MAKING VOICES HEARD

VOICE INTERFACES AND ACCESSIBILITY

Literature Surveys

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Literature Surveys: Voice Interfaces and Accessibility

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1. Background

The World Wide Web Consortium's (W3C) Web Accessibility Initiative provided a set of guidelines in 2008 and 2018 to make the internet more accessible. It also laid down the essential components of web accessibility, one of which is assistive technologies. This includes screen readers, alternative keyboards, switches, and scanning software.[1] Before the advent of consumer voice technologies, the most popular speech-based accessibility technologies were screen readers, which provide audio output for people with visual impairments, and speech dictation software, which provide a text-entry alternative to the keyboard.

The development of voice-enabled products provides the individual with the opportunity to apply speech inputs to more than just text dictation and screen reader software.[2] There has been very little research on how these applications can help people with various accessibility needs. The paucity of research could be due to the lack of funding or lack of interest from companies. Most accessibility studies focus on older adults and features such as emergency services, health monitoring, and light or temperature control. However, there has been little attention paid to how these technologies can be useful to persons with accessibility needs to perform different tasks. Despite the paucity of research, user reports show that voice-enabled devices and smart home appliances are being used by persons with disabilities (PwDs) to navigate their day-to-day activities based on speech inputs. This article explores how effective these technologies are as accessibility devices. For example, an interviewee in this study pointed out that these interfaces can be used to perform simple tasks (like relaying news or the weather) or to access entertainment (turning on YouTube or a music app), but were not effective in productivity apps (such as email dictation).

From an accessibility perspective, the adoption of voice interfaces (VIs) varies depending on the type of disability. Scholars opine that VIs were picked up as assistive technologies by persons who are visually impaired.[3] However, a significant challenge in the adoption of VIs as assistive technologies is its inability to assist deaf and hard of hearing (DHH) individuals.[4] In addition to the DHH community, older people who have debilitating conditions such as dementia,[5] and people who have speech disabilities,[6] find VIs difficult to use.

1 Initiative, W. W. A., "Essential Components of Web Accessibility," Web Accessibility Initiative (WAI), accessed 3 November 2021, 2018, **https://www.w3.org/WAI/fundamentals/components/**

2 Initiative, "Essential Components of Web Accessibility."

3 Brewer, R., et al., "Accessible Voice Interfaces," *CSCW 18 Companion*, 2018, 441-446, accessed on 2 November 2021, **https://doi.org/10.1145/3272973.3273006**.

4 Rodolitz, J., et al. "Accessibility of Voice-Activated Agents for People Who are Deaf or Hard of Hearing," *Journal on Technology and Persons with Disabilities*, no. (2019): 144-156 .

5 Wolters, M., et al., "Designing a spoken dialogue interface to an intelligent cognitive assistant for people with dementia," *Health Informatics Journal 22*, no. 4 1-13 (2015): DOI: 10.1177/1460458215593329

6 Brewer et al, "Accessible Voice Interfaces."

Despite these perceived limitations, Pradhan, A., et al. (2018)[7] conducted a qualitative study to ascertain the accessibility of VIs among PwDs[8] with visual, locomotor, and cognitive impairments. The researchers examined 346 customer reviews of off-the-shelf digital assistants, such as Amazon Echo, Echo Dot, and Tap, and found that 85.6% of them were positive. The study highlighted that the people were using the Amazon Echo not just for the known uses but also for unexpected purposes such as speech therapy and support for caregivers. However it also emphasised that the people faced some difficulty in discovering new features, as well as wished for a better voice-only application.

The next section seeks to provide a holistic overview of the opportunities and challenges that individuals with disabilities face while using VIs.

2. Accessibility benefits and concerns

VIs can be beneficial to individuals who face difficulty in using text-only interfaces. Although there are multiple benefits of using VIs for performing simple to complex tasks, there is a need to look at creating devices that are universally accessible. This section will look at the benefits and concerns that come with deploying VIs as an accessibility feature for PwDs.

