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Review Article

Assistive Technologies for Internet Navigation: A Review of Screen Reader Solutions for the Blind and Visually Impaired

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Abstract - *The internet is a critical resource for individuals with visual impairments (VI), including those with low vision or blindness, enabling access to information and fostering independent participation in society. However, despite advancements in screen reader software, challenges persist in navigating complex and dynamic web content. This narrative review evaluates Assistive Technologies (AT), which enhance internet navigation for VI screen reader users, focusing on design strategies and usability outcomes. A systematic search across the ACM Digital Library, IEEE Xplore, JSTOR, and ScienceDirect identified 698 studies, of which 33 met the inclusion criteria, encompassing 502 participants. Key themes were extracted from bibliographic data, technology descriptions, evaluation methods, and outcomes. The findings reveal that most software-based technologies, including browser extensions and web applications, have limited hardware integration. These solutions improve navigation by providing alternative content representations, enhancing page structure understanding, and automating user tasks. Evaluations demonstrated increased task completion rates, reduced cognitive load, and enhanced efficiency, though variations in study designs and small sample sizes limit the generalizability of results. Despite their promise, these technologies face barriers, including a lack of commercial availability and rapid obsolescence. Addressing these challenges requires modular, user-centred designs employing intuitive multimodal interactions and robust information models tailored to navigation tasks. This review emphasizes the need for scalable, sustainable, and accessible AT innovations through open, collaborative development, ensuring equitable internet access for VI users.*

Keywords - *Visual Impairment (Blindness and Low Vision), Assistive technology, Screen reader, Internet navigation, Human computer interaction design.*

1. Introduction

The Internet serves as a transformative tool for communication, overcoming barriers of distance, time, and physical limitations [1-2]. For individuals with visual impairments (VI), encompassing those with low vision or blindness, the internet fosters community engagement, social support, and improved quality of life [3-5]. However, navigating the internet remains challenging for VI users, often requiring assistive technologies (AT) to facilitate interaction with digital content [6-8]. Screen readers are the most prevalent AT, providing auditory or braille-based textual representation of web content [9-11]. While these tools are indispensable, their one-dimensional approach to presenting information significantly limits access to dynamic web elements, such as tables, graphs, and interactive interfaces, increasing the cognitive burden on users who must manage complex navigational shortcuts across multiple systems [12-16].

To address these challenges, AT for internet navigation have begun to integrate advanced auditory and tactile stimuli aimed at conveying critical spatial, structural, and semantic relationships inherent in web content [9], [17]. These multimodal approaches attempt to bridge the gap between the one-dimensional textual output of traditional screen readers and the rich, interactive visual environments of modern websites. Auditory enhancements may include spatialized audio, dual-voice interfaces, and non-speech auditory cues, such as tones and alerts, to help users identify hierarchical structures, navigate lengthy documents, or interpret contextual information. Similarly, tactile feedback technologies, such as haptic interfaces or vibrotactile stimuli, offer an additional interaction layer by representing spatial layouts, object boundaries, or even directional guidance for navigation tasks.

Despite these advancements, significant design deficiencies persist, undermining the usability and accessibility of such technologies. Inadequate sensory feedback often results in information overload or confusion as users struggle to discern essential cues from redundant or conflicting signals. Overly complex information models, which fail to align with the cognitive processes and needs of VI users, can exacerbate the difficulty of understanding and navigating web content. Furthermore, unfamiliar interaction modalities—such as non-intuitive gestures, unconventional input devices, or insufficient customization options—introduce steep learning curves, making the technologies less accessible to diverse users with varying technical proficiency and needs [18-20]. These limitations underscore the importance of user-centered design approaches that prioritize simplicity, intuitiveness, and adaptability to ensure that AT solutions effectively address the unique challenges of VI internet navigation without imposing additional burdens on users.

