needs, whether it's adjusting font sizes for better readability or configuring input methods for enhanced usability. Moreover, built-in accessibility features

such as screen readers, magnifiers, and alternative input methods cater to a wide range of disabilities, empowering users to personalize their digital experience and navigate the digital landscape with dignity and autonomy. For individuals with disabilities, independence is not merely a goal but a fundamental aspect of quality of life. Next-generation UIs play a crucial role in promoting independence by providing tools and resources that empower users to perform daily tasks, access information, and engage with their surroundings autonomously. From smart home devices that enable remote control of appliances to navigation apps that provide step-by-step directions with audio cues, technology offers a lifeline of support for individuals striving to live independently despite physical or cognitive challenges. Despite the remarkable advancements in next-generation UIs, challenges remain in ensuring equitable access and usability for individuals with disabilities. Issues such as compatibility with assistive technologies, consistency in design standards, and affordability of accessible devices pose significant barriers to adoption and inclusion. Moreover, digital accessibility regulations and standards vary across regions, creating inconsistencies in the implementation of accessibility features and hindering progress towards universal design. Looking ahead, the future of next-generation UIs holds immense promise for advancing accessibility and inclusion for individuals with disabilities. Continued innovation in areas such as artificial intelligence, augmented reality, and wearable technology will further enhance the capabilities of UIs to cater to diverse needs. Moreover, collaboration between technology developers, disability advocates, and policymakers is essential to ensure that accessibility

remains a priority in the design and implementation of digital solutions. By harnessing the transformative potential of next-generation UIs, The roles of next-generation UIs in supporting people with disabilities are multifaceted and profound. From enhancing interaction and communication to promoting independence and addressing challenges, technology has the power to make a tangible difference in the lives of millions worldwide. As we continue to innovate and advance accessibility, let us strive to create a future where technology serves as a tool for empowerment, inclusion, and equality for all [32]–[35].

## 5. Transforming Disability Support: Next generation of UI

The advent of next-generation technology, especially in the domain of user interfaces (UIs), is causing a revolutionary change in the disability support scene. This article explores the technical aspects and implications of next-generation UIs in revolutionizing disability support, examining their potential to enhance accessibility, promote independence, and foster inclusion for individuals with disabilities. Next-generation UIs encompass a diverse range of technologies and innovations aimed at improving user interaction and experience across digital platforms. Interfaces like this are made possible by cutting-edge tech like AI, NLP, gesture detection, and AR to make them user-friendly, flexible, and accessible to everyone. By prioritizing accessibility and usability, next-gen UIs aim to break down barriers and empower individuals with disabilities to fully participate in the digital world. One of the primary objectives of next-gen UIs

is to enhance accessibility for individuals with disabilities. Through customizable interfaces, adaptive features, and assistive technologies, these UIs cater to diverse needs and preferences. Users with mobility disabilities can benefit from speech recognition technology's hands-free interaction, while those with visual impairments can access digital information with the help of screen readers and magnifiers. By providing multiple input modalities and personalization options, next-gen UIs ensure that users can interact with digital devices and services in a manner that best suits their abilities and preferences. Nextgen UIs play a crucial role in promoting independence for individuals with disabilities by providing tools and resources that empower self-reliance and autonomy. Smart home devices, wearable technologies, and mobile applications equipped with accessibility features enable users to perform daily tasks, access information, and navigate their environments with greater ease and confidence. By harnessing the power of AI and IoT, nextgen UIs can anticipate user needs, provide contextually relevant assistance, and adapt to changing preferences, thereby enhancing users' sense of control and agency over their lives. Figure 2 Social model of disability To make sure that digital goods and services are available to everyone, regardless of their ability or disability, next-gen user interfaces are built around inclusive design principles. In order to foster inclusivity and diversity in the digital realm, next-gen user interfaces take varied user demands and views into account from the very beginning of the design process. For example, alternative input methods, such as gesture-based interaction or switch control, enable users with physical disabilities to navigate digital interfaces effectively. Similarly,

captioning, audio descriptions, and language translation features ensure that digital content is accessible to users with sensory impairments or language barriers. Despite their potential benefits, next-gen UIs also present challenges and considerations in their design, development, and implementation. Ensuring compatibility with assistive technologies, addressing privacy and security concerns, and complying with accessibility standards and regulations are critical aspects that require careful attention. Moreover, the digital divide and disparities in access to technology among individuals with disabilities must be addressed to ensure equitable access and participation for all. Looking ahead, the future of next-gen UIs in disability support holds immense promise for advancing accessibility, independence, and inclusion. Continued innovation in AI, IoT, and humancomputer interaction will drive the development of more intuitive, adaptive, and inclusive interfaces. Moreover, collaboration between technology developers, disability advocates, and policymakers is essential to ensure that next-gen UIs meet the diverse needs of individuals with disabilities and promote equal access and opportunity for all. Next-generation UIs have the potential to transform disability support by enhancing accessibility, promoting independence, and fostering inclusion for individuals with disabilities. By leveraging advanced technologies and inclusive design principles, nextgen UIs can empower users to fully participate in the digital world and lead more independent and fulfilling lives. As we continue to innovate and advance next-gen UIs, let us strive to create a future where technology serves as a powerful tool for empowerment, equality, and inclusion for all individuals, regardless of their abilities or limitations [36]–[40].

## 6. Next Generation User Interface: Architecture, Advantages, and Disadvantages

The Next Generation User Interface (UI) represents a significant evolution in the way users interact with digital devices and services. This article explores the architecture of Next Generation UI, its advantages, and disadvantages, shedding light on its impact on user experience and technology advancement [41]–[43].

### 6.1 Architecture of Next Generation UI

The architecture of Next Generation UI is characterized by several key components and principles:

- 1. Advanced Technologies:** Next Generation UI represents a culmination of cutting-edge technological advancements, incorporating sophisticated tools like artificial intelligence (AI), natural language processing (NLP), gesture recognition, and augmented reality (AR). These technologies work in tandem to revolutionize user experiences, providing an intuitive, adaptive, and immersive interface that transcends traditional boundaries. By harnessing the power of AI, Next Generation UIs can learn from user interactions, predict preferences, and tailor experiences accordingly. NLP enables seamless communication, allowing users to interact with devices using natural language commands. Gesture recognition and AR further enhance user engagement by enabling intuitive and interactive interactions, blurring the lines between the physical and digital worlds.

- 2. Adaptive Interface:** At the core of Next Generation UI is its adaptability to the user's preferences, behavior, and context. By dynamically adjusting to user inputs, past interactions, and environmental factors, Next Generation UIs offer a highly personalized and tailored experience. Through continuous learning algorithms, these interfaces evolve over time, finetuning themselves to better serve the user's needs and preferences. Whether it's customizing layout, content, or functionality, Next Generation UIs prioritize user-centric design, ensuring that each interaction is optimized for maximum efficiency and satisfaction.
- 3. Multi-Modal Interaction:** Next Generation UIs embrace a multi-modal approach to interaction, accommodating a diverse range of user inputs and preferences. By supporting voice, touch, gesture, and gaze inputs, these interfaces cater to users with varying abilities and limitations, fostering natural and intuitive interactions. Voice commands enable hands-free operation, while touch and gesture inputs provide tactile feedback and precise control. Additionally, gaze-based interaction offers a novel way for users to navigate interfaces, particularly beneficial for individuals with mobility impairments or visual impairments. By offering multiple interaction modalities, Next Generation UIs promote inclusivity and accessibility, ensuring that all users can engage with digital devices and services effectively.
- 4. Context Awareness:** Next Generation UIs are imbued with context-aware capabilities, enabling them to understand the user's

surroundings, location, and activities. By leveraging sensors, geolocation data, and environmental cues, these interfaces can adapt their behavior and presentation to suit the user's current context. For example, a Next Generation UI on a smartphone may adjust its display brightness based on ambient lighting conditions or suggest relevant information based on the user's location. This contextual awareness enhances the relevance and usefulness of the UI, providing users with timely and pertinent information and services tailored to their specific circumstances.

