Navigating Independence: A Survey of Visually Impaired People's Experiences and Needs

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In this paper, we report the results of an anonymous worldwide survey conducted with visually impaired people to understand their experiences, needs, and challenges in navigation, differentiating our approach from prior work that often has a limited geographic scope and focuses on specific challenges.

Additional Key Words and Phrases: visually impaired, navigation, survey, experiences, needs

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1 INTRODUCTION

Investigating and understanding the navigational needs and preferences of VIB individuals in real-life scenarios is essential for developing appropriate assistive technologies to help them navigate safely and independently in unfamiliar environments. The occasional use of existing technologies by VIB people does not mean that they do not need or are unwilling to use these aids. This indicates that there is a gap between their needs and preferences, and the technologies that have been developed for this purpose.

Therefore, to obtain an overview of the needs, experiences, and challenges of VIB navigation, we designed and implemented a fully accessible online questionnaire and distributed it to visually impaired and blind individuals worldwide through 76 persons and organizations. The main goal of this investigation, in combination with the SLR, was to determine the extent to which recent studies have addressed the VIB navigation needs. We also aimed to determine which of these needs could be addressed using SLAM and related techniques. Notably, our findings highlight that navigation challenges in informal settlements or slums, as mentioned by several survey participants, can be effectively addressed using the SLAM.

The questionnaire was structured into three sections, with 17 closed-ended and two open-ended questions. In the first section, we asked about personal- and sight-related information. In the second section, we asked about participants' personal experiences with the assistive technologies they used for navigation. In the third section, we asked about their needs and preferences for assistive navigation technology. We also asked them to share their views on the ideal assistive technologies.

Table 1 presents the participants' responses to the open-ended questions about the ideal assistive technology for navigation. Based on these comments, we can conclude that, owing to the variety of needs and preferences, the ideal system would be one that can be adjusted and customized for each group of users according to the severity of vision impairment, the environment in which they navigate, the user's physical health, etc. The participants stated that an ideal assistive technology is affordable, lightweight, easy to use, and in the form of a smartwatch or a smartphone. However, some preferred assistive technology in combination with a cane. Respondents in low- to middle-income countries emphasized that these technologies should be commercially available and applicable to informal settlements. Participants preferred to receive surrounding information on demand during navigation.

Our audience was people with vision impairment severity from mild to total blindness in the age range of 15 to 60+ years. Among them, 25 were male, 16 were female, and one was non-binary. Eighteen of the respondents were born with visual impairment, while 24 later lost visual acuity. Participants' information is presented in Table 2.

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Table 1. Participants' responses to the open-ended survey questions

Features of an ideal assistive technology for navigation

- Being able to navigate informal settlements and slums
- Providing surroundings information on demand during navigation
- Providing distance and nature of the obstacles ahead
- Affordable, easy to use, unobtrusive, light, small, intuitive, accurate, low-tech, solar powered, and off-line
- A watch or a phone
- Smart and if it has buttons, the buttons should have different colors
- In combination with a cane
- Based on mainstream products and services not a bespoke device
- Performing one function perfectly, rather than multiple functions that would be reached approximately
- Commercially available
- Smart glasses that integrate with the smart watch
- A robot that would go at guide dog speed, detect obstacles, and describe the environment on demand

Additional comments or suggestions

- The navigation aids should be designed keeping in mind the low to middle-income countries where access to government funding for the acquisition of assistive devices is either non-existent or limited.
- Efforts need to be made to ensure the promotion of open-source technology for further improvement in the future.
- The device should be low-cost for developing countries like Fiji as it is not available here.
- Technological advancement is a little slower in Africa compared to Europe and other parts of the world. Our physical environment is not well plotted/planned, which makes it difficult for some solutions to work efficiently.
- You did not cater to ordinary white canes, yet these are the ones blind people have used for years.
- Most smart canes end up becoming another distraction from what the cane already tells us. Focus on enhancing rather than duplicating feedback.
- When creating assistive devices for navigation for the blind, not well-structured environments, as we have in most places in Africa should be put under serious consideration. Otherwise, they will be useless for most Africans with visual impairments.
- My guide dog is the best guide for my security outdoors.
- I am extremely interested in smart white cane.
- In combination with bone-conduction headphones, I should be able to use my smartphone as a navigation device.
- It would be great if any device could be operated easily with one hand or voice control.

Table 2. Participants information

Feature	**Number of participants**
Region of residence	Africa: 11, Asia-Pacific: 4, Eastern Europe: 9, Latin America and Caribbean:1, Western Europe and North America : 17
Age range	15-30: 9, 30-45: 14, 45-60: 14, 60+: 5
Gender	male: 25, female: 16, non-binary: 1
Born with a visual impairment	yes: 18, no: 24
Vision impairment severity	mild: 4, moderate: 6, severe:17, total blindness: 15

In the following sections, we first review relevant prior research. Then, we present the methodology used to conduct the survey, followed by the key findings and insights derived from our survey. Finally, we discuss the conclusions and limitations of this study.