This study undertakes a narrative review of the existing literature to evaluate the design and effectiveness of AT aimed at improving internet navigation for VI screen reader users. A systematic search was conducted across major databases, including the ACM Digital Library, IEEE Xplore, JSTOR, and ScienceDirect, yielding 33 relevant studies that examined user experiences and technological outcomes. This review synthesizes findings to uncover emerging themes in AT design and evaluates their impact on navigation efficiency, user satisfaction, and accessibility. This study highlights the need for innovative, user-centered, and sustainable solutions by identifying successful strategies and persisting limitations. Such advancements are crucial for ensuring equitable access to the internet, a cornerstone of modern life, for VI users.

2. Methodology

This narrative literature review synthesizes existing research on assistive technologies (AT) to support internet navigation for visually impaired (VI) users relying on screen readers. The review adheres to the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines [21], ensuring methodological transparency, reproducibility, and rigor. Ethical approval was not required as the analysis was based solely on publicly available data and literature.

2.1. Search Strategy and Information Sources

A comprehensive database search was conducted to identify relevant studies evaluating AT for VI screen reader users. The search strategy was meticulously developed to capture a broad spectrum of relevant literature, using the following keywords and Boolean operators: "visually impaired," "blind," "screen reader," "assistive technology," and "internet navigation." The query syntax employed was: ('assistive technology') AND (internet OR web OR webpage OR website) AND navigation AND ('visually impaired' OR blind) AND 'screen reader'. This query was applied to four prominent technology-focused databases: the ACM Digital Library, IEEE Xplore Digital Library, ScienceDirect, and JSTOR.

The search was finalized in July 2024, with specific inclusion criteria to ensure the relevance and quality of selected studies. Only English-language peer-reviewed journal articles and conference papers were considered, while patents, book chapters, and review articles were excluded to maintain focus on primary research. The review prioritized articles presenting empirical evaluations of AT with direct involvement of VI users. The search was restricted to studies reporting design features, usability assessments, and user outcomes related to screen reader technologies to enhance specificity.

This systematic approach facilitated the identification of 698 potential articles. These articles underwent further screening and selection to determine their alignment with the objectives of this narrative review, ultimately narrowing the scope to 33 studies for detailed analysis. Through a structured and transparent search process, the review aimed to capture a comprehensive understanding of the current landscape in assistive technologies for internet navigation by VI screen reader users.

2.1.1. Eligibility Criteria

Eligibility for inclusion in this review was determined through a rigorous screening process that applied specific criteria to ensure relevance and quality. Studies were screened for inclusion based on the following criteria:

1. Type of publication: Peer-reviewed journal articles and conference papers.
2. Focus of research: Studies reporting the results of VI user experiments evaluating AT designed to improve screen reader internet navigation.
3. Publication date: Published before July 2024.
4. Language: English-language publications only.

Only peer-reviewed journal articles and conference papers were considered, as these publication types typically provide the most reliable and robust findings. The review focused exclusively on studies that reported empirical evaluations involving VI users testing AT designed to enhance screen reader-based internet navigation. To maintain currency and applicability, only studies published prior to July 2024 were included. Additionally, the review was restricted to English-language publications to ensure clarity and consistency in the analysis. These criteria were applied systematically to refine the initial pool of 698 articles, ensuring that the final selection of 33 studies provided comprehensive insights into AT design, usability, and effectiveness for VI screen reader users.

Study Selection

The study selection process was conducted in a structured, multi-phase approach to ensure the most relevant and high-quality research was included. This rigorous process consisted of three sequential phases, each designed to progressively refine the pool of articles identified during the initial search. Two reviewers (JN, SO) independently conducted each phase to minimize bias and enhance the reliability of the selection process. Results from each phase were recorded systematically on a standardized spreadsheet, providing a transparent and reproducible record of the decision-making process.

In the first phase, the reviewers screened article titles for relevance to the review's focus on AT for VI screen reader users navigating the internet. Titles that fell outside the scope, such as those addressing unrelated technologies or populations, were excluded. This preliminary step reduced the dataset, allowing the reviewers to focus on potentially applicable articles.