- 5. Seamless Integration:** Next Generation UIs excel in their ability to seamlessly integrate with a wide range of devices, services, and platforms. Through standardized protocols and APIs, these interfaces facilitate interoperability and continuity across different contexts and environments. For example, a Next Generation UI on a smart home device may seamlessly communicate with other connected devices in the home, allowing users to control various aspects of their environment through a single interface. Similarly, Next Generation UIs on mobile devices may integrate with third-party apps and services, enabling users to access a wide range of functionalities without switching between multiple apps. This seamless integration enhances the user experience by providing a cohesive and unified interface across diverse digital ecosystems.

## 6.2 Advantages of Next Generation UI

- 1. Enhanced User Experience:** Next Generation UI elevates the user experience to new heights, surpassing traditional interfaces through its seamless blend of intuitiveness, adaptability, and personalization. By intuitively anticipating user needs, adapting to individual preferences, and delivering personalized interactions, Next Generation UIs foster a deeper and more satisfying user experience that resonates with users on a personal level.
- 2. Improved Accessibility:** Next Generation UI takes significant strides in enhancing accessibility, particularly for users with disabilities or limitations. By embracing multi-modal interaction and context-awareness, these interfaces break down barriers and empower users of all abilities to engage with digital content and services. Whether it's through voice commands, touch gestures, or context-sensitive prompts, Next Generation UIs prioritize inclusivity and accessibility, ensuring that every user can participate fully in the digital experience.
- 3. Increased Efficiency:** Next Generation UI revolutionizes efficiency by optimizing tasks and workflows, streamlining processes, and reducing cognitive load. Through intelligent automation, proactive assistance, and seamless integration with user workflows, these interfaces empower users to accomplish tasks more efficiently and effectively across various domains, from productivity and education to entertainment and leisure. By minimizing friction and maximizing productivity, Next

Generation UIs enhance user efficiency and effectiveness in accomplishing their goals.

- 4. Better Engagement:** Next Generation UI captivates users with immersive and interactive experiences that go beyond mere functionality to evoke genuine engagement and emotional connection. Through rich multimedia content, dynamic visualizations, and interactive elements, these interfaces create captivating and memorable experiences that hold users' attention and foster deeper engagement. By stimulating curiosity, creativity, and exploration, Next Generation UIs transform passive users into active participants, driving higher levels of engagement and interaction.
- 5. Future-Proofing:** Next Generation UI ensures the longevity and relevance of digital products and services by embracing advanced technologies and design principles that are adaptable, scalable, and resilient to change. By leveraging cutting-edge technologies such as AI, machine learning, and adaptive algorithms, these interfaces anticipate and adapt to evolving user needs and preferences, ensuring that they remain relevant and effective in a rapidly changing technological landscape. By future-proofing digital products and services, Next Generation UIs empower organizations to stay ahead of the curve and deliver value to users over the long term.

## 6.3 Disadvantages of Next Generation UI

- 1. Complexity:** Implementing Next Generation UIs can introduce complexity in various aspects, including design, development, and implementation. These interfaces

often require specialized skills and expertise to create and maintain, as they may involve intricate algorithms, advanced technologies, and novel interaction paradigms. Designing intuitive and user-friendly interfaces amidst this complexity requires careful consideration of user needs, preferences, and usability principles, adding another layer of complexity to the development process.

- 2. Privacy Concerns:** Next Generation UIs raise significant privacy concerns due to their capability to collect, analyze, and potentially exploit vast amounts of user data. With features like personalized recommendations, context-aware assistance, and behavioral analysis, these interfaces may inadvertently compromise user privacy and security by accessing sensitive information without explicit consent. Furthermore, the aggregation and analysis of user data for targeted advertising or profiling purposes can raise ethical and legal questions regarding user privacy and data protection.
- 3. Accessibility Challenges:** While Next Generation UIs aim to enhance user experience and inclusivity, they may inadvertently introduce accessibility challenges for users with disabilities or limitations. Interfaces heavily reliant on specific input modalities or sensory cues, such as voice commands or gesture recognition, may pose barriers for individuals with certain disabilities, such as motor impairments or visual impairments. Ensuring that Next Generation UIs are accessible to all users requires careful consideration of accessibility standards, guidelines, and best practices throughout the design and development process.

- 4. Dependency on Technology:** Next Generation UIs are inherently dependent on advanced technologies such as artificial intelligence (AI), natural language processing (NLP), and augmented reality (AR). While these technologies enable innovative and immersive user experiences, they may not be accessible or affordable for all users, leading to disparities in access and adoption. Additionally, reliance on proprietary or closed-source technologies may limit interoperability and hinder the development of open and inclusive digital ecosystems.

- 5. Resistance to Change:** Next Generation UIs may encounter resistance from users accustomed to traditional interfaces, who may find the transition to new interaction paradigms challenging or disruptive. Users may be hesitant to adopt unfamiliar technologies or change ingrained habits and workflows, particularly if they perceive the learning curve as steep or the benefits as uncertain. Overcoming resistance to change requires effective communication, user education, and support mechanisms to help users navigate the transition and realize the potential benefits of Next Generation UIs. Among the many advantages offered by Next Generation UI—a giant leap forward in user interface design—are an improved user experience, accessibility, efficiency, engagement, and future-proofing. But there are other obstacles, such as complexity, privacy worries, accessibility issues, reliance on technology, and aversion to change. Designers, developers, and stakeholders may make better judgements and build interfaces that satisfy users' requirements and

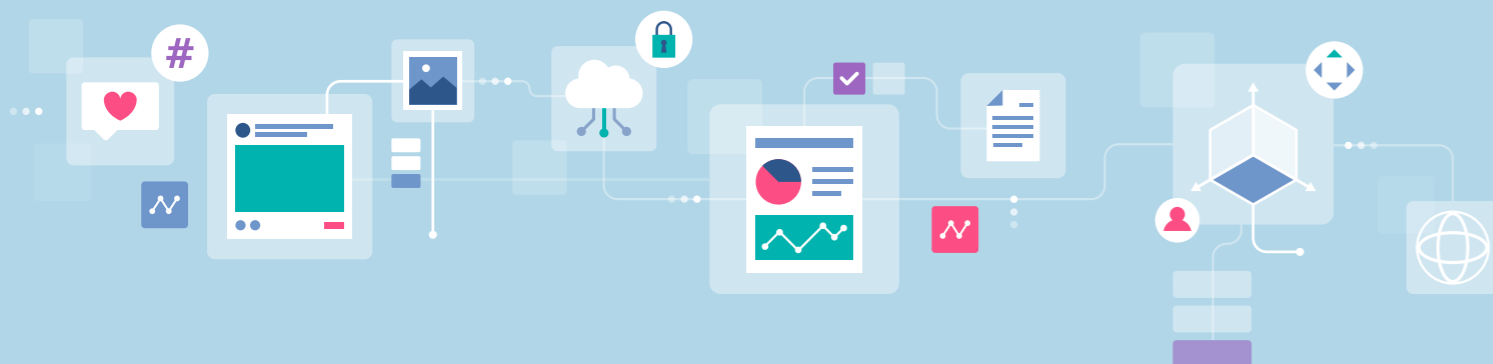


expectations in the digital age if they grasp the architecture, pros, and cons of Next Generation UI.

