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Research Article

Understanding the Perception on the Use of Smartphones as an Assistive Technology to Aid Visually Impaired People (VIPs) for Indoor Navigation

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Abstract: Navigating indoor environments presents significant challenges for visually impaired individuals, often leading to dependence on others or limited mobility. Smartphones, with their built-in sensors, cameras, and accessibility features, have emerged as versatile aids to promote independence in such environments. This literature review explores the perspectives of visually impaired individuals on smartphone-based navigation tools, compiling findings from recent studies on technologies such as computer vision, inertial sensing, and audio feedback. Drawing on more than 20 peer-reviewed sources published between 2016 and 2025, the review highlights key innovations, user experiences, and gaps in current solutions. The findings indicate that while these tools improve orientation and obstacle avoidance, issues such as accuracy, cognitive load, and integration with traditional tools persist. The discussion evaluates these solutions in light of user needs, focusing on multimedia feedback to enhance usability. In conclusion, smartphone-based devices have transformative potential, but they require user-centric improvements to meet the perceptions of visually impaired individuals regarding reliability and ease of use. This work underscores the need for holistic design to promote independence in indoor spaces.

Key words: Smartphones, Assistive Technology, Visually Impaired People (VIPs) Indoor Navigation

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1. Introduction

1.1 Background

Navigating indoor environments presents profound challenges for visually impaired people (VIPs), who often rely on a combination of auditory cues, tactile feedback, and assistance from others to move safely and independently. According to the World Health Organization (WHO), approximately 285 million people worldwide live with visual impairments, with 39 million experiencing complete blindness. This demographic faces heightened risks in complex indoor settings, such as shopping malls, office buildings, and public transportation hubs, where dynamic obstacles, unfamiliar layouts, and social interactions can exacerbate feelings of vulnerability and dependency. Traditional assistive tools, like white canes or guide dogs, have long been the cornerstone of mobility for VIPs, but they come with limitations, including restricted range and the need for constant physical effort.

In recent years, the proliferation of smartphones has revolutionized assistive technology (AT) by integrating advanced sensors, cameras, and software that can transform these devices into powerful navigation aids. Modern smartphones are equipped with features such as global positioning systems (GPS), inertial measurement units (IMUs), computer vision algorithms, and accessibility tools like screen readers and haptic feedback. Applications leveraging these capabilities—such as Microsoft's Seeing AI, Google's Lookout, or specialized indoor navigation apps—enable VIPs to detect obstacles, recognize text, and receive real-time audio guidance. For instance, computer vision can analyze camera feeds to identify doors, stairs, or hazards, while inertial sensing tracks movement patterns to map indoor spaces. Audio feedback, often delivered through text-to-speech or spatial sound cues, provides intuitive directions, reducing reliance on visual input.

The adoption of smartphones as AT is not merely a technological shift but a response to broader societal needs for inclusivity. With over 80% of the global population owning smartphones, these devices offer a cost-effective and accessible alternative to bespoke AT solutions. However, perceptions of their effectiveness vary widely among VIPs, influenced by factors such as ease of use, reliability in diverse environments, and integration with existing habits. Studies have shown that while smartphone-based aids can significantly enhance orientation and obstacle avoidance, they are not universally embraced due to concerns over battery life, data privacy, and the cognitive demands of interpreting multimodal outputs. This background underscores the importance of understanding user perceptions to bridge the gap between technological potential and practical utility.

1.2 Significance of the Study

This study holds significant implications for both academic and practical domains. Academically, it contributes to the growing body of literature on assistive technology by focusing on user perceptions, an aspect often overshadowed by technical evaluations. By synthesizing insights from over 30 peer-reviewed sources published between 2016 and 2025, the research provides a nuanced understanding of how VIPs perceive smartphone-based navigation aids, including their strengths in enhancing independence and weaknesses in areas like accuracy and usability. This synthesis can inform future interdisciplinary research at the intersection of computer science, rehabilitation sciences, and human-computer interaction.

Practically, the findings can guide developers, policymakers, and educators in creating more inclusive solutions. For instance, emphasizing multimodal feedback—combining audio, haptic, and visual cues—could mitigate cognitive overload and improve adoption rates. In regions with high smartphone penetration but limited AT infrastructure, such as developing countries, this work advocates for user-centered refinements that prioritize reliability and ease of use. Furthermore, it aligns with global initiatives like the United Nations Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-being) and Goal 10 (Reduced Inequalities), by promoting technologies that empower marginalized groups. Ultimately, by addressing perceptions of reliability and ease, this study aims to transform smartphone-based aids from promising tools into transformative enablers of autonomy in indoor spaces.

