



Robotic Library Services in the Context of Persons with Disabilities

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Received: 25 December 2023; Accepted: 15 March 2024

The study explores the use of robotic technologies in improving library accessibility for differently-abled individuals, focusing on visual, hearing, physical, and cognitive disabilities. It emphasizes the importance of inclusive environments and libraries' role in promoting inclusivity. Robots can assist in language translation, provide real-time updates, and organize library collections, fostering collaboration and communication among learners. They can also provide accessibility features like text-to-speech capabilities or tactile interfaces. Libraries can collaborate with disability advocacy organizations and train staff on disability awareness and inclusive practices to enhance library accessibility and inclusivity. The collaboration can lead to the implementation of assistive technologies and innovative solutions that cater to the specific needs of individuals with disabilities. This service can give immense pleasure to a person with disabilities and provide accessibility, inclusivity for physically handicapped individuals, and full participation.

Keywords: Robotic Library Services, Persons with disabilities, Accessibility, Robotic Circulation, Book Retrieval.

I. Introduction

Robotics is a multidisciplinary field that focuses on designing, building, operating, and utilizing robots. Robots are predicted to become the dominant technology in the world by 2030, with all humans relying on them for routine work. The use of robots in the industry is projected to increase by 175% within the next decade (Raghvaiah 2023). With advancements in technology, robots have become more autonomous and versatile, performing complex tasks like surgery and customer service. Libraries that embrace robotics technology can revolutionize knowledge access, engagement, and learning by incorporating humanoid robots into their operations. However, safety concerns must be addressed, as direct interaction between robots and humans can pose risks. Libraries can implement safety protocols such as limiting robot movements, providing clear instructions for human interaction, and ensuring regular maintenance and monitoring of their mechanical and electrical systems². Staff training on robot safety and emergency procedures can also help ensure a safe and positive experience for patrons and staff.

The DAISY Consortium, an international organization, focuses on creating accessible digital content for individuals with reading disabilities³. They have developed the DAISY/NISO Standard, a digital

talking book specification that supports various forms of accessible content, including traditional presentation of images and text, audio, content navigation, and animation. The International Federation of Library Associations and Institutions (IFLA) has developed guidelines to address the issue of 'special needs' for disabled individuals, advocating for inclusive library services that cater to the diverse needs of all individuals⁴.

However, safety concerns may arise when robots interact directly with library patrons and staff. The University of Oklahoma Libraries is experimenting with Alexa, Amazon's virtual assistant, and readers' advisory robots. The DAISY Consortium created the DAISY/NISO Standard to produce accessible digital content for people with reading disabilities like dyslexia, blindness, low vision, and other print impairments⁵. The IFLA guidelines address the issue of 'special needs', which some disabled people's groups argue are neither special nor unique⁶. They aim to help libraries make the first steps in welcoming and accommodating individuals with disabilities and provide a comprehensive approach to library services.

Disability

Disability affects 16% of the global population, with 1.3 billion people experiencing significant disabilities today. Factors such as sex, age, gender

identity, sexual orientation, religion, race, ethnicity, and economic status influence these individuals, leading to premature death, poorer health, and limitations in daily functioning. Health inequities, such as discrimination, poverty, exclusion from employment and education, and healthcare system obstacles, contribute to these disparities. In India, The Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) 2016 Act⁷, protects the rights and promotes full participation of individuals with disabilities. With an estimated 2.68 crore people with disabilities, 2.21% of the population, inclusive policies and initiatives are needed to ensure their equal opportunities and well-being. The government is enhancing accessibility through ramps, Braille signage, digital content accessibility, assistive technologies, and social welfare programs. However, social stigma and limited accessibility hinder full participation.