## 7. Conclusion

In conclusion, the review illuminates the profound impact of Next Generation User Interfaces (UIs) in revolutionizing disability support through advanced technologies. Through the utilisation of state-of-the-art advancements such as AI, NLP, and gesture recognition, Next Generation UIs deliver personalized, adaptive, and immersive experiences tailored to the unique needs of individuals with disabilities. These interfaces not only facilitate seamless interaction and communication but also empower users to navigate digital devices and services with newfound ease and autonomy. The architectural framework of Next Generation UIs, characterized by its integration of advanced technologies, adaptive interfaces, multi-modal interaction, context awareness, and seamless integration, lays a solid foundation for a more inclusive and accessible digital ecosystem. There are many

benefits to Next Generation UIs, such as an improved user experience, accessibility, efficiency, engagement, and future-proofing. However, there are also many drawbacks, such as complexity, privacy issues, accessibility barriers, technological dependencies, and opposition to change. The review underscores the imperative of continued innovation and collaboration in designing, developing, and implementing Next Generation UIs to ensure they authentically address the needs and expectations of individuals with disabilities. By confronting challenges head-on and seizing opportunities, Next Generation UIs possess the potential to redefine disability support, empowering individuals to fully embrace digital participation and lead lives marked by independence and fulfillment. As we press forward in advancing technology and accessibility, let us remain committed to forging a future where Next Generation UIs serve as catalysts for empowerment, equality, and inclusion, transcending barriers and embracing the diversity of all individuals, regardless of their abilities or limitations.



## References

- Namoun, A., Tufail, A., Nawaz, W., BenRhouma, O., & Alshantiti, A. (2023). A Systematic Literature Review on Service Composition for People with Disabilities: Taxonomies, Solutions, and Open Research Challenges. *Computational Intelligence and Neuroscience*, 2023(3), 1–40. <https://doi.org/10.1155/2023/5934548>
- Al-Sa'Di, A., & Al-Samarraie, H. (2022). A Delphi Evaluation of User Interface Design Guidelines: The Case of Arabic. *Advances in Human-Computer Interaction*, 2022. <https://doi.org/10.1155/2022/5492230>
- Dianat, F., Khodakarami, V., Shakouri Ganjavi, H., & Hosseini, S. H. (2022). Sustainability Assessment of Electricity Generation Development under the Implementation of Support Policies with Endogenous Financial Resources Using a Hybrid Decision Support Model. *Mathematical Problems in Engineering*, 2022. <https://doi.org/10.1155/2022/7436749>
- Gu, J., Chen, L., Zeng, C., Yang, X., Pan, D., Cao, H., & Qian, Q. (2022). A Retrospective Analysis of Metagenomic Next Generation Sequencing (mNGS) of Cerebrospinal Fluid from Patients with Suspected Encephalitis or Meningitis Infections. *Journal of Healthcare Engineering*, 2022. <https://doi.org/10.1155/2022/5641609>
- Son, J. H., Kim, D. G., Lee, E., & Choi, H. (2022). Investigating the Spatiotemporal Imbalance of Accessibility to Demand Responsive Transit (DRT) Service for People with Disabilities: Explanatory Case Study in South Korea. *Journal of Advanced Transportation*, 2022. <https://doi.org/10.1155/2022/6806947>
- Zhang, H., Duan, Y., Cai, F., Cao, D., Wang, L., Qiao, Z., Hong, Q., Li, N., Zheng, Y., Su, M., Liu, Z., & Zhu, B. (2022). Next-Generation Probiotics: Microflora Intervention to Human Diseases. *BioMed Research International*, 2022. <https://doi.org/10.1155/2022/5633403>
- Ali, M. I., & Kaur, S. (2021). Next-generation digital forensic readiness BYoD framework. *Security and Communication Networks*, 2021. <https://doi.org/10.1155/2021/6664426>
- Asif, M., Khan, W. U., Afzal, H. M. R., Nebhen, J., Ullah, I., Rehman, A. U., & Kaabar, M. K. A. (2021). Reduced-Complexity LDPC Decoding for Next-Generation IoT Networks. *Wireless Communications and Mobile Computing*, 2021. <https://doi.org/10.1155/2021/2029560>
- Mohd Zaki, Z., Ishak, S. F., & Mohamad, K. A. (2021). User Interface Designs of an Educational Mobile Application: A Study of Qiraat Teaching and Learning. *Advances in Human-Computer Interaction*, 2021. <https://doi.org/10.1155/2021/6648550>
- Thompson, B. A. D., & Broome, K. (2021). Social Circus for People with Disabilities: A Video Analysis through the Lens of the MOHO. *Occupational Therapy International*, 2021. <https://doi.org/10.1155/2021/6628482>
- Wang, Y., Lei, J., & Shang, F. (2021). Enabling Device-to-Device (D2D) Communication for the Next Generation WLAN. *Wireless Communications and Mobile Computing*, 2021. <https://doi.org/10.1155/2021/1949352>
- Lavín-Pérez, A. M., Collado-Mateo, D., Caña-Pino, A., Villafaina, S., Parraca, J. A., & Apolo-Arenas, M. D. (2022). Benefits of Equine-Assisted Therapies in People with Multiple Sclerosis: A Systematic Review. *Evidence-Based Complementary and Alternative Medicine*, 2022. <https://doi.org/10.1155/2022/9656503>
- Nour, R. (2022). An Assessment of Accessibility and Usability of Saudi