2 RELATED WORK

Many studies have investigated the challenges and needs of visually impaired individuals in navigating unfamiliar environments. Some studies focused on outdoor navigation [Alwi and Ahmad 2013; Balata et al. 2014; Brunet et al. 2018; El-Taher et al. 2023;

Golledge 1997; Hara et al. 2015; Parkin and Smithies 2012; Wong 2018; Zeng 2015; Zimmermann-Janschitz et al. 2017]. In [Golledge 1997], 50 visually impaired individuals in Santa Barbara, California were surveyed using online questionnaires to understand their challenges when using public buses. This study focused on transportation challenges and solutions, highlighting the importance of enhanced auditory support for VIB navigation. Additionally, [Hara et al. 2015] presented and evaluated a scalable method for improving public transit accessibility for blind riders by leveraging crowdsourcing and GSV to collect accurate bus-stop locations and landmark information. [Zimmermann-Janschitz et al. 2017] primarily focused on outdoor mobility for individuals with vision impairment. This study employed hierarchical cluster analysis based on a nationwide online survey in Austria to classify individuals with vision impairment into five target groups, aiming to enhance their daily independence and accessibility. Navigation challenges in urban environments have been investigated in several studies [Alwi and Ahmad 2013; Brunet et al. 2018; Parkin and Smithies 2012; Wong 2018]. Research by [Parkin and Smithies 2012] revealed issues in urban areas, notably, the lack of separation between footways and carriageways, which impacts VIB navigation. In another investigation, [Alwi and Ahmad 2013] identified the need for outdoor navigation aids, emphasizing on portability and road-crossing assistance. [Wong 2018] revealed the various mobility issues that visually impaired individuals face as they navigate the urban environment. This study was conducted in San Francisco Bay. Additionally, [Brunet et al. 2018] investigated the challenges in complex urban environments through individual interviews, revealing how journey organizational habits influenced navigation strategies.

Indoor navigation has also received considerable attention. [Rousek and Hallbeck 2011] emphasized universal design principles in healthcare facilities, while [Zhao et al. 2018b] highlighted the importance of better design of assistive technologies to address challenges related to contrast, lighting, and visual cues in indoor places. A study by [Kayukawa et al. 2022] assessed the user acceptance and concerns regarding prototype robots in public buildings. In addition, [Jeamwatthanachai et al. 2019] investigated the need to include obstacles, barriers, and accessibility information in indoor navigation technology. User input plays a crucial role, as shown in [Papadopoulos et al. 2020]. This study surveyed 115 participants with visual impairments from Greece, Cyprus, Turkey, and Germany, using a questionnaire. Their research aimed to develop optimally useful audio-tactile maps of campuses by identifying the most important environmental information for visually impaired individuals. In a recent investigation, [Müller et al. 2022] examined the travel behavior of individuals with visual or mobility impairments in unfamiliar indoor settings by surveying 125 participants with blindness, low vision, and mobility impairments, and revealing their specific information needs. Additionally, it highlights the lack of high-quality indoor maps.

Several studies have emphasized the necessity for integrated solutions that enhance mobility both indoors and outdoors. [Williams et al. 2013] interviewed 30 participants residing in the US to explore how people with vision impairments used technology to support navigation. This study provided a deeper view of the range of personality- and scenario-based factors that impact navigation. [Szpiro et al. 2016] conducted a survey observing 11 low vision individuals. The aim of this study was to identify technological design opportunities to assist the visually impaired. [Chaudary et al. 2023] examined 11 blind and visually impaired participants alongside a sighted caretaker in a usability and user experience study of a teleguidance-based navigation assistance system. Their research addressed the navigation difficulties in both indoor and outdoor environments by introducing an expanded evaluation model for future research on assistive systems.

Additionally, it is worth noting that several studies investigated new approaches to enhance navigation experiences of visually impaired individuals and assessed their solutions through surveys. [Baranski and Strumillo 2015; Barontini et al. 2020; Duh et al. 2020; Ganz et al. 2012; Legge et al. 2013; Neugebauer et al. 2020; Ottink et al. 2022; Plikynas et al. 2020; Scheggi et al. 2014; Wang et al. 2017; Williams et al. 2014; Zhao et al. 2018a]. For example, [Williams et al. 2014] studied the differences in how blind and sighted individuals perceive and approach navigation tasks, focusing particularly on pedestrian navigation technology. It aimed to uncover situations in which assistance from sighted individuals could be incorrect or interfere with safe navigation for people with vision impairments. The study sought to raise awareness of these issues, promote understanding, and provide guidance to technology designers to prevent interface problems stemming from these misunderstandings. These solution-oriented investigations have contributed significantly to the development and refinement of assistive technologies and strategies aimed at addressing the unique needs of VIB people.

While valuable insights have emerged from existing research, a notable gap has persisted, often due to geographic limitations or a focus on specific challenges. To address this, our worldwide questionnaire-based study aimed to gain a comprehensive understanding of the needs and experiences of the visually impaired on a global scale.

3 SURVEY METHODOLOGY

This study investigated the challenges, needs, and experiences of visually impaired individuals navigating unfamiliar environments. To conduct the survey, we implemented a fully accessible online questionnaire. The questionnaire is presented in Appendix A. We took great care ensured accessibility by conducting rigorous testing, including evaluation by a blind individual who provided valuable feedback on usability and accessibility. Additionally, we used the WAVE Accessibility browser extension to facilitate manual evaluation and further enhance the accessibility features. Prior to the main data collection phase, a pilot test was conducted with a small group of visually impaired and sighted individuals to identify the usability and accessibility issues.

The survey was distributed to visually impaired participants through 76 individuals and organizations specializing in services and support for VIB people. List of the organizations is provided in Table 3. For privacy reasons, individual information was not included.

Table 3. List of organizations worldwide for distributing survey.