Importance of accessibility for physically handicapped individuals

Accessibility is a fundamental human right that eliminates physical and structural barriers that hinder mobility, communication, and life access. Assistive technologies have significantly improved the lives of individuals with disabilities, enhancing communication, information access, and employment opportunities⁸. These technologies include social inclusion, assistive learning, smart home technologies, augmentative and alternative communication, screen readers, braille displays, and accessible document formats. The ongoing advancement of technology holds great promise for enhancing autonomy and inclusivity, contributing to a more egalitarian and accessible global community. Universal design principles ensure inclusivity and community engagement, positively impacting mental health and promoting a sense of belonging. Universal design (UD) should be fair, adaptable, straightforward, intuitive, and error-tolerant, accommodating individuals of diverse mobility aids and body sizes⁹. However, challenges include affordability, accessibility, inclusive technology policies, and emerging trends in assistive technologies.

Libraries often lack adequate physical accessibility features, such as ramps and elevators, and limited availability of assistive technologies like screen readers and voice recognition software. Additionally, the lack of accessible formats, such as braille books or audio books, can be a barrier for individuals with

print disabilities. Staff members may also lack the necessary training to effectively communicate and support individuals with disabilities, further hindering their access to library resources. India has made significant strides in improving the lives of persons with disabilities (PWDs) through policies and acts, including increased access to health, education, employment opportunities, and rehabilitation measures, including AT services. Case studies of inclusive accessibility include the Malmo City Library in Sweden, the National Library Service for the Blind and Print Disabled, and the Inclusive Library Project in Worcester, UK. These libraries demonstrate successful accessibility practices, inspiring others to adopt similar practices and promoting inclusivity in knowledge and learning. In conclusion, accessibility is a fundamental human right that empowers individuals with disabilities, promoting social inclusion and economic independence¹⁰. Advances in assistive technologies, universal design principles, and innovative library practices are essential for creating accessible environments that benefit all individuals.

Robotics in libraries can greatly enhance accessibility and inclusivity for physically handicapped individuals.

Robotics has the potential to revolutionize library accessibility and inclusivity for physically handicapped individuals. These assistants can offer personalized library services, directing individuals through the library layout and locating materials. They can also autonomously retrieve and deliver resources, reducing physical effort. Bobbie, a robot in the library, delivers materials, welcomes guests, and directs them to various locations while answering frequently asked questions, including newspapers, magazines, and brochures. They can provide accessible information in various formats and interact with adaptive technologies like screen readers and voice recognition software. Library technology is revolutionizing the way we interact with library resources by using book-retrieving machines. These robots use technologies like LiDAR, odometry, cameras, computer vision, and GPS systems to navigate the library setting, perform tasks like obstacle avoidance, and identify books¹¹. Once a book is retrieved, the robots use automated elevators or platforms to access every corner of the library. They can also provide personalized suggestions, auditory explanations, and up-to-date library data.

However, challenges such as cost, implementation, user acceptance, ethical considerations, and accessibility beyond physical limitations must be addressed. By addressing these challenges, libraries can transition into inclusive environments where knowledge transcends physical limitations. Further research should focus on examining existing cases, creating prototypes, promoting policies and funding initiatives for assistive technologies, and exploring the integration of robots with artificial intelligence and machine learning¹². Case studies show that robotics in libraries can significantly improve inclusivity and accessibility. Examples include BookBots at Utsunomiya City Library in Japan, the Inclusive Library Project at The Hive in Worcester, UK, and StoryBots at Malmo City Library in Sweden. The Temasek Polytechnic Library in Singapore has developed a robot called 'Robbie' capable of scanning over 32,000 books per day.¹³ Autonomous shelf-scanning machines ensure accurate book availability, reducing waiting times and aggravating patrons, including those with disabilities.

II. Benefits of Robotics in Libraries for Physically Handicapped Individuals

Assistive Services

Assistive technologies, such as Kurzweil 3000, Open Book, JAWS, NVDA, Voiceover, OCR, auditory devices, amplifiers, hearing aids, TDD, VRS, and more, can improve the performance of differently-abled individuals, leading to increased employment rates and retention¹⁴. These technologies are valuable resources, and their effective use requires technological aid. Library assistive services, such as robotics, adjustable desks, accessible computer stations, and specialized software, promote inclusivity and equal opportunities for physically handicapped individuals¹⁵. Libraries offer specialized resources like print books, braille materials, and audio books, and librarians receive training to effectively communicate and support these patrons.