- Online FinTech Services for People with Disabilities. *Computational and Mathematical Methods in Medicine*, 2022. <https://doi.org/10.1155/2022/8610844>
14. Vanpuymbrouck, L., & Magasi, S. (2024). Confronting Barriers to Equitable Care: A Qualitative Analysis of Factors That Inform People with Mobility Disabilities' Decisions to Self-Advocate in the Context of Healthcare. *Health and Social Care in the Community*, 2024. <https://doi.org/10.1155/2024/9975084>
15. Xie, Y., Dai, B., Zhou, X., Liu, H., Wu, W., Yu, F., & Zhu, B. (2023). Diagnostic Value of Metagenomic Next-Generation Sequencing for Multi-Pathogenic Pneumonia in HIV-Infected Patients. *Infection and Drug Resistance*, 16, 607–618. <https://doi.org/10.2147/IDR.S394265>
16. Li, Y., Meng, X., Luo, Y., Huang, X., Luo, S., & Wang, J. (2023). Next-Generation Sequencing Analysis of 3 Uterine Adenosarcomas with Heterogeneously Differentiated Genomic Mutations. *International Journal of Analytical Chemistry*, 2023. <https://doi.org/10.1155/2023/7436368>
17. Park, G. A., & Lee, O. N. (2022). The Moderating Effect of Social Support on Parental Stress and Depression in Mothers of Children with Disabilities. *Occupational Therapy International*, 2022. <https://doi.org/10.1155/2022/5162954>
18. Gümüşkaya, O., Sen, S., İSik, I., Ayaz, V., Arslan Özkan, H., & Wilson, R. L. (2023). Urban Share of the “burden”: Impact of a Support Organisation on Caregiver Burden of People Affected by Dementia. *Perspectives in Psychiatric Care*, 2023. <https://doi.org/10.1155/2023/2706698>
19. Suhaimi, S. N., Rahman, A. R. A., Din, M. F. M., Hassan, M. Z., Ishak, M. T., & Jusoh, M. T. Bin. (2020). A Review on Oil-Based Nanofluid as Next-Generation Insulation for Transformer Application. *Journal of Nanomaterials*, 2020. <https://doi.org/10.1155/2020/2061343>
20. Aretha, D., Fligou, F., Kiekkas, P., Karamouzou, V., & Voyagis, G. (2019). Extracorporeal Life Support: The Next Step in Moderate to Severe ARDS - A Review and Meta-Analysis of the Literature. *BioMed Research International*, 2019. <https://doi.org/10.1155/2019/1035730>
21. Helton, M., Abu-Rmaileh, M., Thomas, K., Gokden, M., Kanaan, A., & Rodriguez, A. (2020). Pituitary Metastatic Composite Tumors: A Case Report with Next-Generation Sequencing and Review of the Literature. *Case Reports in Oncological Medicine*, 2020, 1–8. <https://doi.org/10.1155/2020/5073236>
22. Bizimungu, T., Harelimana, D., & Marie Ntaganda, J. (2021). A Client-Server and Web-Based Graphical User Interface Design for the Mathematical Model of Cardiovascular-Respiratory System. *Applied Computational Intelligence and Soft Computing*, 2021, 9783162. <https://doi.org/10.1155/2021/5581937>
23. He, X., Zhao, S., & Li, Y. (2021). Faecalibacterium prausnitzii: A Next-Generation Probiotic in Gut Disease Improvement. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 2021. <https://doi.org/10.1155/2021/6666114>
24. Manzoor, S., Bajwa, K. B., Sajid, M., Manzoor, H., Manzoor, M., Ali, N., & Menhas, M. I. (2021). Modeling of Wireless Traffic Load in Next Generation Wireless Networks. *Mathematical Problems in Engineering*, 2021. <https://doi.org/10.1155/2021/7293093>
25. Chen, X., Ding, S., Lei, C., Qin, J., Guo, T., Yang, D., Yang, M., Qing, J., He, W., Song, M., Zhang, Y., Zeng, H., Qin, Q., Yang, L., Long, Y., Chen, Y., Ma, B., Ouyang, R., Chen, P., &

- Luo, H. (2020). Blood and Bronchoalveolar Lavage Fluid Metagenomic Next-Generation Sequencing in Pneumonia. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 2020. <https://doi.org/10.1155/2020/6839103>
26. Da Rosa, S. V., Moysés, S. J., Theis, L. C., Soares, R. C., Moysés, S. T., Werneck, R. I., & Rocha, J. S. (2020). Barriers in Access to Dental Services Hindering the Treatment of People with Disabilities: A Systematic Review. *International Journal of Dentistry*, 2020. <https://doi.org/10.1155/2020/9074618>
27. Lanza, G., Calì, F., Vinci, M., Cosentino, F. I. I., Tripodi, M., Spada, R. S., Cantone, M., Bella, R., Mattina, T., & Ferri, R. (2020). A Customized Next-Generation Sequencing-Based Panel to Identify Novel Genetic Variants in Dementing Disorders: A Pilot Study. *Neural Plasticity*, 2020, 1–10. <https://doi.org/10.1155/2020/8078103>
28. Lersilp, S., Putthinoi, S., Lertrakarnnon, P., & Silsupadol, P. (2020). Development and Usability Testing of an Emergency Alert Device for Elderly People and People with Disabilities. *Scientific World Journal*, 2020. <https://doi.org/10.1155/2020/5102849>
29. Smaradottir, B. F., Berntsen, G. K. R., & Fensli, R. W. (2020). How to Enhance Digital Support for Cross-Organisational Health Care Teams? A User-Based Explorative Study. *Journal of Healthcare Engineering*, 2020. <https://doi.org/10.1155/2020/8824882>
30. Blumenstein, T., Turova, V., Alves-Pinto, A., & Lampe, R. (2016). Sensorimotor Piano System for People with Disabilities. *Journal of Sensors*, 2016. <https://doi.org/10.1155/2016/9825905>
31. Ravn, M. B., Petersen, K. S., & Thuesen, J. (2019). Rehabilitation for People Living with Dementia: A Scoping Review of Processes and Outcomes. *Journal of Aging Research*, 2019, 12–16. <https://doi.org/10.1155/2019/4141050>
32. Heldak, M., Stacherzak, A., & Przybyla, K. (2018). Demand and financial constraints in eliminating architectural and technical barriers for people with disabilities in Poland. *Journal of Healthcare Engineering*, 2018. <https://doi.org/10.1155/2018/1297396>
33. Li, W., Mei, L., Chen, H., Cai, X., Liu, Y., Men, M., Liu, X. Z., Yan, D., Ling, J., Feng, Y., & Dorszewska, J. (2019). New Genotypes and Phenotypes in Patients with 3 Subtypes of Waardenburg Syndrome Identified by Diagnostic Next-Generation Sequencing. *Neural Plasticity*, 2019(endothelin 3). <https://doi.org/10.1155/2019/7143458>
34. Sautto, G. A., Kirchenbaum, G. A., Diotti, R. A., Criscuolo, E., & Ferrara, F. (2019). Next Generation Vaccines for Infectious Diseases. *Journal of Immunology Research*, 2019. <https://doi.org/10.1155/2019/5890962>
35. Yousaf, K., Mehmood, Z., Saba, T., Rehman, A., Munshi, A. M., Alharbey, R., & Rashid, M. (2019). Mobile-health applications for the efficient delivery of health care facility to people with dementia (PwD) and support to their carers: A survey. *BioMed Research International*, 2019. <https://doi.org/10.1155/2019/7151475>
36. Chiu, A., Garvey, J., & Abdelrahman, T. S. (2017). A language and preprocessor for user-controlled generation of synthetic programs. *Scientific Programming*, 2017. <https://doi.org/10.1155/2017/1046161>
37. Awoyemi, B. S., Alfa, A. S., & Maharaj, B. T. (2018). Network Restoration for Next-Generation Communication and Computing Networks. *Journal of Computer Networks and Communications*, 2018. <https://doi.org/10.1155/2018/4134878>