The second phase involved evaluating the abstracts of the remaining articles. Abstracts were carefully examined to determine whether the studies met the predefined eligibility criteria, including type of publication, focus on empirical evaluation involving VI users, and alignment with the study's objectives. Articles that did not provide sufficient detail in the abstract to confirm relevance or adherence to these criteria were excluded at this stage.

In the final phase, the full texts of the shortlisted articles were reviewed in detail. This comprehensive examination allowed the reviewers to confirm that the studies met all inclusion criteria, including methodological rigor and relevance to the design and evaluation of AT for VI screen reader users. Discrepancies in the reviewers' assessments at any stage were resolved through discussion and consensus, ensuring that the final selection represented a robust and focused dataset. This iterative and collaborative approach refined the initial pool of 698 articles to a final set of 33 studies for detailed analysis.

2.2. Data Extraction and Analysis

A comprehensive data extraction process was employed to ensure systematic collection and analysis of information from the selected studies. A data extraction grid, adapted from established methodologies [22], was developed to capture key categories relevant to this review.

These categories included bibliographical data, detailed descriptions of the assistive technologies (AT) under evaluation, the design of the evaluation studies, and the reported outcomes. The grid facilitated consistent and thorough documentation across all selected studies, ensuring no critical information was overlooked.

The first author conducted the data extraction, while a coauthor (SO) independently reviewed the entries for accuracy and completeness. This dual-review approach minimized the risk of errors and enhanced the reliability of the data collection process.

Following the data extraction, a thematic analysis was conducted using a six-step process [23]. This approach allowed for identifying recurring patterns and key insights into the design, functionality, and impact of the AT evaluated in the studies.

The categorization and synthesizing of the data provided a clearer understanding of emerging trends and gaps in the field. The findings were organized and presented using tables, enabling readers to easily compare and contrast the features and outcomes of the included technologies. This tabular presentation, informed by best practices in data visualization [24], [25], ensured that complex information was accessible and comprehensible to diverse audiences.

3. Findings

3.1. Study Selection and Characteristics

The initial search across four databases yielded 698 results, with individual database contributions ranging from 18 to 461 articles. After applying the systematic selection process described in earlier sections, the pool of articles was narrowed to 33 studies. These studies represented the most relevant and rigorous research addressing the review's focus. As summarized in Figure 1, the selection process involved meticulous screening at multiple levels to ensure alignment with the review's objectives.

Figure 1 provides a detailed breakdown of the design characteristics and evaluation outcomes of the 33 AT evaluated. Notably, more than half of these studies were published within the past five years, highlighting the growing interest and advancements in AT for VI screen reader users in recent years. This temporal distribution underscores the dynamic nature of the field and the increasing emphasis on improving accessibility and usability for this population.