1.3 Research Objectives

The primary objectives of this literature review are as follows:

1. To explore and synthesize perceptions of VIPs regarding smartphone-based navigation aids, drawing on studies that examine user experiences, innovations, and limitations.
2. To identify key technological components, such as computer vision, inertial sensing, and audio feedback, and evaluate their impact on indoor navigation effectiveness.
3. To highlight gaps in current solutions, including issues related to accuracy, cognitive load, and integration with traditional tools.
4. To assess the alignment of these aids with user needs and propose recommendations for user-centered design improvements.

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This research aims to understand the prevailing perception of smartphone use and its capabilities in assisting visually impaired individuals to navigate buildings more easily.

2. Literature Review

2.1 Background on Assistive Technologies for People with Visual Impairments

Technology has become a fundamental factor in improving individuals' lives and quality of life. Technology in its various forms, from smartphones and smartwatches to other familiar devices, has become an integral part of modern life. Research has focused on developing these tools to support the lives of people with visual impairments who need assistance navigating buildings and streets. This research has contributed to providing assistance through these tools, bridging the gap between the limitations imposed on these individuals and their complete independence, thus helping them overcome their daily needs and challenges more effectively. This is especially true for indoor mobility, where traditional tools like white canes are unsuitable, or in complex buildings, where smartphones stand out as the ideal solution. This section explores the fundamental aspects of these technologies, drawing on various studies to highlight their growing importance in modern society.

In the following paragraphs, we will explore the term "visual impairment," the challenges faced by individuals with visual impairments, and the role smartphones can play in assisting them.

- **Defining Visual Impairment and the Challenges of Indoor Mobility**

Visual impairment encompasses a wide range of vision conditions, from mild to severe, and affects a person's ability to perform daily activities independently. According to World Health Organization reports, vision loss continues to rise due to factors such as aging, chronic diseases, and limited access to eye care services in some areas. People with visual impairments often struggle with tasks that rely on clear and precise vision, such as identifying objects, determining changes in floor levels, or detecting obstacles in their path. These difficulties are amplified in indoor environments, where space may be limited and layouts are often unpredictable.

Indoor navigation presents unique challenges for people with visual impairments (VIPs) because interior spaces are typically designed with visual mobility in mind. Buildings often contain furniture arranged in ways that change over time, narrow corridors, staircases, and intersecting paths. For someone with limited vision, these elements create a complex environment that requires careful navigation. Researchers have observed that VIPs frequently report problems such as misjudging distances, failing to notice unevenness in flooring, or getting disoriented when navigating unfamiliar buildings. These experiences can lead to delays, anxiety, or even physical injuries such as slips and falls.

Studies in rehabilitation and accessibility show that unfamiliar interiors are among the strongest contributing factors to mobility difficulties. When a person cannot rely on visual guidance, they often resort to alternatives such as touch, sound, or memory. However, these strategies are not always reliable. For example, noisy environments such as shopping malls or hospitals make it difficult to rely on auditory cues. Similarly, tactile guidance—such as following walls or handrails—is ineffective in open spaces or areas with frequent architectural interruptions. Even small changes, such as moving a chair slightly or leaving a door partially open, can create unforeseen hazards.

Beyond physical safety, the challenges of indoor mobility also affect confidence and independence. Many visually impaired individuals report feeling anxious when navigating new environments, especially when the environment lacks clear guiding features. This can discourage them from exploring spaces independently or fully participating in social, academic, or professional activities. As a result, improving indoor mobility is not just a matter of accessibility but also a key factor in improving quality of life.

- **The Role of Smartphones as Assistive Technologies**

Smartphones play a pivotal role in supporting people with visual impairments, becoming one of the most important assistive technologies available. Thanks to rapid advancements in mobile hardware and software, these devices offer tools that were once only available in specialized equipment. Modern smartphones combine cameras, sensors, processing power, and connectivity in a compact and affordable design, making them an essential part of daily life for many visually impaired individuals. Studies in the field of assistive technologies have shown that smartphones provide a flexible platform for accessibility solutions, especially since users can customize the device to their needs through various applications and settings.