38. Bong, W. K., Chen, W., & Bergland, A. (2018). Tangible User Interface for Social Interactions for the Elderly: A Review of Literature. *Advances in Human-Computer Interaction*, 2018. <https://doi.org/10.1155/2018/7249378>
39. Gelšvartas, J., Simutis, R., & Maskeliunas, R. (2018). Projection mapping user interface for disabled people. *Journal of Healthcare Engineering*, 2018.
40. Iannone, A., Ruospo, M., Wong, G., Barone, M., Principi, M., Di Leo, A., & Strippoli, G. F. M. (2018). Mesalazine for people with diverticular disease: A systematic review of randomized controlled trials. *Canadian Journal of Gastroenterology and Hepatology*, 2018. <https://doi.org/10.1155/2018/5437135>
41. Navarro, R. F., Rodríguez, M. D., & Favela, J. (2016). Use and Adoption of an Assisted Cognition System to Support Therapies for People with Dementia. *Computational and Mathematical Methods in Medicine*, 2016(1), 1–11. <https://doi.org/10.1155/2016/1075191>
42. Boessen, A. B. C. G., Verwey, R., Duymelinck, S., & Van Rossum, E. (2017). An Online Platform to Support the Network of Caregivers of People with Dementia. *Journal of Aging Research*, 2017. <https://doi.org/10.1155/2017/3076859>
43. Punchoojit, L., & Hongwarittorn, N. (2017). Usability Studies on Mobile User Interface Design Patterns: A Systematic Literature Review. *Advances in Human-Computer Interaction*, 2017. <https://doi.org/10.1155/2017/6787504>
44. Aqle, A., Al-Thani, D. & Jaoua, A. Can search result summaries enhance the web search efficiency and experiences of the visually impaired users?. *Univ Access Inf Soc* 21, 171–192 (2022). <https://doi.org/10.1007/s10209-020-00777-w>

45. Dena Al-Thani and Aboubakr Aqle. 2023. Evaluating Search Results Overviews and Previews with Visually Impaired Users. In *Proceedings of the 16th International Conference on Pervasive Technologies Related to Assistive Environments (PETRA '23)*. Association for Computing Machinery, New York, NY, USA, 680–685.



# Museums, Exhibitions, Arts and Culture

FIND OUT MORE



# The Current State of Generative Artificial Intelligence Tools for Accessibility in Product Development

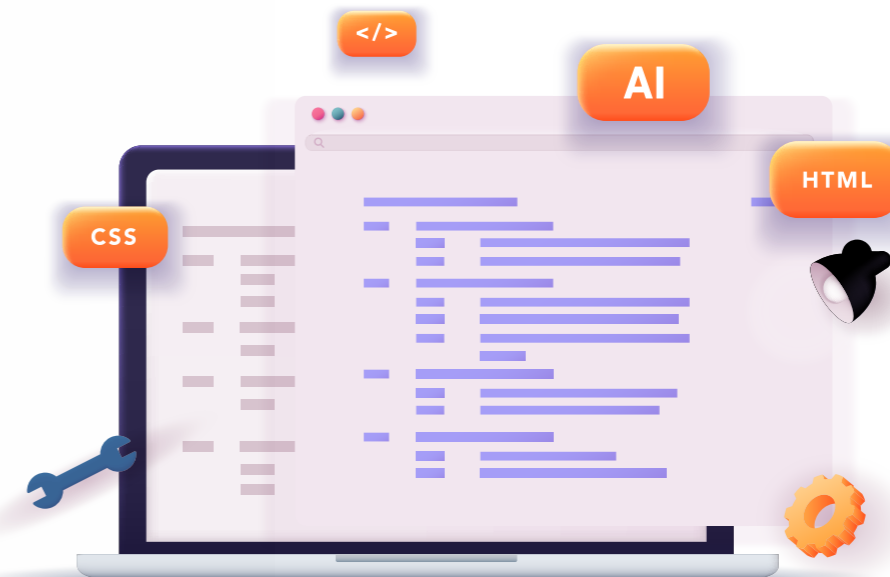
**Iyad Abu Doush**  
College of Engineering and Applied Sciences  
American University of Kuwait  
idoush@auk.edu.kw  
Salmiya, Kuwait

## The Current State of Generative Artificial Intelligence Tools for Accessibility in Product Development

**Abstract** - This paper addresses the pressing need to evaluate the maturity and performance metrics of generative AI tools dedicated to accessibility in product development. The problem lies in the lack of standardized methods for assessing the maturity of generative AI tools tailored to accessibility needs and the absence of universally accepted performance metrics to measure their efficacy. This deficiency hampers the advancement of inclusive design practices and limits the potential impact of AI-driven accessibility solutions. This paper proposes a comprehensive framework for evaluating the maturity of AI tools specifically designed for accessibility in product development. We elucidate the critical criteria integral to this evaluation, encompassing aspects such as usability, reliability, scalability, and adaptability to diverse user needs and contexts. The proposed solution aims to contribute valuable knowledge to the evolving landscape of generative AI tools dedicated to enhancing accessibility in product development. By establishing a structured approach to assessing maturity and advocating for standardized performance metrics, our research endeavors to empower developers, designers, and stakeholders to make informed decisions regarding the adoption and refinement of AI-driven accessibility solutions.

### Keywords

ChatGPT; Copilot; Digital accessibility; AI; Code generation; Accessible product development.





## Introduction

Numerous research endeavors have focused on enhancing developer productivity through various approaches such as code synthesis, code search, and other forms of code recommender systems [1]. Many of these initiatives harness the capabilities of Artificial Intelligence, particularly employing deep learning techniques [2]. A significant development in this domain occurred in June 2021 when GitHub and OpenAI introduced GitHub Copilot—a revolutionary "AI pair programmer" compatible with several IDEs. Fueled by the expansive OpenAI Codex model, trained on a vast corpus of open-source GitHub code. Copilot excels in proposing code snippets across various programming languages. Additionally, ChatGPT, another powerful tool in this realm, offers a conversational interface that can be leveraged for code generation and product development [3]. These tools leverage vast datasets to create generative models, with the aim of producing code that facilitates the development of accessible products. However, the maturity of these tools remains a critical consideration.

Copilot provides users with three primary functionalities: converting comments to code, suggesting tests that match implementation code, and auto-filling for repetitive code. The conversion of comments to code, which is initiated when a user writes a comment describing the logic they intend to implement. Although a Copilot suggestion can be triggered by a natural language comment alone, optimal results are achieved when users supplement their input with meaningful names for function parameters and descriptive comments [2].

ChatGPT can be used to generate code by engaging in a conversational interaction with the model. The user needs to clearly express the intent for code generation. Then furnish relevant context and details about the code to generate. Finally, interact with ChatGPT through a series of prompts and responses to refine the code [3].

The use of Large Language Models (LLM), like ChatGPT, to automatically improve web accessibility explored in the work [4]. The paper compares ChatGPT's effectiveness in detecting and fixing accessibility issues to manual testing on two non-compliant websites. Results show promise for ChatGPT in enhancing web accessibility, vital for meeting WCAG 2.1 guidelines and creating more inclusive online platforms. The burgeoning field of Artificial Intelligence (AI) has witnessed a substantial integration of tools aimed at fostering accessibility in product development.

In light of this inquiry, this research addresses several key questions. Firstly, it explores effective methods for assessing the maturity of generative AI tools dedicated to accessibility in product development and elucidates the criteria integral to this evaluation. Secondly, the paper delves into the diverse performance metrics employed to gauge the effectiveness and efficiency of these tools and proposes potential standardization measures. This exploration aims to contribute valuable knowledge to the evolving landscape of generative AI tools dedicated to enhancing accessibility in product development.

Various metrics serve as benchmarks to evaluate the effectiveness and inclusivity of generative AI tools' code outcomes. Measures encompassing code functionality, visual structure, complexity, consideration of multiple input devices, and the severity level of accessibility issues within the generated code are pivotal for comprehensive assessment. By incorporating these multifaceted measures into the evaluation process, stakeholders can make informed decisions regarding the selection and optimization of AI tools for accessibility in product development. This holistic approach ensures the delivery of inclusive digital experiences that cater to the diverse needs of users across different abilities.