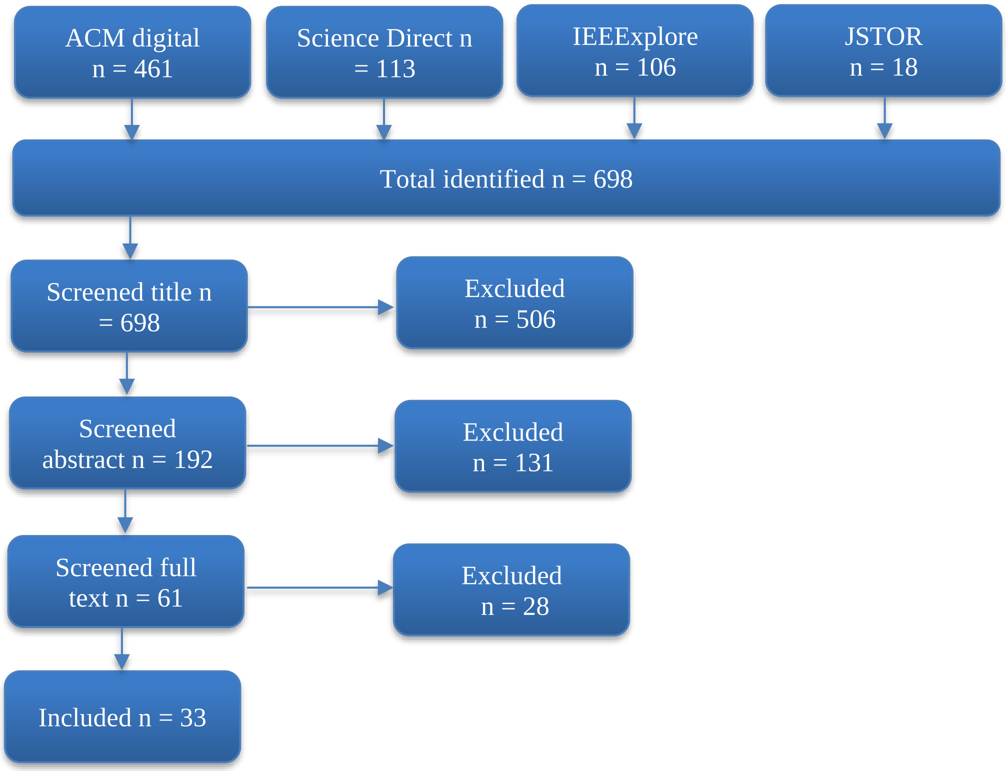

Fig. 1 Study selection and characteristics

3.1.1. Technology Design

The AT reviewed in this study exhibited a strong reliance on software components, with notable diversity in their implementation and functionality. The majority were browser extensions, accounting for 25 out of 33 technologies, while others included web applications (n=4), desktop applications (n=3), and a single screen reader extension (n=1). Though less common, hardware components were integrated into three technologies, leveraging devices such as the Wiimote, the Surface Dial, and a haptic feedback robot. These hardware elements primarily aimed to complement the software features by providing tactile interaction capabilities. However, only three technologies incorporated haptic feedback, highlighting its limited adoption within the current landscape. The most common functions of these technologies were:

- Providing alternative presentation (n=24): Simplify page layout, add descriptive text and hide website elements.
- Overviewing information (n=10): Aid information seeking and skimming through textual summaries, navigable tables of contents and accessible contextual cues.
- Interacting with data records (n=9): Annotate and restructure tables and search results with centralized filtering and sorting controls.
- Communicating visual semantics (n=7): Provide non-visual cues of graphs, styles and layouts.
- Automating common tasks (n=6): Simplify web navigation by predicting and automating user tasks or triggering natural language commands.

All the technologies reviewed sought to enhance standard screen reader outputs by introducing additional layers of information. Most commonly, these enhancements were based on semantic relationships (n=29), enabling the representation of contextual connections between web elements. A smaller subset utilized hierarchical structures (n=18) to clarify the organization of content, while others employed visuospatial cues (n=11) to convey the spatial layout and formatting of web elements in non-visual modalities.

The functions of these technologies varied widely, reflecting their attempts to address distinct challenges faced by visually impaired (VI) users. The most prevalent function was providing alternative content presentation (n=24), achieved by simplifying page layouts, adding descriptive text, and hiding non-essential website elements to improve clarity. Ten technologies focused on facilitating information seeking by enabling users to skim content through textual summaries, navigable tables, and accessible contextual cues. Nine technologies offered enhanced interaction with data records, allowing users to annotate, filter, and sort tables and search results. Seven technologies aimed to communicate visual semantics, offering non-visual representations of graphs, styles, and layouts. Finally, six technologies automated common navigation tasks by predicting user intents and enabling natural language commands, streamlining the browsing experience for VI users. This array of functionalities underscores the diverse and evolving strategies employed in the design of AT to improve internet accessibility and usability for screen reader users.