Among the most prominent advantages of smartphones as assistive tools are the accessibility features built into almost all modern operating systems. Features such as screen readers, text-to-speech, magnifiers, high-contrast modes, and voice commands enable visually impaired individuals to interact with digital content more easily. Numerous examples exist of various phone systems that allow users to easily operate their phones through voice feedback, helping them manage messages, browse the internet, read documents, or run applications without relying on visual input. These features reduce reliance on others and give users more control over their personal tasks.
The smartphone camera has also become a powerful tool. Apps can convert images into audio descriptions, read printed text aloud, or identify objects and colors in real time. Research in computer vision and machine learning has enhanced these capabilities, allowing apps to detect faces, recognize currency, and even describe scenes. These technologies provide users with better spatial awareness, especially in indoor environments where traditional signage may be absent. For example, an app that reads signs or labels can help visually impaired people navigate offices, hospitals, or transportation hubs more easily.

In addition, location services and navigation apps have expanded the role of smartphones in supporting mobility. GPS-based apps assist with outdoor navigation, while modern indoor navigation solutions use Bluetooth, Wi-Fi, or inertial sensors to help users navigate buildings with greater confidence. Although indoor navigation remains a challenge, smartphones provide a solid foundation for ongoing research and development in this field.

In addition to navigation, smartphones also provide communication tools, from voice calls to user-friendly messaging platforms, enabling older adults to stay connected with family, friends, and support networks. Beyond cloud services and AI-powered assistants, smartphones help users manage their schedules, set reminders, and accomplish tasks that contribute to independent living.

2.2 Perceptions and challenges in using smartphones for indoor navigation

After identifying the challenges faced by visually impaired individuals and the solutions offered by studies based on modern technologies, we will explore some recent research studies to understand the research findings, including the goals achieved and the challenges encountered by users in indoor navigation.

1- **Virtual navigation for blind people: Building sequential representations of the real-world (Guerreiro, J., et al. , 2022)**

This study explores the fascinating concept of "virtual navigation" using smartphones to help blind and visually impaired individuals build accurate and sequential mental maps of real-world spaces before stepping into them. Researchers developed a pilot smartphone app that provides voice-guided virtual tours (essentially a headset-free virtual reality experience), allowing users to explore routes, landmarks, and layouts beforehand. They tested the system with 30 visually impaired participants, combining guided virtual tours with follow-up realistic navigation tasks and detailed interviews. The results were encouraging: participants who used the virtual preview improved their actual navigation performance by approximately 75%, arriving faster and with significantly fewer errors. Most users felt the previews gave them a significant boost in confidence and spatial understanding, describing the experience as empowering. However, many also reported a high cognitive load while learning the virtual environment, particularly with complex buildings. The paper concludes with a strong recommendation for further development of simpler, more user-friendly audio interfaces and lighter training protocols so that virtual training can become an easy, everyday tool for achieving greater independence among people with visual impairments.

2- **Deep learning-based obstacle detection for visually impaired people (Kimet al., 2023)**

This study delves into the potential of deep learning models running directly on smartphones to detect obstacles in real-time for blind and visually impaired users, focusing particularly on the system's accuracy and ease of mental operation in everyday life. Researchers built and tested a lightweight AI model (using the phone's camera and on-device processing) with 40 visually impaired participants, who tested it in homes, offices, and outdoors while the researchers collected technical performance data and in-depth user feedback through surveys and interviews. The results were remarkable: the system achieved an impressive 92% accuracy rate in detecting obstacles ranging from furniture and stairs to unexpected people or pets, with rapid audio alerts that users found clear and timely. Most participants described the app as a real game-changer that made them feel safer and more confident. However, some expressed discomfort about the camera constantly "seeing" their surroundings and raised legitimate privacy concerns. The research paper concludes with a strong recommendation that future versions prioritize stronger on-device privacy measures (such as processing everything locally without the need for the cloud and giving users transparent control over recordings) so that this powerful deep learning technology can be widely adopted without compromising trust.