Organization	Contact
National Federation of the Blind	General and community relations
National Federation of the Blind	Communications and marketing
World Blind Union	General headquarter in Canada
World Blind Union	Secretary for Africa
World Blind Union	Secretary for Asia
World Blind Union	Secretary for Asia Pacific
World Blind Union	Secretary for Europe
World Blind Union	Secretary for Latin America
World Blind Union	Secretary for North America/Carribbean
European Network of Independent Living	Contact person
European Disability Forum	General
Association for the Advancement of Assistive Technology in Europe	Contact person
Vision Australia	General
University of Southampton	PhD student
Osaka Metropolitan University	Associate Professor
Politecnico di Milano	Associate Professor
Sookmyung Women's University	Professor
Fujitsu	Ontenna Project leader
University of York	Professor
University of Pannonia	Professor
University of Notre Dame Australia	Associate Professor
Hochschule Darmstadt	PhD student
BlindAid Organisation	General
VICTA	General
Schweizerische Blinden- und sehbehindertenverband SBV	General
Schweizerischer Baumeisterverband	Contact person
Schweizerischer Blindenbund	Contact person
University of Zurich	student active in the commission for student with disabilities
Hilfsgemeinschaft der Blinden und Sehschwachen Österreichs	Contact person
Universität Linz	Professor
Interkantonale Hochschule für Heilpädagogik (HfH)	Advanced Lecture
Global Cooperation on Assistive Technology (GATE)	Discussion form
French Associate for People with Visual Impairment (UNADEV)	Contact form
American fFion des Aveugles de France	Contact form
Royal National Institute of Blind People (RNIB)	Contact form
Swiss National Association of and for the Blind (SNABLIND)	Contact form
International Federation of Library Associations and Institutions (IFLA)	Contact person
CBM Global Disability Inclusion, Amstelveen, Netherlands	Executive Director
CBM Global Disability Inclusion, Dublin, Ireland	Contact person
IBSA -International Blind Sports Federation, Bonn, GERMANY	President
IBSA -International Blind Sports Federation, Romania	Secretary General
The DAISY Consortium, Zurich, Switzerland	The DAISY Consortium, Zurich, Switzerland
International Agency for the Prevention of Blindness (IAPB), UK	Chief Executive Officer
International Guide Dog Federation, UK	Chairperson
Sightsavers, UK	Chief Executive Officer
International Council for Education of People with Visual Impairment (ICEVI), India	Chief Executive Officer
Hadley Institute for the Blind and Visually Impaired, USA	President & CEO
Perkins School for the Blind, USA	Executive Director of Perkins International
G3ict: The Global Initiative for Inclusive ICTs	LinkedIn
Blind Institute of technoligy (BIT)	Contact person
AVAAVA	Contact form
AssisTech Foundation (ATF)	info@empower2022.in
CEO of Level access	LinkedIn
University of Paris France	Professor

We provided our questionnaire to these organizations and persons and requested their assistance in distributing it widely, without imposing any restrictions on the participants they approached. The participants' inclusivity was a deliberate choice. We aimed to gather a diverse dataset representing the experiences and needs of visually impaired individuals on a global scale considering a wide spectrum of age groups, geographical locations, and socioeconomic backgrounds. Additionally, ethical considerations, including ensuring participant confidentiality and adherence to data security protocols, were also addressed. Data collected from the survey responses were analyzed using a combination of quantitative methods to examine the collected data in a systematic and statistical manner and qualitative methods to gain deeper insights from open-ended responses. We hope that our findings will be a valuable complement to existing research.

4 SURVEY INSIGHTS

This survey aimed to understand the experiences and preferences of visually impaired individuals regarding assistive navigation technology. This survey covered personal information, experiences, and preferences and provided a view of the challenges faced by VIB individuals and their desired solutions. Appendix A shows the detailed questionnaire used in this survey along with the corresponding percentage distribution of responses for each question. Additionally, Appendix B provides a visual representation of survey results.

In terms of personal information, respondents came from diverse regions, with Western Europe and North America being the most prominent (40.48 %), Africa (26.19%), and Eastern Europe (21.43%) also showing significant participation. The age range varied widely, with the majority falling between 30-45 and 45-60 years old, each accounting for 33.33%. This distribution underscores the fact that challenges cut across generations. While the majority of participants were male (59.52%), there was also a significant representation of females (38.1%) and a noteworthy presence of non-binary individuals (2.38%). Of the respondents, 57.14% were not born with visual impairment, whereas the remaining participants were born with visual impairment. The severity of impairment also varied, with 40.48% reporting severe impairment and 35.71% experiencing total blindness.

In terms of personal experience, the survey found that navigation apps on smartphones were the most commonly used assistive technologies, with a usage rate of 66.67%. However, a significant proportion (23.81%) did not use digital assistive technology, indicating the need for more accessible and user-friendly solutions. Satisfaction with assistive technologies was generally positive, with 56.26% reporting satisfaction, although some respondents reported dissatisfaction (25.01%), and others were uncertain (6.25%). However, providing adequate feedback in various environments is challenging, particularly in places with numerous obstacles or high noise levels. The respondents faced various challenges when navigating unfamiliar environments. Finding a way to their desired destination was a prominent challenge, cited by 29% of participants, followed by locating objects in outdoor environments (24%). The respondents also expressed concerns about collisions, with head-level obstacles (38.55%) and ground-level hazards (20.48%) being paramount. These insights emphasize the importance of obstacle detection and avoidance capabilities at different levels of the body. Among the participants who used assistive technologies, 93.75% used them for outdoor navigation or both outdoor and indoor navigation. This demonstrates the importance of outdoor navigation for VIB people. However, only 17.4% of the papers under our review proposed solutions for outdoor or both indoor and outdoor scenarios.