Technology Evaluations

Evaluations of the technologies consistently demonstrated positive usability outcomes, highlighting their potential to enhance internet navigation for VI users. However, the significant variation in experimental designs, participant demographics, task goals, and data collection methods across studies limits the generalizability of these results. This diversity in methodology also hinders the establishment of clear correlations between specific design choices and their respective usability outcomes. For example, the evaluations collectively involved 502 participants, including 328 individuals who were blind, 26 with low vision, and 55 whose specific visual impairments were not detailed. Participants represented a broad range of sociodemographic backgrounds and varying levels of screen reader experience. Despite this diversity, the majority of studies (n=23) were conducted with small sample sizes, often ranging from just 1 to 15 participants, which may constrain the applicability of the findings.

The types of tasks evaluated in these studies varied but could be grouped into three primary categories: information retrieval tasks (n=19), such as locating specific data or content; website exploration tasks (n=12), which assessed general navigation and discovery; and transactional tasks (n=9), including activities like purchasing products or booking services. Most studies (n=30) employed comparative experimental designs, collecting data under at least two conditions: one involving using a standard screen reader alone and the other incorporating the evaluated AT.

Quantitative metrics were widely used to measure usability and efficiency. These metrics included reductions in task completion time (n=20), the number of commands required (n=10), and cognitive effort (n=12), as well as improvements in task completion rates (n=11). In addition to quantitative measures, qualitative feedback was collected in 29 studies. This feedback emphasized improvements in usability, accessibility, and user satisfaction, providing valuable insights into the technologies' impact on the overall web navigation experience. Together, these evaluations underscore the significant advancements in AT design while also highlighting areas where further refinement is needed to ensure broad accessibility and effectiveness.

4. Discussion

The technologies reviewed demonstrate significant potential to enhance web navigation for visually impaired screen reader users through a combination of innovative strategies. These approaches can be broadly categorized into three primary mechanisms: supplementing non-linear information, providing overviews or descriptions of content, and optimizing common navigation tasks, such as locating and synthesizing information, completing forms, and enabling natural language interactions. Empirical evidence suggests that these strategies contribute to more accessible and user-friendly technologies by reducing cognitive load and improving navigation efficiency for VI users.

4.1. Non-linear Information

4.1.1. Semantic Relationships

Assistive technologies often leverage semantic relationships embedded in web content, utilizing contextual and interconnected elements to deliver features such as semantic annotation, which clarifies relationships between webpage elements, natural language interfaces for intuitive interaction, concept clustering to streamline information retrieval, and topic segmentation to navigate lengthy texts [26]. Examples like chatbot-based systems [27-28] and Speed-dial [29] illustrate how semantic relationships can facilitate web navigation. However, these relationships alone are insufficient for deep content engagement [30]. Effective designs must empower users with granular control over cursor movement, screen representation, and task execution [31]. Limitations, such as the need for domain-specific knowledge and the absence of automated annotation tools, hinder the scalability of this approach. However, advancements in artificial intelligence (AI) show promise for overcoming these barriers [32].

Hierarchical Relationships

Hierarchical relationships, which organize information structures within web pages, are fundamental to effective screen reader use and critical for orientation and navigation [15], [33], [34]. These relationships have been integral to assistive web technologies since the early days of the internet [35], [36], [37], [38], enabling non-visual access to tables, spreadsheets, diagrams, audiobooks, and structured documents [39], [40], [41], [42]. For instance, navigating hierarchies provides VI users with a conceptual overview [28] and allows selective reading of sections, which is particularly beneficial on unfamiliar web pages [43], [44]. Hierarchical models also enable users to adopt physical navigation strategies, such as identifying "landmarks" within frequently visited sites [45]. However, the effectiveness of hierarchical designs depends on adherence to W3C accessibility standards and logical organization of webpage content [43].