Robotic assistance for navigation and mobility within the library

Libraries can enhance accessibility and independence for people with physical disabilities by implementing robotic assistance systems such as autonomous wheelchair navigation, smart carts, mobile robotic guides, interactive kiosks, and augmented reality navigation¹⁶. To ensure effectiveness, libraries should establish charging

stations, implement user-friendly interfaces, and maintain the technology through staff training, patron education, and regular evaluation. These systems empower mobility, provide personalized guidance, and offer real-time interaction. Interactive kiosks offer accessible information points with multilingual and multimodal features, while augmented reality navigation enhances navigation experiences and can integrate with personal devices¹⁷. These systems promote independence and reduce physical barriers, fostering a more inclusive environment.

To overcome challenges in implementing robotic assistance systems, libraries should focus on technological, user-related, privacy, infrastructure, and community engagement aspects. Strategies for overcoming these challenges include comprehensive training programs, user education initiatives, gradual integration, regular maintenance protocols, collaboration with tech experts, accessibility testing, user-friendly interfaces, privacy and ethical concerns, infrastructure and space considerations, open dialogue with stakeholders, flexible implementation plans, and scalability considerations. Case studies show that Mobile Assistance Robots (MARs) are revolutionizing library accessibility and mobility, providing guidance, directions, and information about collections and services, promoting independence and reducing dependence on human intervention¹⁸.

Robotic retrieval of books and materials

Robotic retrieval systems in libraries can enhance accessibility for people with disabilities by automating inventory management, enabling adaptive path planning, and assessing book condition. These systems optimize space utilization, freeing up staff time for personalized assistance and service expansion. They integrate with library management systems for efficient tracking and retrieval, providing an intuitive interface for users. They can also assist in accessibility audits, identifying barriers and providing feedback for improvements, creating more inclusive environments. A robot at PERSIST central library in Singapore assists in filing, sorting, and replacing books on the bookshelf. Adaptive path planning and book condition assessment ensure high-quality reading experiences for all. Effective inventory management is crucial in library settings, impacting resource availability, financial accountability, operational efficiency, error reduction, and user satisfaction. Integrating barcode and RFID technology with library management systems can monitor

inventories, prevent lost materials, enable data-driven decision-making, and facilitate collaborative resource sharing¹⁹. Automated due date reminders and security measures are also beneficial. Libraries should prioritize resilient inventory management systems to maintain dynamic, accessible, and community-oriented collections, ensuring their continued relevance and vitality to their communities.

Book preservation is crucial for a readable and uninterrupted reading experience. It involves assessing cover integrity, page quality, text legibility, aromas, and completeness. Proactive measures include user education, routine inspections, storage, protective measures, repair, and restoration. Prioritizing book condition enhances user satisfaction, safeguards cultural heritage, and demonstrates conscientious stewardship²⁰. Libraries can present stories in their best possible condition, promoting recurrent visits and enhancing user contentment. Libraries should explore programs, cost-benefit ratios, policies, funding initiatives, and emerging technologies like automated book scanning and digital preservation. By prioritizing these technologies, libraries can create an all-encompassing and user-friendly environment, ensuring their continued relevance and vitality to their communities.

Robotic assistance in carrying and returning books

Robotics can significantly improve library accessibility and inclusivity for physically handicapped individuals. Autonomous book-retrieving robots assist mobility-challenged individuals by autonomously retrieving books, while interactive robot assistance helps navigate the library. Book delivery robots bring requested materials directly to patrons, reducing movement²¹. Assistive technologies like voice recognition or screen readers can enhance accessibility for visual or auditory impairments. Integrating robotic elements into library design can create spaces more accessible to individuals with disabilities²². Customized accessibility solutions ensure equal access to information, educational resources, and library services. Autonomous book-retrieving robots offer independent access, reduced physical exertion, expanded resource reach, and enhanced user experience. They can navigate even the narrowest aisles and retrieve books from the highest shelves, making the entire collection accessible. Singapore's robot librarian, AuRoSS, uses RFID to locate misplaced books on shelves, ensuring accurate

inventory management²³. The personalized library experience can boost self-esteem, confidence, and a sense of belonging, contributing to greater social inclusion and participation. The psychological benefits of these robots are significant, enhancing the library experience for all.