## Generative AI to Improve Code Accessibility

In recent years, the integration of artificial intelligence (AI) within software development has heralded significant advancements in accessibility. Among these innovations, generative AI stands out as a transformative force, particularly in the realm of code accessibility. This section explores the burgeoning landscape of Generative AI and its profound implications for enhancing accessibility in product development. By automating the creation and modification of code structures, Generative AI not only expedites the development process but also fosters inclusivity by empowering developers of all skill levels to create accessible software. Within this context, we delve into four distinct cases where Generative AI demonstrates its efficacy [5].

# 74

**A. Code Generation for Accessibility:** AI tools utilize extensive datasets to generate code that fosters accessibility in product development. However, the maturity of these tools is still evolving. One key challenge lies in their ability to accurately describe content through code. While tools can suggest accessibility attributes, integrating them with precise values based on content remains a hurdle. The following is an example use case of a prompt to generate accessible code using Copilot:

**Prompt:** Act as accessibility coach subject matter expert to create accessible HTML table that conform with WCAG 2.1 A and AA success criteria. The table has 5 rows and 3 columns with the headers Name, Email, and Date of birth. When possible, use semantic HTML to ensure it is operable using the keyboard. Also, follow ARIA Authoring Practices guide and related design patterns.

**Generated Code:** Here's an example of an accessible table with the specified headers and content:

```
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <title>Accessible Table Example</title>
</head>
<body>
  <table role="grid" aria-label="User Information">
    <thead>
      <tr>
        <th scope="col">Name</th>
        <th scope="col">Email</th>
        <th scope="col">Date of Birth</th>
      </tr>
    </thead>
    <tbody>
      <tr>
        <td>John Doe</td>
        <td><a href="mailto:john@example.com">john@example.com</a></td>
        <td>1985-07-15</td>
      </tr>
      <tr>
        <td>Jane Smith</td>
        <td><a href="mailto:jane@example.com">jane@example.com</a></td>
        <td>1990-03-22</td>
      </tr>
      <!--Add more rows as needed -->
    </tbody>
  </table>
</body>
</html>
```



# 75

**B. Accessibility Feedback:** When evaluating accessibility issues within code, the reliability of feedback from AI tools is still a concern. For instance, these tools may struggle to determine if the values assigned to attributes accurately describe the content. This uncertainty poses challenges for developers relying on AI-generated feedback to ensure accessibility compliance.

**Prompt:** Act as accessibility coach subject matter expert to identify accessibility issues and how to fix them in the following HTML table. This is to ensure that the code conform with WCAG 2.1 A and AA success criteria. When possible, check the use of semantic HTML to ensure it is operable using the keyboard. Also, ensure it follows ARIA Authoring Practices guide and related design patterns. The following is the HTML table code:

```
<table>
  <tr>
    <td>Row 1, Column 1</td>
    <td>Row 1, Column 2</td>
  </tr>
  <tr>
    <td>Row 2, Column 1</td>
    <td>Row 2, Column 2</td>
  </tr>
  <tr>
    <td>Row 3, Column 1</td>
    <td>Row 3, Column 2</td>
  </tr>
</table>
```

**Response:** The following is the Recommendations section of the response:

- Add a <caption> element to describe the purpose of the table (e.g., "Sales Data for Q1 2024").
- If the table has headers, use <th> elements for them.
- Provide alternative text for any non-text content (if applicable).
- Test keyboard navigation within the table.

**C. Repair Recommendations and Guidance:** An essential aspect of AI tools in product development is their capacity to provide repair recommendations. While tools can identify accessibility issues, the ability to guide developers on fixing these issues is crucial.

**D. Creation of Test Cases:** AI tools are expected not only to identify accessibility issues but also to actively contribute to the creation of accessible code and test cases. The maturity of these tools is reflected in their ability to not only point out problems but also propose solutions.

One of the main challenges of utilizing AI tools for software development of accessible products is to integrate content and code generation in a way that ensures semantic and structural coherence. For example, an AI tool may be able to suggest accessibility attributes for HTML elements, such as alt, aria-label, or role, but it may not be able to assign appropriate values

to these attributes based on the content and context of the web page. Moreover, an AI tool may not be able to verify if the values provided by the developer are accurate and descriptive enough for assistive technologies to help users with disabilities. Therefore, an AI tool should not only generate code, but also provide feedback and repair recommendations to help developers fix accessibility issues and improve code quality.

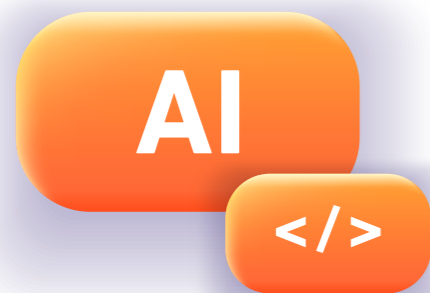
3

## Performance Indicators for Code Accessibility

Assessing the efficacy of AI tools in ensuring code accessibility presents a multifaceted challenge. Currently, there exists a lack of standardized methodologies for evaluating code accessibility, necessitating the identification of suitable performance indicators. These indicators encompass various aspects, such as the quantity and severity of accessibility errors detected by the tool, the comprehensiveness and precision of the generated code, the satisfaction and usability of individuals with disabilities interacting with the product, and the adherence to pertinent accessibility standards and guidelines. However, it's imperative to recognize that these indicators can be influenced by factors like the nature, purpose, and complexity of the product, as well as the characteristics of its target audience and user scenarios. Thus, an effective AI tool must demonstrate adaptability across diverse contexts and deliver actionable insights to both developers and stakeholders.

In evaluating the performance of AI tools for enhancing accessibility in product development, a holistic approach is necessary. This approach involves considering various metrics to gauge the tool's effectiveness. Metrics may include precision in identifying accessibility issues, accuracy in suggesting relevant accessibility attributes, and the integration of context-based values to ensure the accuracy of content. Additionally, the tool's effectiveness in providing actionable recommendations for repairs, its capability to generate accessible code and test cases, and its ability to provide insightful feedback on the overall accessibility level of the code are crucial factors to assess. By comprehensively evaluating these aspects, stakeholders can gain a deeper understanding of the tool's impact on enhancing code accessibility and ensure that it meets the diverse needs of users across different contexts and scenarios.

Previous work in the area of measuring AI generated code includes [6] presenting measure for evaluating quality of generated code to be compilation and runtime errors, wrong outputs, code style, maintainability, and efficiency. Another work [7] proposes to use validity, correctness, efficiency in terms of time and space complexity.



In this work we propose a set of measures to evaluate the accessibility of the generated code. These measures are not presented previously in the literature. Firstly, the visual order of the code plays a crucial role in enhancing readability and comprehension, particularly for developers and individuals utilizing screen readers. Tools should prioritize generating code with a clear and logical structure, facilitating easier navigation and comprehension. Secondly, the consideration of multiple input devices broadens the accessibility scope, accommodating users with varying abilities. AI tools should generate code that supports diverse input modalities, including keyboard navigation, voice commands, and gesture controls, fostering an inclusive user experience. Lastly, evaluating the severity level of accessibility issues within the generated code aids in prioritizing and addressing critical barriers to access. The code generated by the tools needs to be evaluated in terms of the severity of accessibility shortcomings, empowering developers to allocate resources effectively and prioritize remediation efforts.