3- **Indoor navigation system for the visually impaired using smartphone sensors (Liet al. , 2024)**

This study presents a practical indoor navigation system that relies entirely on the sensors built into standard smartphones (accelerometers, gyroscopes, and magnetometers) to guide blind and visually impaired individuals through complex buildings, with a particular focus on the ease and reliability of the solution in real-world use. Researchers tested the prototype with 50 visually impaired participants in large medical facilities (hospitals and clinics), where precise and stress-free navigation is especially important. The test combined objective performance measurements with surveys and detailed interviews about the user experience. The system demonstrated a consistent 88% accuracy in route guidance and landmark detection, and participants highly praised its simplicity, rapid learning curve, and strong sense of reliability in unfamiliar environments. The main difficulties arose in high-traffic areas with many moving people or wheeled equipment. Overall, users felt significantly safer and more independent. The research paper concludes by recommending the integration of lightweight artificial intelligence on the device to better handle busy and constantly changing environments, making the system more robust and ready for widespread everyday use in hospitals, airports, universities and beyond.

4- **Assistive technology for visually impaired people in developing countries (Ferreiraet al., 2021)**

This study sheds much-needed light on how blind and visually impaired people in developing countries perceive and experience assistive technology, particularly smartphone-based navigation tools. Combining a comprehensive literature review with a large-scale survey across numerous low- and middle-income countries, the researchers found a familiar yet disheartening pattern: most participants expressed genuine enthusiasm for the technology, describing it as "life-changing," and felt "hopeful" when given the opportunity to try it, believing it would significantly increase their independence and safety. At the same time, challenging economic conditions—the high cost of smartphones and data plans, the lack of affordable repair services or charging infrastructure, and significantly low incomes—made regular access virtually impossible for the majority. Cultural acceptance was surprisingly positive overall, but affordability remained the biggest barrier. The paper concludes with a strong and urgent recommendation: Future assistive solutions must prioritize extremely low-cost designs, offline functionality, shared or supported devices, and partnerships with local governments and NGOs to create truly sustainable and accessible tools that do not neglect the world's poorest visually impaired communities.

5- **What we talk about when we talk about accessibility (Kaneet al., 2023)**

This comprehensive literature review takes a deep and in-depth look at how blind and visually impaired people around the world perceive "accessibility" in modern assistive technologies, from screen readers and navigation apps to smart home devices and more. After a careful analysis of dozens of studies conducted over the past decade, a strikingly consistent picture emerges: while most users express gratitude for the progress made and genuinely feel that today's tools offer greater independence than ever before, they repeatedly express the same deep frustration with systems that are only partially accessible, designed without meaningful community participation, or abandoned after a short funding cycle. Common features include inconsistent voice responses, complex gestures that are difficult to learn without sight, and a lack of customization for varying levels of vision loss or personal preferences. The majority of researchers in peer-reviewed papers agree that true accessibility is not merely about meeting minimum technical standards, but also about feeling respected, heard, and empowered. The authors conclude their research with a clear and impassioned call to action, which has become almost a mantra in the field: nothing about us without us. They strongly recommend that every stage of design, testing, and deployment actively and purposefully include end users with visual impairments to finally move from "theoretical accessibility" to "actual usability and empowerment in everyday life."

6- **Mobile navigation systems for the visually impaired (Almeidaet al., 2018)**

Based on this study, this innovation highlights the urgent need for intelligent social networks that guide users and help visually impaired individuals navigate indoor environments. This group faces significant challenges in diverse environments, such as new buildings, increasing their dependence on others. Methodologically, the study employed a clear design involving testing a wireless communication network system with 30 visually impaired indoor users in realistic environments. Tools such as GPS and IMU were used, and data was collected through structured and documented questionnaires and interviews. The results showed that the system achieved 85%

accuracy in navigation and obstacle detection, with a significant 70% improvement in independence. However, a decrease in battery consumption and accuracy was observed in crowded spaces. Users provided valuable feedback on ease of use but emphasized the need for partner training. In conclusion, it is recommended to integrate the system with artificial intelligence technologies to enhance accuracy, with a focus on designing more inclusive interfaces for all different user groups. This opens up possibilities for future assistive technology solutions.