Visuospatial Relationships

Visuospatial relationships convey meaning through attributes like spatial positioning, color, size, and shape. These relationships are particularly valuable when accessibility standards are lacking or hierarchical structures are unclear, and they assist VI users in creating content for visual and non-visual audiences [46]. The reviewed technologies addressed these relationships by converting visuospatial cues into auditory or tactile stimuli and mapping page layouts to keyboard regions, enabling spatially corresponding interactions. However, presenting complex visuospatial relationships non-visually remains challenging, requiring significant cognitive and spatial ability [33], [47]. Moreover, spatial representations may not always be the most efficient method for conveying structural information or supporting information retrieval [48], [49].

Interaction Modalities

All reviewed technologies relied on auditory feedback from screen readers, though only one [20] incorporated additional auditory techniques. Effective auditory designs must balance enhanced functionality with avoiding user confusion from overlapping or continuous sounds [17]. Techniques such as concurrent speech [50], dual-voice and spatialized speech [51], auditory icons [52], and pitch or stereo-based spatialization [53] can enrich auditory navigation experiences when implemented thoughtfully.

Haptic feedback was leveraged in only three technologies, employing force feedback and vibrotactile stimulation to convey non-linear relationships. Combining auditory and haptic feedback can reduce cognitive effort and improve navigation efficiency [54]. Research on mobility aids demonstrates that cognitive maps formed through audio-tactile interaction are more effective than those based solely on verbal descriptions when navigating physical spaces [55]. However, hardware challenges—including high costs, limited availability, and obsolescence risks—pose barriers to widespread adoption.

Of the three technologies with hardware components, tools like haptic feedback robots, gaming console controllers (Wiimote), and computer dials (Surface Dial) expanded user interaction possibilities through intuitive gestures such as tapping, sliding, swiping, and turning. These gestures complemented traditional screen reader input methods, including voice commands and keyboard shortcuts, offering a more versatile and user-friendly navigation experience. The integration of tactile and auditory feedback ensured that these technologies provide a richer and more accessible interaction paradigm for VI users.

Design Considerations

The findings of this review underscore several essential design considerations for developing AT that effectively support impaired screen reader users. A foundational element of effective AT design is the implementation of appropriate information models. These models must strategically integrate hierarchical, spatial, and semantic webpage information to align with users' navigation goals and the intended contexts of use [56]. By combining these dimensions, AT can present information in ways that reflect the complexity of modern web environments while simplifying navigation for VI users. Ensuring this alignment between user needs and technology functionality is vital to enhancing accessibility and reducing cognitive burden. Additionally, thoughtful integration of these models can empower users to navigate websites with increased precision and confidence.

Equally important is the need for clear multimodal interactions which balance simplicity and functionality. By employing intuitive and familiar input gestures while minimizing redundant or excessive feedback, multimodal designs can significantly reduce user cognitive overload [19]. For instance, feedback mechanisms should be concise yet informative, providing enough guidance without overwhelming the user. This balance ensures that technologies are accessible to users with varying levels of technical proficiency. Furthermore, clear multimodal interactions improve the user experience by enabling smoother transitions between tasks and reducing the mental effort required to understand and use the technology. Such thoughtful design choices not only increase usability but also enhance user satisfaction.

AT must supplement rather than replace familiar screen reader strategies to preserve user autonomy. Alternative interaction methods should complement existing tools, ensuring VI users can retain control over their navigation processes while benefiting from additional functionalities [20]. This complementary approach respects the skills and preferences of experienced screen reader users, allowing them to integrate new technologies into their existing workflows seamlessly. Moreover, maintaining compatibility with familiar strategies minimizes the learning curve for users adopting these technologies. This balance between innovation and familiarity is key to ensuring AT solutions' long-term adoption and success. User-friendly design is another critical pillar of effective AT development. Interfaces should prioritize intuitiveness, customization, and learnability to accommodate users across a wide range of experience levels [57]. By creating designs that are easy to understand and adapt, developers can empower users to refine their skills and navigate the technology efficiently and independently. Customizable features, in particular, allow users to tailor the interface to their specific needs and preferences, further enhancing accessibility. This focus on user-centered design increases engagement and fosters a sense of ownership and competence among users.