Preferences for assistive technologies varied, with the majority favoring wearable options (61.9%), such as smart glasses and smartwatches, highlighting a preference for hands-free solutions. Handheld devices, such as smart canes, were preferred by 28.57% of participants. Except for one respondent with mild visual impairment, the rest of the participants who desired handheld assistive technologies had severe or total blind visual impairment. Notably, 9.52% of respondents expressed openness to exploring alternative options. This diversity in preference reflects the need for a wide range of assistive device options tailored to individual choices and requirements.

Speech-based information (40.48%) was the preferred mode of information delivery, thus underscoring the importance of auditory cues. A combination of feedback methods (30.95%) and tactile feedback (19.05%) also favored the participants. This multifaceted preference underscores the importance of versatile solutions that serve to the diverse communication requirements. For those opting for tactile feedback, the hands and arms (35.29%) emerged as the preferred areas for receiving sensory input, highlighting the significance of tactile interfaces in enhancing the navigation experience.

The factors influencing the path selection are notable. An obstacle-free path (20.47%) and providing route information (18.11%) ranked highest, while quick re-routing after obstacle detection (12.6%) and routing through the shortest distance (12.6%) were also significant. Regarding the important characteristics of assistive technologies, respondents prioritized ease of use (21.79%), cost-effectiveness (17.95%), and effective obstacle identification (12.89%). These insights provide valuable guidance for future technological development, emphasizing the importance of user-friendly, affordable, and obstacle-aware solutions. The diversity of responses highlights the need for personalized, adaptable solutions that serve to the unique needs and challenges faced by VIB people.

5 LIMITATIONS

Our survey has several notable strengths, such as its global reach; inclusivity across a wide range of age groups and socioeconomic backgrounds; and exploration of the preferences, challenges, and experiences of visually impaired individuals. However, it is essential to note the limitations of this study that may have influenced the results. One potential concern is the possibility of sampling bias. Given that the respondents were recruited online, there may be a bias toward individuals with internet access and familiarity with digital surveys. This may exclude parts of the visually impaired population who have limited internet access or digital literacy, resulting in a lack of representation of their perspectives. Moreover, online accessibility may present challenges for individuals who rely on alternative communication methods such as Braille. Additionally, it is important to note that the survey was conducted exclusively in English, potentially excluding valuable insights from non-English speakers. Furthermore, our survey was based on a relatively small sample of the target audience rather than the entire VIB population. Additionally, it is worth noting that the data collection period for our survey was relatively brief, owing to time constraints. While we strived to reach as many respondents as possible during this limited timeframe, this constraint may have influenced the overall sample size. Addressing these limitations in future research could contribute significantly to a more comprehensive understanding of the challenges and needs of the visually impaired.

6 CONCLUSION

One of the most valuable conclusions drawn from the survey analysis is the substantial preference of visually impaired individuals for wearable assistive technology. By prioritizing the development and enhancement of wearable devices, developers can align their efforts with the expressed needs and preferences of the users. Additionally, the results of our survey underscore the importance of assistive technologies with low mental load and ease of use, as these factors were highlighted as significant by the respondents. Furthermore, this study revealed that the challenges of navigation in developing countries and informal settlements or slums have largely been overlooked. Moreover, the wide range of responses in our survey underscores the need for tailored and flexible solutions that address the distinct requirements and obstacles encountered by visually impaired individuals.

It is worth mentioning that the presence of similar findings in our study and previous studies reinforces the significance and persistence of navigation challenges. Despite previous research, these challenges remain critical concerns. By gathering input from a broad and diverse range of participants, we aimed to underscore the ongoing importance of addressing navigation challenges for the visually impaired community on a global scale.

We conducted a semi-structured survey of the visually impaired worldwide. This survey was distributed globally, without restrictions related to geography, age, or socioeconomic status. This approach differentiates our study from previous research, which often has a limited geographical scope and focuses on specific challenges. The main goal of our study was to examine the extent to which recent studies have met the VIB navigation needs. We also wanted to determine which of these needs may be met by using SLAM and related techniques. Notably, our findings showed that navigation issues in informal settlements can be effectively addressed using SLAM.Additionally, this investigation reinforced the significance and persistence of the navigation challenges. Despite previous research, these challenges remain critical concerns. By gathering inputs from a broad and diverse range of participants, we aimed to underscore the ongoing importance of addressing navigation challenges for the visually impaired community on a global scale.

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A QUESTIONNAIRE

To facilitate clear and concise representation, the data in this questionnaire were rounded to two decimal places, allowing for a more precise and user-friendly presentation.

