Web Search Results Exploration for Blind Users

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In the contemporary digital landscape, web search functions as a pivotal conduit for information dissemination. Nevertheless, blind users (BUs) encounter substantial barriers in leveraging online services, attributable to intrinsic deficiencies in the information structure presented by online platforms. A critical analysis reveals that a considerable segment of BUs perceive online service access as either challenging or unfeasible, with only a fraction of search endeavors culminating successfully.

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1. Introduction

In the contemporary digital age, web search engines have established themselves as critical access points for online information, processing approximately 3.5 billion queries daily, a significant portion of which are centered on exploratory information seeking [1][2]. These exploratory sessions are characterized by users engaging with the search engines with complex, divergent queries aimed at broad-based learning about intricate topics [3]. This interaction typically entails users inputting keyword-based queries and consulting a series of document snippets presented in a linear list by the search engine, ranked according to their relevance to the query [4][5].

This linear interaction paradigm has not been exempted from scholarly criticism, chiefly due to its convergence tendency and a lack of alignment with the needs for diverse content exploration. The central issue lies in the fact that the search results are indexed and optimized based on offline evaluative metrics like precision and recall, which, while gauging relevance, fail to encapsulate subjective user satisfaction, particularly for blind users (BUs) [6][7]. Consequently, recent scholarly endeavors are channeling efforts towards the development of intuitive search engines and evaluative metrics that integrate human-centric considerations [8].

Blindness is a visual impairment that affects individuals’ ability to perceive visual information, either partially or entirely. As a significant portion of the population, the BUs face numerous challenges in today’s digital landscape. Hence, web accessibility is becoming increasingly crucial to ensure that BUs can access online information seamlessly. Understanding how BUs interact with the web is essential to fostering an online environment that adapts to their diverse needs and allows them to fully participate in the digital world. In this context, exploring the technologies that assist BUs to navigate the web effectively is becoming essential to foster an environment where BUs can participate equally. The traditional interfaces present significant challenges for the BUs when interacting with the web. The subsequent subsections briefly discuss the BU information seeking on the web and the existing accessibility technologies, along with the associated challenges.

2. BU Information Seeking

Information searching on the web is a challenging task for BUs [9]. This is due to the enormity of the information on the web and the lack of appropriate navigational support for the BUs. On the contrary, the existing web search engines, being the gateway to accessing information on the web, treat BUs similarly to sighted ones and offer no special assistance in information searching and navigation [9]. Hence, BUs are left at the discretion of navigational support from third-party assistive tools. In such a scenario, the BUs are constrained to use assistive tools [10], such as screen readers and talking software, JAWS, voice assistants, Braille, etc. The screen readers primarily convert text into synthesized speech and use an automated voice to read out the content [11]. Depending on the structure of a document, the voice may provide structural speech, including headings, links, buttons, and text, allowing BUs to navigate and interact with the information. JAWS (Job Access with Speech) is similar to screen readers with the additional functionality of Braille displays, allowing blind users to access information in Braille format [12]. The voice assistants, such as Siri, Google Assistant, Alexa, etc., can help BUs with various web-related tasks, including searching for information, setting reminders, or reading emails [13].

The BUs face a lack of assistive tools and applications. There is an immense need to develop systems that better adapt to the BU's needs and preferences [14]. While the third-party assistive tools provide an interface for accessing the information, they are incapable of effectively rendering the information best suited to the BU's cognitive capabilities. As a result, studies indicate that BUs are hesitant to use assistance due to a lack of trust in such systems.

3. BU Accessibility Standards

To overcome the structural difficulties of the content, various accessibility standards are introduced. Firstly, the Web Content Accessibility Guidelines (WCAG) and Authoring Tool Accessibility Guidelines (ATAG) introduced by the World Wide Web Consortium (W3C) provide guidelines and success criteria for making web content more accessible. This includes adding alternate text, making information navigable without a mouse, and establishing structured documents. Section 16 of the Rehabilitation Act requires [15] federal agencies to ensure that their electronic and information technology is accessible by providing appropriate captions and means to skip duplicate content. Accessible Rich Internet Applications (ARIA) ensure that the core navigational features are accessible to the BUs, such as dropdown menus and tab panels, via screen readers [16]. User Agent Accessibility Guidelines (UAAG) from W3C focus on enabling assistive technology conformance with BUs by allowing them to adjust preferences, such as speech rate and Braille display settings, to enhance their browsing experience.