4

## Conclusion & Future works

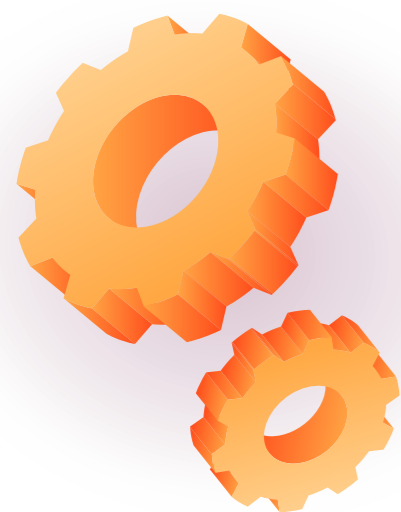
In conclusion, while generative AI tools for accessibility in product development exhibit considerable promise, their current stage of development raises concerns regarding their reliability and effectiveness. Overcoming technical and methodological challenges, such as integrating content and code generation, providing robust feedback and repair recommendations, creating suitable test cases and metrics, and adapting to diverse contexts and requirements, remains paramount for their advancement. Achieving this goal necessitates further research and collaboration among researchers, developers, users, and accessibility experts. Moving forward, it is imperative to focus on enhancing the reliability of feedback mechanisms, refining repair recommendations, and ensuring the accurate integration of attribute values within AI tools for accessibility. The proposed performance indicators can serve as a valuable benchmark for evaluating and advancing the maturity of these tools in facilitating accessibility in product development. Furthermore, the proposed standardization measures require validation through expert review and real-world case studies to ensure their practical relevance and applicability. One promising avenue for advancing the field of Artificial Intelligence Tools for Accessibility in Product Development is the establishment of a comprehensive "golden dataset" comprised of accessible code samples. This dataset would serve as a benchmark for evaluating the efficacy of generative AI tools in producing accessible code and identifying areas for improvement. Additionally, testing the ability of current generative AI tools to generate code that meets

accessibility standards and comparing the results against this golden dataset presents an exciting opportunity for future research. Performance measures outlined in the present study can be utilized to quantify any shortcomings observed in the code generated by AI tools. By systematically analyzing the generated code against the golden dataset, researchers can identify patterns of deficiencies and assess the extent to which current generative AI tools fall short in producing accessible code. This analysis can provide valuable insights into areas requiring further development and refinement.

Through ongoing research and collaboration, we can drive forward the evolution of AI tools for accessibility, ultimately fostering a more inclusive and equitable digital landscape for all users.

#### References

1. S. Luan, D. Yang, C. Barnaby, K. Sen, and S. Chandra, 'Aroma: Code recommendation via structural code search', Proc. ACM Program. Lang., vol. 3, no. OOPSLA, pp. 1–28, 2019.
2. N. Nguyen and S. Nadi, 'An empirical evaluation of GitHub copilot's code suggestions', in Proceedings of the 19th International Conference on Mining Software Repositories, 2022, pp. 1–5.
3. [3] N. M. S. Surameery and M. Y. Shakor, 'Use chat gpt to solve programming bugs', Int. J. Inf. Technol. Comput. Eng., no. 31, pp. 17–22, 2023.
4. A. Othman, A. Dhouib, and A. Nasser Al Jabor, 'Fostering websites accessibility: A case study on the use of the Large Language Models ChatGPT for automatic remediation', in Proceedings of the 16th International Conference on Pervasive Technologies Related to Assistive Environments, 2023, pp. 707–713.
5. J. Liu, C. S. Xia, Y. Wang, and L. Zhang, 'Is your code generated by chatgpt really correct? rigorous evaluation of large language models for code generation', Adv. Neural Inf. Process. Syst., vol. 36, 2024.
6. Y. Liu et al., 'Refining ChatGPT-generated code: Characterizing and mitigating code quality issues', ACM Trans. Softw. Eng. Methodol., 2023.
7. B. Yetistiren, I. Ozsoy, and E. Tuzun, 'Assessing the quality of GitHub copilot's code generation', in Proceedings of the 18th international conference on predictive models and data analytics in software engineering, 2022, pp. 62–71.



# Virtual Reality Glasses for Pain Management in Children with Cerebral Palsy: Current Knowledge and Future Directions

Abdullah Al Shami

Hamad Medical Corporation  
aalshami@hamad.qa  
Doha, Qatar





**Abstract**

Cerebral palsy (CP) is a prevalent neurological condition that causes secondary musculoskeletal pain, impacting children's functional status, quality of life (QoL), and sleep patterns. Addressing pain management within rehabilitation programs for children with CP is crucial. Virtual reality (VR) glasses have emerged as a promising tool for managing pain and distress during medical procedures. This paper reviews current knowledge on the use of VR glasses for pain management in children with CP and discusses future research and clinical implementation directions.

**Keywords**

Virtual Reality Glasses; Pain Management; Children; Cerebral Palsy

**1. Introduction**

Cerebral palsy (CP) is a prevalent neurological condition and a leading cause of physical disabilities in children globally (1). It affects movement and causes secondary issues like musculoskeletal pain, impacting daily life, functionality, quality of life (QoL), and sleep (2). Several studies highlight the significant impact of pain on the well-being of children with CP, increasing the focus on pain management in rehabilitation programs (3).

Virtual reality (VR) technology is being used as a new method to help children undergoing medical procedures manage pain and distress (4). Specifically, VR glasses show potential in reducing pain and discomfort in children with CP, providing an innovative solution to the difficulties of pain management in this population.

This paper aims to explore the emerging practice of using VR glasses to manage pain among children with CP. By reviewing the current state of knowledge and discussing potential future directions, this study seeks to contribute to the ongoing discourse surrounding effective pain management strategies for individuals living with CP.



**Figure 1.**  
Virtual reality technology

**2. Exploring Virtual Reality as a Tool for Pain Management in Children with Cerebral Palsy**

In this section, we delve deeper into the utilization of virtual reality [VR] glasses for pain management among children with cerebral palsy [CP]. We explore key concepts, provide evidence and examples, and explain their significance within the broader context of pediatric healthcare.

**Introduction to Virtual Reality (VR)**

Virtual reality [VR] is a computer technology that generates a simulated three-dimensional environment. In recent years, virtual reality [VR] technology has become increasingly popular as a non-pharmacological method for managing pain in different medical environments, VR glasses offer an immersive experience that distracts patients from painful stimuli, thereby reducing perceived pain intensity and distress [5].

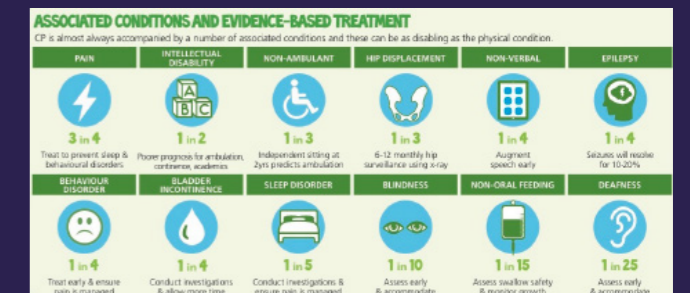
**VR Applications in Healthcare:**

VR technology has been used in diverse healthcare applications, from training medical professionals to managing pain and anxiety during medical procedures [4]. Studies show the potential of using virtual reality for people with disabilities, demonstrating its diverse benefits in enhancing accessibility and improving quality of life through various research projects and successful assistive applications [11].