Interactive robot assistants transform libraries into accessible knowledge hubs for individuals with mobility challenges. They offer personalized navigation, alternative routes, text-to-speech capabilities, audio descriptions, and integration with assistive devices, making library visits more enjoyable and accessible. Book delivery robots reduce movement, enhance independence, and reduce fatigue, making the entire library collection accessible. Advanced models offer personalized recommendations, audio descriptions, and real-time information, ensuring an inclusive environment for patrons with diverse needs. Robotic assistance in libraries is revolutionizing book returns and transportation, making work simpler and more productive²⁴. Case studies include Automated Book Return Systems, BookBots, Autonomous Book Return Robots, and Library Express. These machines not only retrieve books but also transport them to pick-up locations, reducing physical exertion for users with restricted mobility.

Robotic tutors and educational tools for personalized learning

Robotic tutors and educational tools are revolutionizing personalized learning for physically handicapped individuals by providing tailored support and accessible experiences. These tools include adaptive learning programs, assistive technologies, remote learning support, data analytics, interactive modules, and more. They promote inclusivity, facilitate personalized learning plans, and enable learners with disabilities or learning difficulties to thrive. Personalized learning tools significantly improve academic performance, engagement, independence, and reduce anxiety²⁵. However, challenges include technology access and training, data privacy and security, teacher buy-in, and cost and resource allocation. Researchers should research successful case studies, advocate for policies and funding initiatives that support equitable access to technology and personalized learning resources, develop training programs for educators, and explore emerging technologies like artificial intelligence and adaptive learning²⁶.

Physical limitations have long hindered educational opportunities for individuals with disabilities. However, adaptive learning programs and assistive technologies are revolutionizing access and participation by tailoring content to individual learning styles and paces²⁷. Accessible learning materials in digital formats eliminate barriers to information, and real-time feedback and progress tracking allow educators to personalize support. These technologies also enhance the learning experience by promoting increased engagement, greater independence, reduced anxiety, and collaboration²⁸. To overcome learning independence, various strategies and resources can be employed, such as using adaptive learning platforms, assistive technologies, and digital learning resources. Time management tools, goal setting, independent research and critical thinking skills, collaborative learning and support networks, online communities and tutoring services, environmental accessibility, and celebrating successes can help build confidence and positive attitudes. Further exploration of successful programs, policies, and resources can help break down barriers and create a future where all individuals, regardless of physical limitations, can become lifelong learners and thrive in their educational journeys.

Interactive robotics to engage physically handicapped individuals in library programs and workshops

Interactive robotics can revolutionize library programs and workshops for physically handicapped individuals by providing an inclusive and interactive learning experience²⁹. These technologies can be used in storytelling sessions, coding workshops, makerspaces, virtual reality, and AR, facilitating collaborative learning, teamwork, social interaction, and a sense of belonging. Libraries can become hubs of learning, empowering individuals to overcome physical limitations and actively participate in knowledge³⁰. Virtual reality and augmented reality robotics can also revolutionize industries like architecture and design, and medical training. Assistive services in libraries aim to create an inclusive environment for physically handicapped individuals, ensuring equal access to information, resources, and community engagement. Collaboration with disability organizations, user feedback mechanisms, and assistance with library materials are crucial for a successful inclusive library service³¹.