Title: *A questionnaire about navigational assistive technologies for visually impaired people for PhD research*

A.1 Personal Information

1. Region of residence
   - ◯ Africa (26.19%)
   - ◯ Asia-Pacific (9.52%)
   - ◯ Eastern Europe (21.43%)
   - ◯ Latin America and Caribbean (2.38%)
   - ◯ Western Europe and North America (40.48%)
2. What is your age?
   - ◯ Under 15 0%
   - ◯ 15-30 years old 21.42%
   - ◯ 30-45 years old 33.33%
   - ◯ 45-60 years old 33.33%
   - ◯ 60+ 11.90%
   - ◯ Prefer not to answer 0%
3. What gender do you identify as?
   - ◯ Male 59.52%
   - ◯ Female 38.1%
   - ◯ Non-binary 2.38%
   - ◯ Prefer not to answer 0%
4. Were you born with a visual impairment?
   - ◯ Yes 42.86%
   - ◯ No 57.14%
   - ◯ Prefer not to answer 0%
5. What is the severity of your visual impairment?
   - ◯ Mild 9.52%
   - ◯ Moderate 14.29%
   - ◯ Severe 40.48%
   - ◯ Total Blindness 35.71%

A.2 Personal Experience

6. What kind of digital assistive technologies for navigation do you use?
   - ◯ Smart cane 4.76%
   - ◯ Navigation apps on a smartphone 66.67%
   - ◯ Navigation apps on a smartwatch 0%
   - ◯ Other assistive technologies (by selection, please fill out the next text entry field.) 4.76%

     Please specify what kind of digital assistive technologies for navigation you use. ______
     - White cane
     - White cane
   - ◯ I don't use any digital assistive technology for navigation (why not? please fill out the next text entry field.) 23.81%

     Please specify what kind of digital assistive technologies for navigation you use. ______
     - They are not available at a cheap cost in my country as they are produced and imported as foreign products.
     - Don't have access to any.
     - Because I have polio I can't move my fingers and I everything on smart phone is too small.
     - I rely mainly on memory when navigating.
     - This is because my functional vision can assist me navigate simple to relatively complex terraine. Further, I often make use of a sighted guide, who is usually handy during my work and running errands.

- Expensive.
- I find the need to use speech feedback via headsets or similar difficult as need to use hearing a lot when mobile so can be undermining.
- Manage without.
- I don't have access to any at the moment.
- It's difficult to have information. I only know One shop. I have no friends like me.

7. Where do you use digital assistive technologies for navigation?
   - ◯ Indoor 6.25%
   - ◯ Outdoor 50%
   - ◯ Both indoor and outdoor 43.75%
8. To what extent are you satisfied with the assistive technologies you use for navigation?
   - ◯ Very satisfied 9.38%
   - ◯ Satisfied 46.88%
   - ◯ Unsatisfied 15.63%
   - ◯ Highly unsatisfied 9.38%
   - ◯ Neither satisfied nor dissatisfied 12.5%
   - ◯ Uncertain 6.25%
9. Is the feedback (guidance) provided by your assistive technologies enough to guide you in an unfamiliar place?
   - ◯ Yes 18.75%
   - ◯ Not enough for indoor places 12.5%
   - ◯ Not enough for outdoor places 25%
   - ◯ Not enough for places with many obstacles 31.25%
   - ◯ Not enough for noisy places 9.38%
   - ◯ Not enough for other reasons (by selection, please fill out the next text entry field.) 3.13%

   Please specify why the feedback provided by your assistive technologies is not enough to guide you in an unfamiliar place. ____________

   - The direction is not accurate enough both indoor & outdoor.
10. Do your assistive technologies provide you enough time to react to the obstacles?
    - ◯ Always 6.25%
    - ◯ Most of the time 34.38%
    - ◯ Sometimes 37.5%
    - ◯ Rarely 12.5%
    - ◯ Never 6.25%
    - ◯ Do not know 3.13%
11. What is most challenging for you when you explore an unfamiliar environment? (You can choose more than one option)
    - ☐ Finding the objects and places in indoor environments, such as doors and stairs. 22%
    - ☐ Finding the objects and places in outdoor environments, such as sidewalks and bus stops. 24%
    - ☐ Detecting the objects and obstacles in front of me. 19%
    - ☐ Finding my way to my desired destination. 29%
    - ☐ Other (by selection, please fill out the next text entry field.) 6%
    - ☐ Please specify other challenges when you explore an unfamiliar environment. ____________
      - Number of stairs to my last destination.
      - Managing to walk through vehicles when crossing streets and walking in crowded spaces.
      - I'm in wheel chair so many places are not build for me.
      - Differentiating obstacles in a dimly lit environment. I also have difficulties tracing my way, especially small paths at night.
      - Other people.

- Find my way around around in large areas indoors such as big hallways and outdoors such as large avenues or squares. The lack of auditory and tactile clues is the most challenging for me.

12. In terms of collision avoidance, which height levels are of most concern to you? (You can choose more than one option)
   - ☐ Head level 38.55%
   - ☐ Chest level 20.48%
   - ☐ Leg level 19.28%
   - ☐ Ground-level and drop-offs 20.48%
   - ☐ None of these (by selection, please fill out the next text entry field.) 1.2%
   - ☐ Please specify why the height level is not of most concern to you. ______
     - I have a dog guide.