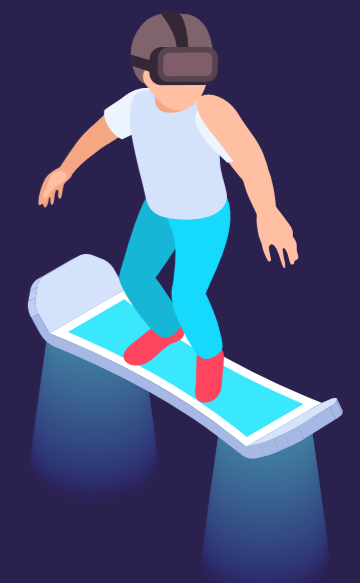
**VR for Pain Management in CP**

Children with CP often suffer from chronic musculoskeletal pain caused by their neurological condition. VR glasses show potential in providing pain relief by immersing children in engaging virtual environments (2).

Pain in cerebral palsy [CP] refers to any discomfort or unpleasant sensation experienced by individuals with CP that may result from musculoskeletal issues, neurological abnormalities, or associated medical conditions.



**Figure 2.**  
Associated conditions and evidence-based treatment Findings from a systematic review by Novak et al. 2012 [6]



### Evidence and Examples of VR Efficacy

Numerous studies have demonstrated the effectiveness of VR-based interventions in mitigating pain among pediatric populations undergoing medical procedures such as venipuncture, wound care, and physical therapy [7]. Virtual reality glasses improve the healthcare experience for both patients and caregivers by immersing children in captivating virtual environments, reducing pain and increasing engagement [8]. The “gate theory” of attention is the most widely accepted model in explaining the impact of VR on pain [9].

### Customizable VR Interventions for CP

Additionally, the adaptable features of VR technology enable healthcare providers to create customized interventions that cater to the distinct requirements and desires of each patient with CP. Using interactive games, guided imagery, or relaxation exercises, VR headsets provide a flexible means of administering personalized pain relief treatments both in medical facilities and at home [10].



## 3. Conclusion

**In conclusion, the utilization of virtual reality [VR] glasses for pain management among children with cerebral palsy [CP] holds significant promise as a non-pharmacological intervention. Through immersive experiences and distraction techniques, VR glasses have demonstrated effectiveness in alleviating pain and distress associated with various medical procedures and chronic musculoskeletal issues in pediatric populations with CP.**

**As evidenced by the literature, VR technology offers a platform for delivering personalized pain management interventions that cater to the unique needs and preferences of individual patients.**

**Furthermore, the customizable nature of VR interventions allows for adaptation to different clinical settings and home environments, expanding access to effective pain relief for children with CP across diverse healthcare contexts.**

**Moving forward, continued research and clinical implementation of VR-based pain management interventions are essential to further elucidate their efficacy, optimize intervention protocols, and enhance healthcare outcomes for children with CP. By harnessing the potential of VR technology, healthcare providers can contribute to improving the quality of life and overall well-being of children living with CP, ultimately fostering a more compassionate and effective approach to pediatric pain management.**

**In summary, VR glasses represent a promising tool in the multidisciplinary management of pain among children with CP, offering innovative solutions to address the complex challenges associated with pediatric pain in this population.**

**Moving forward, future research should focus on conducting large-scale studies to validate VR's efficacy, explore long-term effects, and establish optimal usage protocols. Clinical implementation efforts should prioritize the development of standardized guidelines, healthcare provider training, and ethical considerations related to VR use in pediatric populations. Additionally, technological advancements are needed to enhance VR hardware and software for improved user experience and accessibility. Patient-centered customization is crucial, emphasizing tailored VR interventions to meet individual patient needs and preferences, ensuring adaptability across various healthcare settings, including home use. These future directions aim to further elucidate VR's role in pediatric pain management, ultimately enhancing the quality of life for children with CP.**

### References

1. Rosenbaum P. (2003). Cerebral palsy: what parents and doctors want to know. *BMJ (Clinical research ed.)*, 326(7396), 970–974. <https://doi.org/10.1136/bmj.326.7396.970>
2. Penner, M., Xie, W. Y., Binopal, N., Switzer, L., & Fehlings, D. (2013). Characteristics of pain in children and youth with cerebral palsy. *Pediatrics*, 132(2), e407–e413. <https://doi.org/10.1542/peds.2013-0224>
3. McKearnan, K. A., Kieckhefer, G. M., Engel, J. M., Jensen, M. P., & Labyak, S. (2004). Pain in children with cerebral palsy: a review. *The Journal of neuroscience nursing : journal of the American Association of Neuroscience Nurses*, 36(5), 252–259. <https://doi.org/10.1097/01376517-200410000-00004>
4. Jones, T., Moore, T., & Choo, J. (2016). The impact of virtual reality on chronic pain. *PLoS ONE*, 11(12), e0167523.
5. Arane, K., Behboudi, A., & Goldman, R. D. (2017). Virtual reality for pain and anxiety management in children. *Canadian family physician Medecin de famille canadien*, 63(12), 932–934.
6. Iona Novak, Monique Hines, Shona Goldsmith, Richard Barclay; Clinical Prognostic Messages From a Systematic Review on Cerebral Palsy. *Pediatrics* November 2012; 130 (5): e1285–e1312. [10.1542/peds.2012-0924](https://doi.org/10.1542/peds.2012-0924)
7. Jeffs, D., Dorman, D., Brown, S., Files, A., Graves, T., Kirk, E., Meredith-Neve, S., Sanders, J., White, B., & Swearingen, C. J. (2014). Effect of virtual reality on adolescent pain during burn wound care. *Journal of burn care & research : official publication of the American Burn Association*, 35(5), 395–408. <https://doi.org/10.1097/BCR.0000000000000019>

8. Gerçeker, G. Ö., Binay, S., Bilsin, E., Kahraman, A., & Yılmaz, H. B. (2018). Effects of Virtual Reality and External Cold and Vibration on Pain in 7- to 12-Year-Old Children During Phlebotomy: A Randomized Controlled Trial. *Journal of perianesthesia nursing : official journal of the American Society of PeriAnesthesia Nurses*, 33(6), 981–989. <https://doi.org/10.1016/j.jopan.2017.12.010>
9. Gold, J. I., Belmont, K. A., & Thomas, D. A. (2007). The neurobiology of virtual reality pain attenuation. *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society*, 10(4), 536–544. <https://doi.org/10.1089/cpb.2007.9993>
10. Shiri, S., Feintuch, U., Weiss, N., Pustilnik, A., Geffen, T., Kay, B., Meiner, Z., & Berger, I. (2013). A virtual reality system combined with biofeedback for treating pediatric chronic headache--a pilot study. *Pain medicine (Malden, Mass.)*, 14(5), 621–627. <https://doi.org/10.1111/pme.12083>
11. Dhouib, A. (2023). The Potential of using Virtual Reality for People with Disabilities. *Nafath*, 8(22).



# THE HEARTBEAT OF OUR HERITAGE



[nmoq.org.qa](http://nmoq.org.qa)

Follow us to be updated with NMoQ on