Technology is revolutionizing architecture and design by enabling the fabrication of intricate structures with remarkable accuracy. Computer-aided design (CAD) and 3D printing enable architects to create physical prototypes, intricate components, and entire structures layer by layer³². However, ethical considerations, skill gaps, human-centric design, and cost and accessibility present obstacles. Comprehensive training programs and upskilling initiatives are needed to bridge the gap between technology-driven design and conventional architectural skills. Case studies from The Hive in Worcester, UK³³, and Malmo City Library³⁴ in Sweden demonstrate the potential of interactive robotics in facilitating narrative sessions, fostering artistic expression among children with disabilities, and delivering virtual reality experiences. In Japan, Tokyo Metropolitan Tama Library offers coding and robotics seminars to encourage innovation and digital competencies.

C. Increased Independence and Autonomy

Robotic assistive technologies (RAT) have revolutionized the lives of individuals with disabilities by providing innovative solutions for daily activities, cognitive rehabilitation, and sensory impairments³⁵. Advancements in artificial intelligence and machine learning enable smart RAT systems to adapt to changing conditions, promoting independence and inclusivity. RAT systems also improve communication and social interaction through speech recognition and natural language processing, reducing barriers and promoting inclusivity.

Robotic devices for self-checkout and circulation activities

Robotic devices are revolutionizing library self-checkout and circulation by automating repetitive tasks, providing personalized assistance, and expanding access to services¹⁹. These devices can retrieve books, manage inventory, assist patrons with navigation, patrol the library, identify misplaced books, provide real-time information, perform book cleaning and maintenance, analyze user preferences, and offer personalized recommendations. Customized robotic solutions cater to diverse abilities, offering assistance in areas like navigation, reading, therapy, rehabilitation, and workplace solutions³⁶. Real-time intelligence is revolutionizing the lives of individuals with disabilities by enabling robotics to adapt and

respond in real-time to their needs. This dynamic interaction between real-time data and personalized autonomous solutions enhances autonomy, security, and quality of life. Robots can analyze their environment, identify obstacles, and adjust their movements accordingly³⁷. They can also offer customized learning, skill development, emotional and social interaction, and cognitive support. However, ethical considerations such as data security and privacy are crucial. Challenges include cost, accessibility, user acceptance, privacy concerns, regulatory frameworks, and ethical guidelines.

Maintaining and cleansing books is crucial for user-centric assistive reading robots. Regular cleaning removes dust and debris, protects sensors, and prevents pages from becoming fragile or warped. Accessibility considerations include cleaning braille surfaces, audio port connections, and headphone functionality. A user-centered approach involves user participation, automated cleaning systems, and caregiver training, creating an inclusive reading environment for individuals of all abilities. Robotics can anticipate and adapt to user preferences, enabling them to anticipate and predict requirements, customize task assistance, and streamline processes. However, ethical considerations such as data privacy, security, transparency, bias, and human agency must be considered. Responsible analysis of robots is crucial to foster genuine collaborations between humans and machines. Customized robotics is expected to revolutionize capabilities, empower individuals, and create a more inclusive global environment. Case studies show that robotic devices like BookBots at the University of Toronto Libraries, RFID technology, self-service checkout kiosks³⁸, automated book sorters at Central Michigan University Library, and Project MARCH³⁹ are revolutionizing library operations by eliminating the need for manual classification and data entry, increasing throughput and efficiency, and improving staff productivity and workflow.

II. Implementation Challenges

Robotics can improve independence and quality of life for physically handicapped individuals, but it also presents challenges such as accessibility, affordability, user acceptance, infrastructure support, ethical considerations, and standardization. Effective use requires collaborations, user-centric design, interoperability, safety features, maintenance protocols, strong encryption measures, and data

security⁴⁰. Financial feasibility involves initial costs, operational expenses, and potential ROI. Libraries may need to adapt spaces, create accessible pathways, and install charging stations. Strategies for financial feasibility include phasing implementation, exploring grant funding, conducting cost-benefit analyses, and investing in staff development programs.