A.3 Preferences

13. What kind of assistive technology for navigation do you prefer?
   - ◯ Wearable (e.g. smart glasses, smart watches, wear on the shoulder, shoes, ...) 61.9%
   - ◯ Handheld (e.g. smart cane, ...) 28.57%
   - ◯ Other (by selection, please fill out the next text entry field.) 9.52%

     Please specify what kind of assistive technology for navigation you prefer. ______
     - The application MyWay Pro on my iPhone.
     - An ordinary white cane.
     - White cane, not smart.
     - I really can't say because I haven't used any.
14. How do you prefer to receive information about your surroundings?
   - ◯ Speech 40.48%
   - ◯ Beeping sound 9.52%
   - ◯ Tactile (vibration) 19.05%
   - ◯ A combination of the above or something else (by selection, please fill out the next text entry field.) 30.95%

     Please specify how you prefer to receive information about your surroundings. ______
     - Vibration and speech
     - Speech and vibration
     - A combination of the above
     - Any audio method
     - Speech and Haptic
     - Beep but must be loud to alert me.
     - Vibration is also good to me.
     - A combination of speech, (3d) audio and maybe vibrations
     - Tactile feedback is somewhat limited unless you learn a code that can be utilized such as Morse code. Less complex information is fine through vibration, but there are times I must still use braille. I can't understand synthesized speech well enough to use it.
     - Tactile and speech
     - Audio, Tactile, sound
     - It would be nice if the assistive technology could guide me exactly to doors, entries, and so on. This could be by voice or vibration. What's very challenging outdoors is to find my way and I don't know if and where I have to pass a street and in how much meters.
     - Speech for directions and haptic/vibrations for obstacles
     - All of them
15. In the case of tactile feedback, which part of your body do you prefer to receive the feedback? (Multiple options possible)
   - ☐ Forehead 8.82%
   - ☐ Shoulders 17.65%

- [ ] Wrists 23.53%
- [ ] Hands and arms 35.29%
- [ ] Waist 5.88%
- [ ] Legs 1.47%
- [ ] Feet 7.35%

16. Which of the following characteristics are most important to you when using assistive technology for navigation? (Multiple options possible)
- [ ] Low mental load 14.1%
- [ ] Low physical effort 12.82%
- [ ] Ease of use 21.79%
- [ ] Identification and avoidance of obstacles 12.82%
- [ ] Low weight of the device 14.1%
- [ ] Low cost 17.95%
- [ ] Receiving remote help 6.41%

17. Which of the following options are important to you for choosing a path when traveling from one place to another? (Multiple options possible)
- [ ] Routing through the shortest distance 12.6%
- [ ] Routing through a path with the fastest traveling time 11.81%
- [ ] Routing through a path with low cost 8.66%
- [ ] Routing through an optimal path with the least hurdles (as obstacle-free as possible) 20.47%
- [ ] Providing route information 18.11%
- [ ] Providing constant assistance for navigating from my location to my desired destination 15.75%
- [ ] Re-routing quickly from my position to my desired destination once an obstacle has been detected in the suggested path 12.6%

18. What should your ideal assistive technology for navigation look like? ______
- That can navigate informal settlements or slums.
- Information for the routing (go left, right), Information during the navigation.
- Fast and intuitive
- Accurate and affordable
- In combination with a bone conduction headphones, I should be able to use my smart phone as a navigation device.
- Affordable
- It would look like a watch.
- Smart and if it has buttons, the buttons should be a different colour.
- A watch or phone
- Easy to use, light and quick to notice sound, and if it can work off line.
- While I like the cane, I want to learn how to use more advanced technology; say, on my phone, etc.
- It should be low tech.
- Blends in with the white cane as much as possible. Provides an option for tactile, audio, or both feedback.
- solar powered
- It should be very unobtrusive so that other people don't immediately see it. It should work reliable, and be an addition to my cane
- Discreet
- It should be based around mainstream products and services. I have no interest in purchasing a bespoke device.
- A device that bears little weight, has ease of us and is non-obvious to others when in use.
- Specific feedback from whatever device I am using in terms of the distance and nature of the obstacle in front of me.
- Easy
- Bright and clear, don't need little bits of information, just a clear walking route.
- Not heavy Small

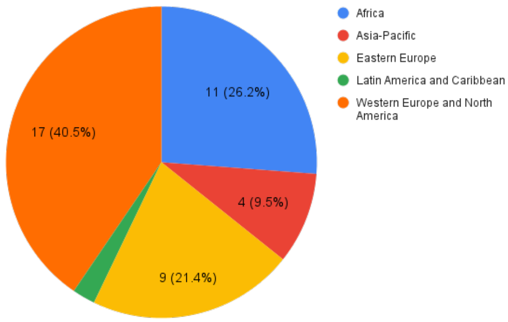
- Smart cane with all devices I can get on them.
- Mind not to develop an assistive technology that makes everything (obstacle detection, route calculation, environment description, etc.). Rather focalize on one function that the technology would feel perfectly than on multiple functions that would be reached approximately.
- Easy to use and integrated in or collaborate with commercially available hard-and software.
- It should be as small as possible or usable with my Smartphone or Smartwatch.
- A device that requires minimal effort from me and help me navigate true most obstacles.
- Smart glasses that integrate easily with the apple watch and allow me to connect to a service like AIRA easily as needed.
- Ideally I would like to have a robot that would go at the speed of a guide dog and that would detect obstacles and describe the environment to me when I ask.
- Smartphone or compter

A.4 Last comments

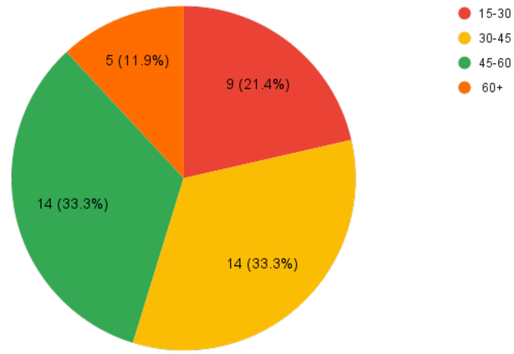
Do you have any additional comments or suggestions? ______