However, studies report that these standards are often overlooked, and most websites do not implement these guidelines [17]. BUs express difficulty in navigating and finding the required information on the web. Moreover, a percentage of the BUs are over the age of 18 [18]. In this regard, there is an immediate need to explore a tool that can structure the content information content that adopts the BU cognitive needs and allows them to explore the information on the web effectively.

4. BU State-of-the-Art Tools

Roy et al. [19] developed a voice-activated email prototype, considering the cognitive needs of BUs. Their system operated on three basic commands: send, read, and exit to compose the email, read the inbox, and exit the program, respectively. Fayyaz et al. [20] devised an approach to reduce BU's cognitive load by presenting the summarized information in PDF tables. They used contextual information such as data types, captions, matching sentences, etc., and devised a keyboard-based navigational menu for interaction. Bukhaya et al. [21], Nair et al. [22], and Christopherson et al. [23] leveraged image processing techniques via deep learning to convert the visual information into text for subsequent processing by a text reader. Tucket et al. [24] embedded Near Field Connectivity (NFC) in academic pages preloaded with the speak command.

Zeboudj et al. [25] used the Pigeon algorithm to efficiently find relevant web pages and used resultantly retrieved web documents as pseudo-relevance feedback from the initial query. Subsequently, they extracted keywords via the Frequent Pattern Growth algorithm to determine the optimal query for reformulation. Figueroa-Gutiérrez et al. [26] proposed an architecture considering image processing techniques to automatically extract graphs under an image format, generating a description accessible to users with visual impairments. Meliones et al. [27] used the augmented voice assistance of Alexa to allow elderly BUs to generate voice commands. The system maps the request to relevant services on the web, retrieves the relevant documents, and speaks to the BUs.

However, the existing tools are concerned with enhancing the content for better accessibility by voice assistants. The summarized literature is also presented in **Table 1**. A practical investigation to restructure the information presentation mechanism for BUs considering their cognitive capabilities is yet to be undertaken.

Table 1. Summarizing the references, approaches, and limitations of the studies mentioned in the literature review.

Cited	Approach	Limitations
[9]	BUs face challenges due to lack of navigational support	Reliance on third-party assistive tools
[10]	Utilization of screen readers, JAWS, voice assistants	Limited effectiveness of assistive tools
[19]	Voice-activated email prototype	Focused on a specific application (email)
[20]	Reduce cognitive load using summarized information	Limited to information presented in tabular format
[21][22][23]	Leverage image processing to convert visual information	Relies on image recognition; may not cover all content

Cited	Approach	Limitations
[24]	Embed Near Field Connectivity (NFC) for interaction	Limited to specific contexts (academic pages)
[25]	Pigeon algorithm for efficient web page retrieval	Focused on improving search result relevancy
[26]	Image processing for automatic graph description	Limited to content with graphical elements
[27]	Voice assistance augmentation for BUs	Primarily extends voice assistant functionality

5. Issues and Motivations

The Internet has become the most ubiquitous technology for seeking information online. Combined with easy access to handheld devices and the ability of the web to interconnect immense amounts of information, the users' information-seeking paradigm is now relying on online information-provider services such as search engines. However, the literature has shown that 81% of Internet BU users still consider accessing online services difficult or impossible [28]. Among them, only 53% of BUs are reported to succeed in their navigation tasks on the web [29]. Hence, the web can then be a cause of exclusion for BUs. These difficulties may be explained by the inherent shortcomings of online information providers. Notably, the information interaction of BU users with online information providers is linear. This presents numerous shortcomings. The BUs has to determine the relevancy of the information content sequentially, which is time-consuming. Subsequently, information seeking in a linear search paradigm is cognitively challenging for BUs, which often results in information disorientation for BUs. Furthermore, the effectiveness of a web service is determined solely by the offline empirical evaluation measures of precision and recall, ignoring the behavioral and usability aspects of designing a search engine.