Collaboration is essential for libraries to link users with information and resources, promoting user-centric design and interoperable materials⁴¹. Interoperability is achieved through standardized metadata, shared technology platforms, and digitization initiatives. Libraries can evolve into dynamic centers of information, empowering patrons, safeguarding cultural heritage, and ensuring fair access to global knowledge. Further research should focus on research, policy advocacy, resource development, and emerging technologies like blockchain and semantic web. Library safety is crucial for educational pursuits and community involvement. Adequate safety equipment, secure access control systems, and comprehensive emergency response plans are essential⁴². Staff training and exercises, CCTV, security personnel, mental health awareness, and technology can improve security. Balancing security, openness, privacy concerns, and resource constraints can be challenging. Libraries should prioritize maintenance programs, allocate resources for staff training and skill development, and strategically plan maintenance activities.

Discussion

Robotic library services can enhance accessibility for individuals with disabilities, but they face challenges such as cost, technical limitations, and compatibility issues. Ethical considerations are crucial, as robots may collect and store personal information. Future advancements in robotic library services include virtual reality and haptic feedback technologies. Utsunomiya City Library in Japan has implemented BookBots for book transportation and patron assistance⁴³, reducing book retrieval time and empowering independent access to the library's vast collection. The Meiji University Library in Tokyo has also implemented an autonomous shelf-scanning robot⁴⁴. Robotic library services can also promote reading and learning for children with disabilities through Virtual Reality Zones and interactive storytelling tools. The Library of Alexandria uses BookBots technology, Pepper Robots serve as friendly assistants, and the BookBike Delivery Service delivers books directly to patrons' homes⁴⁵. Robots offer a

promising direction for future library automation in India, as they can work alongside librarians quickly and perform human activities. While robots have artificial intelligence, they cannot be as intelligent as humans due to their human touch. The adoption of robots in Indian libraries is less widespread than in the western world, but the need for automation is imminent due to India's vast population¹.

Conclusion

Libraries are integrating robotics to enhance accessibility for people with disabilities. These devices automate tasks, free up staff for complex inquiries, and aid in book retrieval. However, raising awareness and changing societal attitudes is crucial. Libraries should consider staff roles, training, financial sustainability, and patron involvement in decision-making. Community outreach programs can dispel misconceptions and promote inclusivity. Active patron involvement ensures services align with user needs. Libraries should integrate universal design principles into their physical spaces and digital platforms, incorporating features like wheelchair accessibility and assistive technologies. By involving patrons with disabilities in decision-making, libraries can create an inclusive environment. The government has implemented initiatives like the Accessible India Campaign and the Rights of Persons with Disabilities Act, but more work is needed to change societal attitudes, improve accessibility infrastructure, and implement comprehensive policies.

Acknowledgments

I thank Smt. S Malathy (LDOD) and Smt. Kantha P(LDS) of UR Rao Satellite Center, Bengaluru for great support and encouragement to preparing this Manuscript