- The navigation aids should be designed keeping in mind the low to middle income countries where access to government funding for the acquisition of assistive devices is either non-existent or limited.
- Efforts need to be made to ensure the promotion of open source technology for further improvement in the future
- The device to be low cost for developing countries like Fiji as it it not available here
- I would love to get a copy of the report about this survey. And I would request for continuous collaboration.
- Technological advancement is a little slower in Africa compared to Europe and other parts of the world. Our physical environment is not well plotted/planned - which makes it difficult for some of the supports to work efficiently.
- You did not cater for ordinary white canes; yet these are the ones blind people have used for years.
- Your questions were confusing in regards to digital or non-digital assistive technology. Most smart canes end up becoming another distraction from what the cane already tells us. Focus on enhancing rather than duplicating that feedback.
- Not at all. The questionnaire captures a bulk of my thoughts.
- When creating assistive devices for navigation for the blind, I think not well structured environments, like we have in most places in Africa should be put under serious considerations. Otherwise, they will be useless to most Africans with visual impairment.
- My guide dog us the best guide for my security outdoor.
- As low cost as possible
- I'm very interested in smart white cane.
- It would be great if any device could be opporated easily with one hand or voice controls.

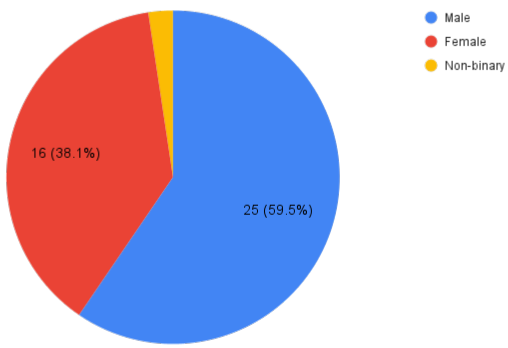
B VISUAL REPRESENTATION OF SURVEY RESULTS



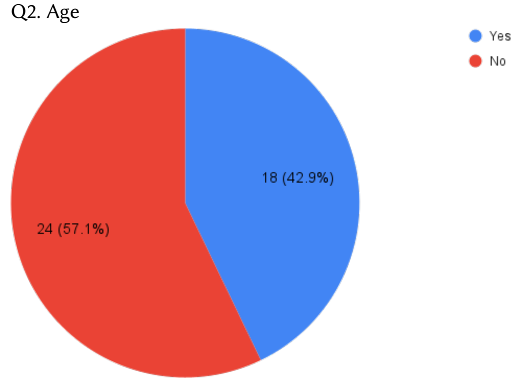
Q1. Region of residence



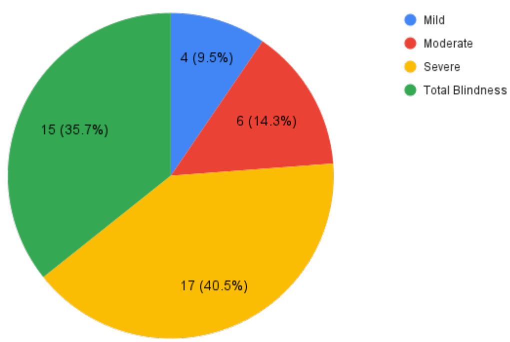
Q2. Age



Q3. Gender

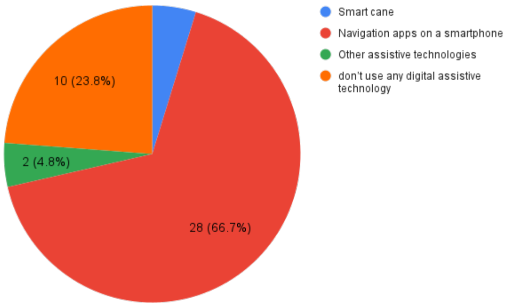


Q4. Born with a visual impairment

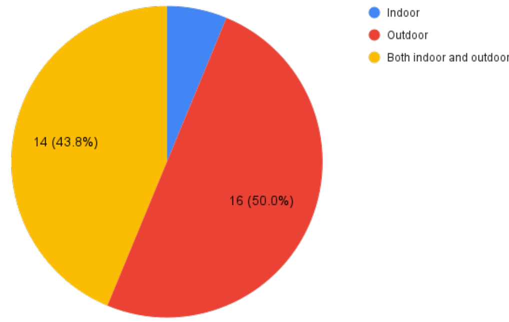


Q5. Severity of visual impairment

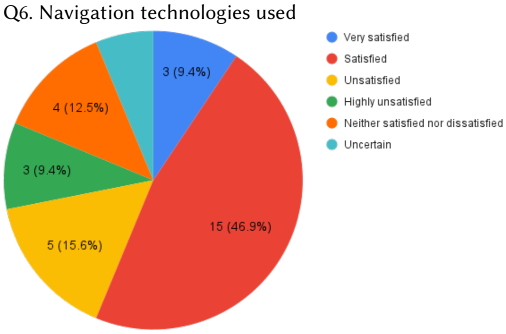
Fig. 1. Personal information



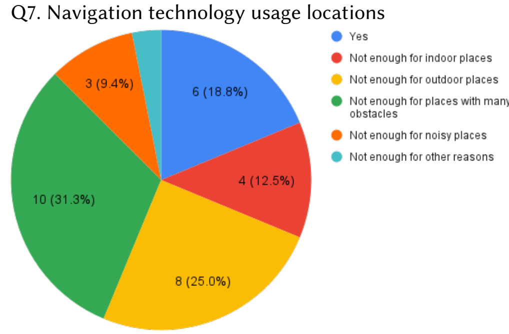
Q6. Navigation technologies used



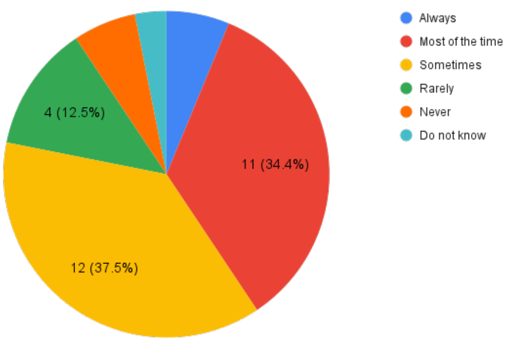
Q7. Navigation technology usage locations