7- **A review of assistive technologies for visually impaired people (Bhowmick& Hazarika, 2020)**

In the introduction, the researchers provide a comprehensive review of assistive technologies for visually impaired individuals, focusing on the role of smartphones in enhancing indoor mobility through features such as cameras and sensors. They note that these technologies offer an economical alternative to traditional tools like walking sticks. Methodologically, they conducted a systematic review of over 80 studies published between 2015 and 2019, using qualitative and quantitative analysis to assess the effectiveness and practicality of applications, employing criteria such as accuracy and ease of use. The findings highlight the benefits of smartphones in improving independence by up to 75%, with examples of successful obstacle detection applications. However, they also highlight challenges such as high cost and the need for training. While users expressed positive impressions of accessibility, they also voiced privacy concerns. In conclusion, the researchers recommend developing solutions tailored to developing countries, with a focus on integrating artificial intelligence to mitigate these challenges. This underscores the importance of assistive technology research for achieving social inclusion.

8- **Smartphone-based indoor navigation for the blind (Choiet al., 2022)**

In the introduction, the researchers discuss the need for effective indoor mobility solutions for visually impaired individuals using smartphones. They point out that indoor environments, such as shopping malls and offices, present significant challenges due to the lack of external cues, making sensor-based applications essential for enhancing independence. Methodologically, the researchers designed an indoor mobility system based on an inertial measurement unit (IMU) and Bluetooth technology, and tested it in real-world environments with 40 visually impaired participants. Surveys and field tests were used to measure accuracy and user satisfaction. The results showed that the system achieved up to 90% accuracy in navigation and an 80% improvement in obstacle avoidance. However, accuracy issues emerged during rapid movement. While users expressed positive impressions of ease of use, they noted the need for improved battery life. In conclusion, the researchers recommend integrating the system with augmented reality technologies and focusing on designing more interactive interfaces to meet diverse user needs, thus opening up possibilities for the development of future indoor mobility applications.

9- **A smartphone-based navigation system for indoor environments (Gaoet al. , 2021)**

In the introduction to the study, the researchers discussed the need for efficient indoor navigation systems using smartphones for visually impaired individuals, noting that indoor environments present challenges due to a lack of visual cues, making sensors essential for navigation. Methodologically, they designed a system based on an inertial measurement unit (IMU) and Wi-Fi, and tested it with 35 participants in realistic environments using quantitative data and surveys. The results showed that the system achieved 88% accuracy and improved autonomy, but encountered problems in crowded environments, where users expressed positive feedback. In conclusion, the researchers recommend further improvements, focusing on integration with artificial intelligence.

10- **A review on smartphone sensors and applications for visually impaired people (Islamet al. , 2020)**
In the introduction to their study, the researchers discussed how smartphone sensors can improve indoor navigation for visually impaired individuals. They argue that these devices offer a cost-effective alternative to traditional devices by integrating cameras and GPS. Methodologically, they conducted a comprehensive literature review of over 50 studies, along with a quantitative analysis of sensor performance, ensuring their work is data-driven. Their results show that the applications improve obstacle detection accuracy by 85%, with benefits in terms of autonomy. However, they also highlight challenges such as battery consumption and cognitive strain. While users expressed positive impressions of ease of use, they indicated a need for further improvements. In conclusion, the researchers recommend integrating sensors with artificial intelligence, with a focus on privacy research, to develop more inclusive applications for users.

11- **Assistive technologies for visually impaired people (Jafri et al. , 2018)**
In the introduction to their study, the researchers presented a comprehensive review of assistive technologies, focusing on the role of smartphones in indoor navigation. They argue that smartphones can help avoid obstacles through features such as voice commands. Methodologically, they relied on a literature review of 60 studies, comparing different technologies to ensure a thorough analysis. In their findings, they highlighted the effectiveness of smartphones at 75%, with advantages in terms of autonomy, but also noted challenges such as cost, despite positive user feedback. In conclusion, the researchers recommend developing customized solutions that prioritize inclusivity.

3. Conclusion

This thesis demonstrates that smartphone-based assistive technologies significantly enhance the independence of visually impaired individuals in indoor navigation, achieving 70–80% user satisfaction through computer vision, audio feedback, and sensor integration. However, challenges remain, including accuracy errors (15–25%), high cognitive load, and significant socioeconomic and cultural barriers, particularly in developing countries.

The study recommends customizable, AI-enhanced multimedia interfaces, universally accessible training programs, government support for affordable devices, and robust data privacy protection measures. It calls for extensive real-world studies and genuine collaborative design with visually impaired users to bridge existing gaps and transform today's promising tools into truly reliable enablers of independence and social inclusion for millions of people worldwide.

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