A modular approach to AT design further enhances adaptability and scalability. By leveraging software and hardware modules based on standard protocols, developers can reduce barriers to innovation while allowing users to easily integrate additional functionalities [58-59]. Modular implementation supports the use of off-the-shelf peripherals, such as USB Human Interface Devices, as well as custom-built components. This flexibility enables users to expand the capabilities of their AT as their needs evolve, ensuring that the technology remains relevant over time. Additionally, modularity simplifies maintenance and updates, promoting long-term usability and sustainability.

Finally, participatory and open development models are critical for creating truly inclusive AT solutions. Actively involving VI users throughout the design and evaluation process ensures that the resulting technologies address real-world needs and preferences, minimizing the risk of creating inaccessible or ineffective systems [58], [60]. Furthermore, open-source collaboration fosters innovation by leveraging multidisciplinary expertise and incorporating diverse perspectives [61-63]. This collaborative approach not only enhances the quality of the technology but also contributes to the development of equitable systems, policies, and communities. Together, these design considerations provide a comprehensive framework for creating AT that is user-centric, functional, and sustainable, paving the way for more accessible digital experiences for VI users.

Limitations

This review offers valuable insights into assistive technologies designed for screen reader-based internet navigation by visually impaired users. However, certain limitations should be acknowledged. The exclusion of 24 studies that lacked user evaluations by VI individuals may have omitted important design considerations that could contribute to a broader understanding. Furthermore, the relatively small number of technologies included in the review, coupled with generally small sample sizes and experimental design variations, limits the findings' generalizability. These constraints highlight the need for more comprehensive evaluations and larger participant cohorts to strengthen the reliability and applicability of future research in this area.

Future Research

While the evaluated technologies demonstrated promising outcomes in enhancing accessibility and usability, they also face notable challenges. These include limited evaluation by VI users, the lack of commercial availability, rapid obsolescence of components, and underrepresentation in human-computer interaction (HCI) research [64]. To address these barriers, adopting an open-source development model presents a viable pathway forward. Open-source frameworks could facilitate equitable, sustainable, and affordable innovation by distributing research, development, and distribution costs and benefits among a collaborative network. This approach encourages the co-creation of assistive tools, incorporating diverse expertise and perspectives while ensuring long-term support and adaptability [62], [65].

5. Conclusion

This narrative review examined 33 assistive technologies designed to support internet navigation for VI screen reader users, focusing on their design features and impact on user experience. Most of these technologies were software-based, primarily implemented as web browser extensions, with only a few incorporating hardware components. The reviewed technologies employed diverse strategies to enhance web accessibility, including alternative content presentations, page overviews, improved data record interactions, visual semantics annotation, and the automation of user intents. Key design considerations identified include using appropriate information models tailored to specific navigation tasks, implementing intuitive multimodal interactions, and leveraging modular and customizable components. Evaluations consistently demonstrated promising outcomes, such as reduced cognitive load, improved task efficiency, and enhanced navigation experiences. However, the absence of commercially available solutions highlights the need for sustainable development models that prioritize long-term viability and accessibility. This gap underscores an opportunity for future research and development to focus on co-creating modular, sustainable, and widely available assistive technologies that better serve the needs of VI internet users.

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Appendix 1 Design characteristics and evaluation outcomes of included studies