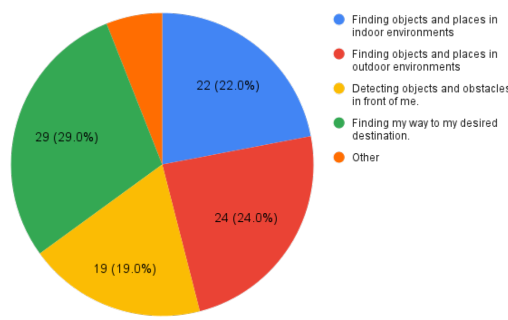
Q8. Satisfaction with navigation assistive technology



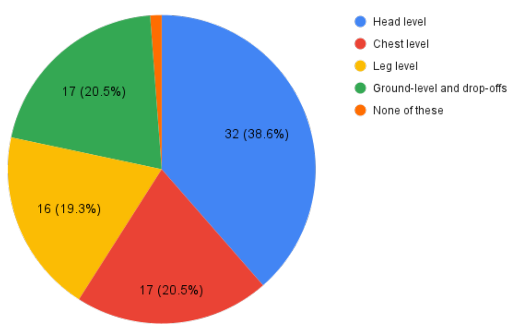
Q9. Adequacy of assistive technology guidance



Q10. Obstacle reaction time assessment

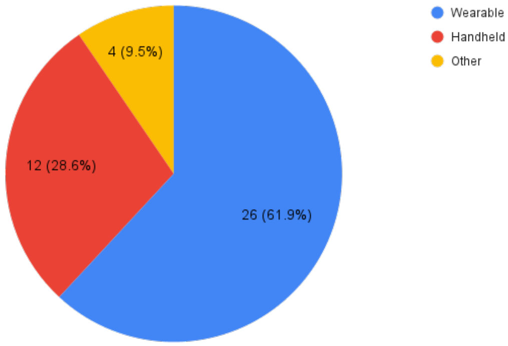


Q11. Challenges in unfamiliar navigation

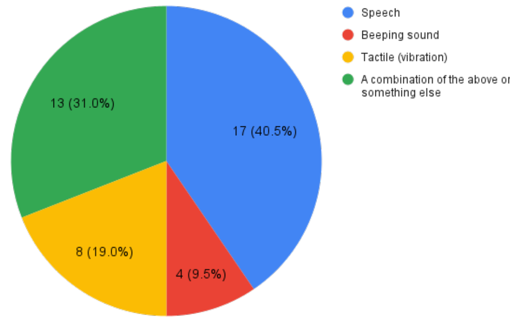


Q12. Height concerns for collision avoidance

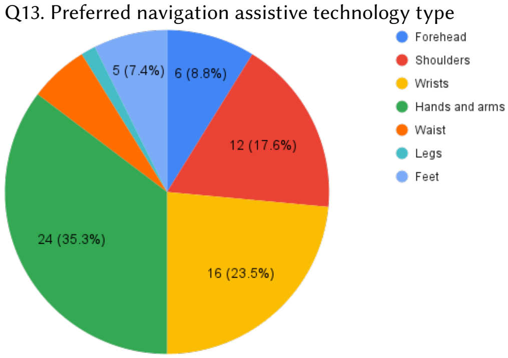
Fig. 2. Personal experience



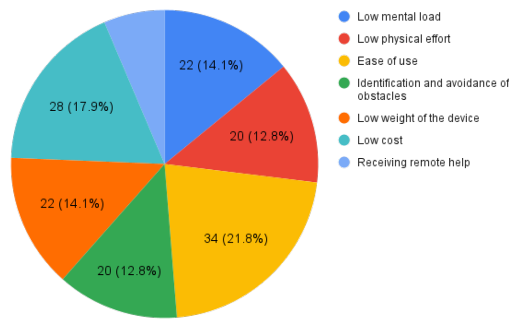
Q13. Preferred navigation assistive technology type



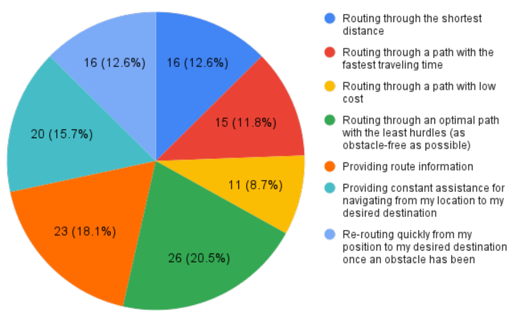
Q14. Preferred information delivery methods



Q15. Preferred tactile feedback area on the body



Q16. Key priorities in navigation assistive technology



Q17. Path selection preferences for travel

Fig. 3. Preferences