References

1. Khan, A.; Khusro, S. Blind-friendly user interfaces—A pilot study on improving the accessibility of touchscreen interfaces. Multimed. Tools Appl. 2019, 78, 17495–17519.
2. Anuyah, O.; Milton, A.; Green, M.; Pera, M.S. An empirical analysis of search engines' response to web search queries associated with the classroom setting. Aslib J. Inf. Manag. 2020, 72, 88–111.
3. Kulshrestha, J.; Eslami, M.; Messias, J.; Zafar, M.B.; Ghosh, S.; Gummadi, K.P.; Karahalios, K. Search bias quantification: Investigating political bias in social media and web search. Inf. Retr. J. 2019, 22, 188–227.
4. Rashid, U.; Saleem, K.; Ahmed, A. MIRRE approach: Nonlinear and multimodal exploration of MIR aggregated search results. Multimed. Tools Appl. 2021, 80, 20217–20253.
5. Khan, A.R.; Rashid, U.; Saleem, K.; Ahmed, A. An architecture for non-linear discovery of aggregated multimedia document web search results. PeerJ Comput. Sci. 2021, 7, e449.

6. Zhang, F.; Liu, Y.; Mao, J.; Zhang, M.; Ma, S. User behavior modeling for Web search evaluation. AI Open 2020, 1, 40–56.
7. Khan, A.; Khusro, S. An insight into smartphone-based assistive solutions for visually impaired and blind people: Issues, challenges and opportunities. Univers. Access Inf. Soc. 2021, 20, 265–298.
8. Zhang, H.; Park, S.O.; Joo, S.H.; Kim, J.H.; Kwak, S.K.; Lee, J.S. Precisely-controlled, a few layers of iron titanate inverse opal structure for enhanced photoelectrochemical water splitting. Nano Energy 2019, 62, 20–29.
9. Ullah, A.; Khusro, S.; Ullah, I. Towards a Search and Navigation Platform for Making Library Websites Accessible to Blind and Visually Impaired People. In Software Engineering Research in System Science; Silhavy, R., Silhavy, P., Eds.; Springer: Cham, Switzerland, 2023; pp. 595–607.
10. Kim, N.W.; Ataguba, G.; Joyner, S.C.; Zhao, C.; Im, H. Beyond Alternative Text and Tables: Comparative Analysis of Visualization Tools and Accessibility Methods. Comput. Graph. Forum 2023, 42, 323–335.
11. Messaoudi, M.D.; Menelas, B.A.J.; Mcheick, H. Review of Navigation Assistive Tools and Technologies for the Visually Impaired. Sensors 2022, 22, 7888.
12. Brinkley, J.; Tabrizi, N. A desktop usability evaluation of the facebook mobile interface using the jaws screen reader with blind users. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting; SAGE Publications: Los Angeles, CA, USA, 2017; Volume 61, pp. 828–832.
13. Branham, S.M.; Mukkath Roy, A.R. Reading between the guidelines: How commercial voice assistant guidelines hinder accessibility for blind users. In Proceedings of the 21st International ACM SIGACCESS Conference on Computers and Accessibility, Pittsburgh, PA, USA, 28–30 October 2019; pp. 446–458.
14. Alluqmani, A.; Harvey, M.A.; Zhang, Z. The Barriers to Online Clothing Websites for Visually Impaired People: An Interview and Observation Approach to Understanding Needs. In Proceedings of the 2023 ACM Designing Interactive Systems Conference, DIS ’23, New York, NY, USA, 10–14 July 2023; pp. 753–764.
15. Taylor, Z.; Bicak, I. Two-year institution and community college web accessibility: Updating the literature after the 2018 Section 508 amendment. In Graduate Students’ Research about Community Colleges; Routledge: London, UK, 2021; pp. 125–135.
16. Hristov, H.; Enkov, S.; Bliznakov, M.; Uzunov, A. Method for Designing Accessible Web Content in The Web Space of “Paisii Hilenarski” Plovdiv University. Int. J. Emerg. Technol. Learn. 2022, 17, 184–196.