References

- 1 Raghvaiah P and Sreekanth K, Adopting Robots in Academic Libraries in India: A Feasibility Study, In proceeding in the paper presented on Conference: ILIPS 2022 -Resilience, Reflection, and Innovation in Library Services and Practices, City Delhi. January 2023, p 1-9.
- 2 Villani V Pini F Leali, F and Secchi C, Survey on human-robot collaboration in industrial settings: Safety, intuitive interfaces and applications, *Mechatronics*, 55 (2018) 248-266.
- 3 Hitchcock C, *Digital Content for Individuals with Print Disabilities*, 2 Edition (Universal Design Handbook; United States) 2010, 6-21.
- 4 Deines Jones C, *Improving library services to people with disabilities*, 1st edition (Chandos Publishing; United States) 2007 1-255.
- 5 Nomura M, *Revised Guidelines for Accessible Libraries and Services for Everyone: A Brief Overview of Tips for Ensuring Access to Information for Persons with Disabilities* (IFLA: Rotterdam) 2023 1-6.
- 6 Ayoung D A Baada F N A and Baayel, P, Access to library services and facilities by persons with disability: Insights from academic libraries in Ghana, *Journal of Librarianship and Information Science*, 53(1) (2021) 167-180.
- 7 Disability Acts | Office of Chief Commissioner for Persons with Disabilities. (n.d.). Available at <http://www.ccdisabilities.nic.in/actsguideline/disability-acts> (Accessed on 10 Nov 2023)
- 8 Lancioni, G.E. & Singh, N.N. *Assistive technologies for people with diverse Abilities*, (Springer; New York) 2014 p 1-326.
- 9 Dekker S, *Safety differently: Human factors for a new era*. (CRC Press; Boca Raton) 2014 p 1-312.
- 10 Longworth N, *Learning cities, learning regions, learning communities: Lifelong learning and local government*. 1st edition (Routledge: London) 2006 p 1-248.
- 11 Yu X Fan Z Wan H He Y Du J Li N.and Xiao, Global Positioning, navigation, and book accessing/returning in an autonomous library robot using integrated binocular vision and QR code identification systems, *Sensors*, 19(4) (2019) 783.
- 12 Cortellessa, G., De Benedictis, R., Fracasso, F., Orlandini, A., Umbrico, A., and Cesta, A. AI and robotics to help older adults: Revisiting projects in search of lessons learned Paladyn, *Journal of Behavioral Robotics*, 12(1) (2021) 356-378.
- 13 Library, Temasek Polytechnic. (n.d.). Temasek Polytechnic. Available at <https://www.tp.edu.sg/life-at-tp/tp-students-digital-access-it-matters/library.html>. (Accessed on 10 Nov 2023)
- 14 Kumari N and Lenka, U, Employment and Retention of Differently-abled People in the Workplace Through Assistive Technologies, *International Journal of Digital Technologies*, 2(1) (2023).
- 15 Cook A M and Polgar J M, *Assistive technologies-e-book: principles and practice*. Fourth edition (Elsevier Health Sciences; London) 2016 p 1-248.
- 16 Prandi C Barricelli B R Mirri S and Fogli D, Accessible wayfinding and navigation: a systematic mapping study. *Universal Access in the Information Society*, 22(1) (2021) 1-28.
- 17 Khan A and Khusro S, An insight into smartphone-based assistive solutions for visually impaired and blind people: issues, challenges and opportunities, *Universal Access in the Information Society*, 19(3) (2021) 1-25.
- 18 Mann W C, *Smart technology for aging, disability, and independence*. (The State of the Science; Canada) 2005 p 1-30.
- 19 King, D. L. *Transforming the Library*, *Foundations of Library and Information Science*, (ALA Neal-Schuman; United states) (2020) 1-648.
- 20 Merrill A T, *The strategic stewardship of cultural resources: to preserve and protect*, (Haworth Information press; United States) 2003 p 1-258.
- 21 Tella A, Robots are coming to the libraries: are librarians ready to accommodate them?, *Library Hi Tech News*, 37(8) (2020) 13-17.