2.1. Individuals with vision impairment or low vision

VIs have made it easier for visually impaired people to perform simple, commonplace tasks to a certain extent. An empirical study of 16 participants with vision impairments revealed that there were different types of tasks that digital voice assistants could complete.[9] According to the sample, they used digital voice assistants to play music, check the weather, set a timer, and listen to the news. On the other hand, playing games, shopping online, calling contacts, playing the radio, and reading books were less common.[10] Emerging trends in smart devices and smart home appliances, such as Ambient Assisted Living (AAL),[11] offer new opportunities for people to access services through voice. According to Rashidi and Mihailidis, "AAL technologies provide help with daily activities, based on monitoring activities of daily living (ADL) and issuing reminders, as well as helping with mobility and automation"[12] Offshoots of AAL that utilise VIs include smart home technologies, mobile wearables or sensors, and assistive robotics, among

7 Pradhan, A., et al., "'Accessibility Came by Accident': Use of Voice-Controlled Intelligent Personal Assistants by People with Disabilities," *CHI*, 2018, https://doi.org/10.1145/3173574.3174033

8 Pradhan, A., et al., "'Accessibility Came by Accident': Use of Voice-Controlled Intelligent Personal Assistants by People with Disabilities," *CHI*, 2018, https://doi.org/10.1145/3173574.3174033

9 Pradhan et al., "'Accessibility Came by Accident'."

10 Pradhan, et al., "'Accessibility Came by Accident'."

11 Research suggests that use of information and communication technologies (ICTs) in the daily living and working environment may enable older adults to stay active longer, remain better socially connected, and live more independently into old age. For more on AAL see: Grazia Cicirelli et al., "Ambient Assisted Living: A Review of Technologies, Methodologies and Future Perspectives for Healthy Aging of Population," *Sensors* 21, no. 10 (2021): p. 3549, https://doi.org/10.3390/s21103549.

12 Rashidi, P. and Mihailidis, A., "A Survey on Ambient-Assisted Living Tools for Older Adults," *IEEE Journal of Biomedical and Health Informatics*, 17, no. 3 (2013) 579-590.

others.[13] In an empirical study, Vacher, et al. (2013) shed light on the usability of AAL for the visually impaired, the elderly, and people with no special needs.[14] They found that visually impaired participants favoured the adoption of smart home technologies, although they wished that they would render support for more complex tasks such as sending messages, emails or contacting emergency services.[15]

2.2. Individuals with locomotor disability

Smart home appliances with VIs have the potential to be of assistance to individuals with locomotor or sensory-motor disabilities. Presently, individuals can control electronic devices and the locks of their homes through voice commands.[16] Another possible advantage of VIs is that they can be potentially used to control wheelchairs.[17] In addition, VIs such as the 'listening keyboard' enable locomotor-disabled individuals to provide voice inputs, rather than traditional text inputs, to their smartphones and desktops.[18] Research proves that a listening keyboard offers better functionality than a graphical user interface; the former has a 63% better error rate and a typing rate that is 74% better.[19] If developed along the same lines as the 'listening keyboard', voice commands can also help people with limited mobility control their desktop cursors.[20]

2.3. Individuals who are deaf and hard of hearing

Although VIs are beneficial for visually impaired and motor-impaired people , the primary accessibility challenge is for DHH individuals. According to Fok, et al., "as automatic speech recognition (ASR) systems are largely trained using speech from hearing individuals, speech-controlled technologies are typically inaccessible to deaf users".[21] However, the outputs of some digital assistants for DHH individuals are also displayed as captions instead of voice. However, the subsequent problem with captions is that they become impossible for DHH individuals who are not literate to interact with them.[22]

13 Rashidi and Mihailidis, "A Survey on Ambient-Assisted Living Tools."

14 Vacher, et al., "Experimental Evaluation of Speech Recognition Technologies for Voice-based Home Automation Control in a Smart Home," Conference: Fourth Workshop on Speech and Language Processing for Assistive Technologies SLPAT 2013, 4th Workshop on Speech and Language Processing for Assistive Technologies, Grenoble, France, (2013).

15 Vacher et al., "Experimental Evaluation."

16 Pradhan et al., "'Accessibility Came by Accident'."

17 Pacnik, G. et al., "Voice Operated Intelligent Wheelchair – VOIC", in Proceedings of the *IEEE International Symposium on Industrial Electronics* 3, (2005): 1221-1226, **https://ieeexplore.ieee.org/document/1529099**.

18 Manaris, B., et al., "A Listening Keyboard for Users with Motor Impairments – A Usability Study," *International Journal of Speech Technology* 5 (Kluwer Academic Publishers, 2002); 371–388.

19 Manaris et al.,"A Listening Keyboard."

20 Dai, L., et al., "Speech-Based Cursor Control: a Study of Grid-Based Solutions," ASSETS 2004 – The Sixth International ACM SIGACCESS Conference on Computers and Accessibility.