	Technology description													Participants			Evaluation scenario		Experimental task			Reported outcomes				
Bibliographical reference	Browser extension	SR extension	App	HW	Haptic feedback	Alternative presentation	Page overview	Data Records	Visual semantics	Automate intent	Semantic info.	Hierarchical info.	Spatial/visual info.	Low vision	Both	Blind	Only SR vs. AT	Only AT	Information retrieval	Website exploration	Transaction	Reduced time	Reduced shortcut number	Reduced cognitive effort	Increased completion rate	Positive user feedback
Elzer et al., 2008 [66]	✓								✓		✓		✓			10		✓		✓					✓	✓
Lunn et al., 2008 [67]	✓					✓			✓			✓	✓	1		3	✓		✓			✓			✓	✓
Candan et al., 2009 [68]	✓					✓					✓	✓		1		3	✓		✓			✓	✓		✓	✓
A. Brown et al., 2012 [69]	✓					✓	✓				✓	✓		2		10	✓				✓					✓
Abidin et al.,		✓			✓		✓		✓				✓			11	✓			✓					✓	

2012 [33]																										
Puzis et al., 2012 [70]	✓									✓	✓					17	✓				✓	✓		✓		✓
Limpanadusadee et al., 2012 [71]			✓*pc	✓		✓						✓				1	✓		✓			✓				
Ahmed, 2012 [72]	✓					✓	✓				✓					23	✓		✓			✓		✓		✓
Ghahari et al., 2012 [73]			✓*web				✓				✓					10	✓			✓		✓	✓	✓	✓	✓
Al-Mouh et al., 2013 [74]			✓*web			✓			✓		✓	✓	✓			5		✓		✓						✓
Wong et al., 2016 [75]			✓*web	✓	✓			✓		✓	✓		✓		15			✓			✓				✓	✓
Grober & Koster, 2017 [76]	✓					✓	✓				✓	✓	✓			1	✓		✓							✓
Ashok et al., 2017 [77]	✓									✓	✓					18	✓		✓		✓	✓	✓			✓
Khurana et al., 2018 [78]	✓					✓	✓		✓			✓	✓	2		8	✓		✓	✓					✓	✓
Giraud et al., 2018 [79]			✓*pc			✓					✓	✓				76	✓		✓		✓	✓		✓		✓
Song et al., 2019 [20]			✓*pc				✓		✓		✓		✓			14	✓			✓						✓
Ashok et al.,	✓			✓	✓	✓				✓	✓	✓				12	✓				✓	✓				✓

2019 [80]																										
Williams et al., 2019 [81]	✓+ human					✓		✓			✓		✓			21	✓		✓	✓		✓		✓	✓	✓
Lee & Ashok, 2020 [82]	✓					✓	✓				✓	✓				5	✓		✓	✓			✓			
Xie et al., 2020 [83]			✓* web			✓		✓			✓	✓			40		✓		✓	✓				✓		✓
Hae-Na Lee et al., 2020 [84]	✓						✓				✓	✓				15	✓			✓		✓	✓			✓
Ferdous et al., 2021 [85]	✓					✓					✓	✓				15	✓				✓	✓	✓	✓		✓
Y. Wang et al., 2022 [86]	✓					✓		✓			✓	✓	✓			5	✓			✓						✓
Barbosa et al., 2022 [87]	✓+ human									✓	✓					9	✓		✓			✓				✓
Aqle et al., 2022 [88]	✓					✓		✓			✓	✓				16	✓		✓			✓			✓	✓
Aiyer et al., 2023 [89]	✓					✓		✓			✓	✓				11	✓		✓			✓	✓	✓		✓
Prakash et al., 2023 [90]	✓					✓					✓					11	✓		✓		✓	✓	✓		✓	✓
Sunkara et al., 2023 [91]	✓					✓					✓					14	✓			✓				✓		✓
Ferdous et al., 2023 [92]	✓					✓		✓			✓	✓		16		14	✓		✓			✓	✓	✓		✓

Al-Thani & Aqle, 2023 [93]	✓					✓		✓			✓	✓				35	✓		✓			✓				
Zhang et al., 2024 [94]	✓					✓					✓		✓	4		6	✓									✓
Silva et al., 2024 [95]	✓					✓	✓				✓					8	✓		✓			✓		✓		✓
Prakash et al., 2024 [96]	✓					✓		✓	✓	✓	✓					14	✓		✓		✓	✓	✓	✓	✓	✓