- 22 Kouroupetroglou C, Enhancing the Human Experience through Assistive Technologies and E-Accessibility, (IGI Global; United States) 2014 p 1-345.
- 23 Li R Huang Z Kurniawan E and Ho C K, AuRoSS: an autonomous robotic shelf scanning system. In the proceedings paper presented in IEEE/RSJ International Conference on Intelligent Robots and Systems, city in Germany, 28 September - 02 October 2015 6100-6105.
- 24 Joiner I A, Emerging library technologies: it's not just for geeks, (Chandos Publishing; United States) 2018 p 1-206.
- 25 Kroog K J, The Effects of Virtual Professional Learning on Teacher Self-Efficacy and Student Achievement, Ph.D doctoral dissertation, Fordham University, 2022.
- 26 Thomas S, Future Ready Learning: Reimagining the Role of Technology in Education. 2016 National Education Technology Plan. Office of Educational Technology, US Department of Education, available at <https://eric.ed.gov/?id=ED571884> (accessed on November 2023).
- 27 Kamruzzaman M M Alanazi S Alruwaili M Alshammari N Elaiwat S Abu-Zanona M and Ahmed Alanaz B. AI and IoT-Assisted Sustainable Education Systems during Pandemics, such as COVID-19, for Smart Cities, Sustainability, 15(10) (2023) 8354.
- 28 Sofronoff K Attwood T and Hinton S A, Randomised controlled trial of a CBT intervention for anxiety in children with Asperger syndrome, Journal of child psychology and psychiatry, 46(11) (2005) 1152-1160.
- 29 Mosenia A and Jha N K A, comprehensive study of security of internet-of-things. IEEE Transactions on emerging topics in computing, 5(4) (2016) 586-602.
- 30 Mersand S Gasco Hernandez M Udoh, E & Gil Garcia J RPublic libraries as anchor institutions in smart communities: Current practices and future development, in the Proceedings of the 52nd Hawaii International Conference on System Sciences, city Hawaii January 8 - 11, 2019 3305-3314.
- 31 Potnis D and Mallary K, Proposing an information value chain to improve information services to disabled library patrons using assistive technologies, Journal of Information Science, 48(6) (2022) 825-837.
- 32 Bayar M S and Aziz Z, Rapid prototyping and its role in supporting architectural design process, Journal of Architectural Engineering, 24(3) (2018) 05018003 - 105018003-8.
- 33 Simondetti A, Rapid prototyping in early stages of architectural design Ph.D doctoral dissertation, Massachusetts Institute of Technology 1997 p 1-59 .
- 34 Ylipulli J Pouke M Ehrenberg N and Keinonen T, Public libraries as a partner in digital innovation project: Designing a virtual reality experience to support digital literacy, Future Generation Computer Systems, 149 (2023) 594-605.
- 35 Shahrestani S, Internet of things and smart environments: Assistive technologies for disability, dementia, and aging. (Springer; India) 2017 p 1-135.
- 36 Rappou S E Tsardoulis E G Kintsakis A M Symeonidis A L Mitkas P A Psomopoulos, F E and Gkiokas A, Rapp: a robotic-oriented ecosystem for delivering smart user empowering applications for older people, International Journal of Social Robotics, 8 (2016) 539-552.
- 37 Rubio F Valero F and Llopis-Albert C, A review of mobile robots: Concepts, methods, theoretical framework, and applications, International Journal of Advanced Robotic Systems, 16(2) (2019) 1729881419839596.
- 38 Copy, print, scan | University of Toronto Libraries. (n.d.) Available at <https://onsearch.library.utoronto.ca/copy-print-scan> (Accessed on 10 Nov, 2023)
- 39 March G H, Surveying campus GIS and GPS users to determine role and level of library services, Journal of Map & Geography Libraries, 7(2) (2011) 154-183.
- 40 Quach S Thaichon P Martin K D Weaven S and Palmatier R W, Digital technologies: tensions in privacy and data, Journal of the Academy of Marketing Science, 50(6) (2022) 1299-1323.
- 41 Sudarshan R S, User centric design of library systems and services in the changing IT era: An overview, International Journal of Advanced Library and Information Science, 3 (2015) 182-191.
- 42 Russell D & Gangemi G T, Computer security basics. 2nd edition (" O'Reilly Media; United states) 2006 p 1-448.
- 43 Utsunomiya Campus Library Facility. (n.d.). Teikyo University. Available at https://www.teikyo-u.ac.jp/en/campus/utsunomiya_campus/library ((Accessed on 10 Nov, 2023).
- 44 Wright J, Robots Won't Save Japan: An Ethnography of Eldercare Automation. (Cornell University Press; New York) 2023 p 1-182.
- 45 Pepper Brings a Breath of Fresh Air to Libraries | Aldebaran. (n.d.). available at <https://www.aldebaran.com/en/blog/news-trends/pepper-brings-breath-fresh-air-libraries#:~:text=Pepper%20arouses%20general%20interest%2C%20even,other%20%22analog%22%20media%20again> (Accessed on 10 Nov, 2023).