21 Fok, R., et al., "Towards More Robust Speech Interactions for Deaf and Hard of Hearing Users," ASSETS 2018, DOI: **http://dx.doi.org/10.1145/3234695.3236343**

22 Rodolitz et al., "Accessibility of Voice-Activated Agents."

A study revealed that a few individuals with hearing impairments who use digital assistants, faced difficulties in understanding voice outputs, although they did benefit from modifying the speech settings or pairing earphones.[23] In an attempt to explore alternative methods of using digital assistants, Rodolitz, et al. conducted an extensive study. The researchers considered the modality of using gesture control, as opposed to voice control, in a bid to use American Sign Language (ASL) instead of natural language in digital assistants.[24] Unfortunately, however, they found that with the current state of technology, it is unfeasible to use ASL to interact with digital assistants.[25]

To summarise, the literature on VIs suggests that accessibility is often incorporated as an afterthought in these technologies.[26] Incorporating the needs of individuals with disabilities into the UX design process is the need of the hour.

3. Policy schemes for accessibility

There is a shortage of technical communication research on the design of spoken language devices.[27] This lack of research translates to a lack of established standards, which is a major challenge in voice-enabled device accessibility. Significant policies promulgated in the global context to overcome this challenge include the United Nations Convention on the Rights of Persons with Disabilities (CRPD) and the World Wide Web Consortium (W3C).

India has also ratified the CRPD, whose Article 9(1) reads, "To enable persons with disabilities to live independently and participate fully in all aspects of life, States Parties shall take appropriate measures to ensure persons with disabilities access".[28] The CRPD Committee promotes the use of universal design, which encourages the development of products and services for all people without the need for specialised design.[29] Consequently, the Government of India formulated the National Policy on Universal Electronic Accessibility to ensure the adoption of universal design and accessibility standards in electronics and information and communication technologies (ICTs).[30]

23 Pradhan et al., "'Accessibility Came by Accident'."

24 Rodolitz et al., "Accessibility of Voice-Activated Agents."

25 Shivashankara, S. and Srinath, S., "A Review on Vision Based American Sign Language Recognition, Its Techniques, and Outcomes," Proceedings of the 7th International Conference on Communication Systems and Network Technologies (CSNT), IEEE, 2017.

26 Pradhan et al., "'Accessibility Came by Accident'."

27 H. M. Lawrence, "Beyond the Graphic User Interface", in *Rhetorical Speculations: The Future of Rhetoric, Writing, and Technology*, ed. S. Sundvall, (University Press of Colorado, 2019).

28 Pyaneandee, C. (2019). *International disability law: A Practical Approach to the United Nations Convention on the Rights of Persons with Disabilities*, (Taylor & Francis, 2019).

29 Article 2, UN General Assembly, "Convention on the Rights of Persons with Disabilities: resolution/adopted by the General Assembly," 24 January 2007, A/RES/61/106.

30 The Centre for Internet and Society and The Office of the Chief Commissioner for Persons with Disabilities, Department of Disability Affairs Ministry of Social Justice & Empowerment Govt. of India, National Compendium of Laws, Policies and Programmes for Persons with Disabilities, 2014, **https://cis-india.org/accessibility/blog/national-compendium-of-laws-policies-programmes-for-persons-with-disabilities**.

One of the primary aims for formulating the CRPD and the National Policy on Universal Electronic Accessibility is ensuring the democratisation of technology. This will be achievable if interfaces are designed to be more accessible and inclusive.[31]

4. The future of accessible VIs

VIs have the immense potential to be of assistance to persons who are limited by solely textual interfaces. With the increased uptake of smart appliances in homes and offices, we must consider the universal accessibility of devices so that people with various accessibility needs can use them with ease.

5. Conclusion

Voice-enabled products enable people to apply speech inputs and voice commands to access a variety of services. However, there is very little research on how these applications can help people with various accessibility needs. There is also a need to ensure that not only the device, but even the website, setup, and privacy policies are designed so everyone can access it. Additionally, developers and designers of both hardware and software should look at how to make the devices accessible to people with different types of disabilities; these could be through multiple channels of input and output, tactile markers, and audio feedback. This would go a long way in ensuring that commonly used technologies, including VIs and services are universally accessible to persons with diverse accessibility needs.

31 Feenberg, A., "Democratizing Technology: Interests, Codes, Rights," *The Journal of Ethics* 5 no.2 (2001), 192–193.