17. Manjari, K.; Verma, M.; Singal, G. A survey on assistive technology for visually impaired. Internet Things 2020, 11, 100188.
18. Theodorou, P.; Meliones, A. Gaining insight for the design, development, deployment and distribution of assistive navigation systems for blind and visually impaired people through a detailed user. Univers. Access Inf. Soc. 2023, 22, 1–27.
19. Roy, T.S.; Namratha, N.; Malleswari, T.N. Voice E-Mail Synced with Gmail for Visually Impaired. In Proceedings of the 2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS), Coimbatore, India, 2–4 February 2023; IEEE: Piscataway, NJ, USA, 2023; pp. 802–807.
20. Fayyaz, N.; Khusro, S. Enhancing Accessibility for the Blind and Visually Impaired: Presenting Semantic Information in PDF Tables. J. King Saud Univ. Comput. 2023, 35, 101617.
21. Bhukhya, C.; Bhumireddy, K.; Palakonalu, H.V.R.; Singh, S.K.; Bansod, S.; Pal, P.; Kumar, Y. Virtual Assistant and Navigation for Visually Impaired using Deep Neural Network and Image Processing. Res. Sq. 2023; preprint.
22. Nair, A.K.; Sahoo, J. Edge Eye: A voice assisted campus navigation system for visually impaired. In Proceedings of the 2021 3rd International Conference on Signal Processing and Communication (ICPSC), Coimbatore, India, 13–14 May 2021; pp. 125–129.
23. Christopherson, P.S.; Eleyan, A.; Bejaoui, T.; Jazzar, M. Smart Stick for Visually Impaired People using Raspberry Pi with Deep Learning. In Proceedings of the 2022 International Conference on Smart Applications, Communications and Networking (SmartNets), Palapye, Botswana, 29 November–1 December 2022; pp. 1–6.
24. Tŭcek, D.; Koprda, S.; Magdin, M.; Balogh, Z. Didactic Tool for the Visually Impaired. In Advances in Information and Communication; Springer: Cham, Switzerland, 2023.
25. Zeboudj, M.; Belkadi, K. Designing a Web Accessibility Environment for the Visually Impaired. In Proceedings of the 2022 3rd International Conference on Embedded Distributed Systems (EDiS), Oran, Algeria, 2–3 November 2022; pp. 154–157.
26. Figueroa-Gutiérrez, S.; Montané-Jiménez, L.G.; Carlos Pérez-Arriaga, J.; Rojano-Cáceres, J.R.; Toledo-Toledo, G. Towards Automatic Interpretation Of Statistical Graphs For The Visually Impaired. In Proceedings of the 2021 9th International Conference in Software Engineering Research and Innovation (CONISOFT), San Diego, CA, USA, 25–29 October 2021; pp. 180–188.
27. Meliones, A.; Maidonis, S. DALÍ: A digital assistant for the elderly and visually impaired using Alexa speech interaction and TV display. In Proceedings of the 13th ACM International Conference on PErvasive Technologies Related to Assistive Environments, New York, NY, USA, 30 June 2020; pp. 1–9.

28. Giraud, S.; Thérouanne, P.; Steiner, D.D. Web accessibility: Filtering redundant and irrelevant information improves website usability for blind users. Int. J. Hum. Comput. Stud. 2018, 111, 23–35.
29. Xie, I.; Babu, R.; Lee, T.H.; Castillo, M.D.; You, S.; Hanlon, A.M. Enhancing usability of digital libraries: Designing help features to support blind and visually impaired users. Inf. Process. Manag. 2020, 57, 102110.