Veiviser: scoping challenges in the deployment of augmented reality navigation for impaired individuals

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Abstract. This study reports on the development and evaluation of a multimodal augmented reality (AR) indoor navigation prototype using Visual Positioning technology designed to improve mobility for individuals with visual impairments or other disabilities and deployed in the public sector. Particular focus was on scalability, transparency, and privacy. Based on consultation with different user groups in a user-centered design (UCD) process, different technological possibilities were identified, and an application was developed and evaluated. The evaluation incorporated a System Usability Scale (SUS) test and post-test interviews. Results were promising, demonstrating that the prototype is user-friendly and effective. Subsequently, we reflected on the implications of a deployment at a larger scale and potential risks to privacy and transparency. Several issues related to privacy and scaling the application to support more users and offer wide navigation opportunities were identified and discussed in the article.
Keywords: Augmented and Virtual Reality, Visual Positioning, Mobile and wearable technologies, Human-computer interaction, Interaction design.

1 Introduction

Around 15% of the global population faces some form of disability, with 1 in 5 women and 1 in 10 children experiencing disabilities [1, 2]. Disabled individuals encounter barriers affecting inclusion, empowerment, and wellbeing, particularly pronounced in low-income countries due to challenges like accommodation affordability, limited medical assistance, and accessibility to Assistive Technologies (ATs) [3]. World Health Organization (WHO) statistics mention that approximately 285 million people are blind or visually impaired, with 246 million experiencing visual impairment and 39 million facing complete blindness [4, 5].

Assistive technologies, encompassing various devices and modifications, play a vital role in supporting individuals with disabilities, addressing challenges in daily activities [6]. These technologies aid people facing difficulties in communication, mobility, learning, and more, with different disabilities requiring tailored assistive solutions [7]. Assistive technology extends beyond individual devices to include equipment, services, and environmental modifications that empower individuals to overcome physical, social, infrastructural, and accessibility barriers, facilitating active and independent lives as equal members of society [8].

Several works targeted mobility and have attempted to create and test navigation systems for people with various types of impairment. Originally, the majority of such systems targeted outdoor navigation most often using GPS technology. GPS-based navigation is well-known and widely used for outdoor wayfinding. However, the technology depends on satellite signals that cannot penetrate building structures, making it ineffective for indoor environments. Municipalities in Norway and abroad acknowledge the need for indoor and outdoor navigation technologies that reduce barriers and promote independence across a broad spectrum of users, including those with sensory, cognitive, physical, or linguistic challenges. For people with disabilities, and especially for the visually impaired, safe and efficient navigation is a significant challenge [6]. Independence hinges on overcoming obstacles like identifying pits, hanging obstacles, stairs, traffic junctions, signposts, wet floors indoors, and slippery outdoor paths [9–11].

There are currently few options for navigational aids for the impaired for indoor use. Most proposed localization technologies rely on proprietary hardware like beacons or RFID tags, making them difficult to set up and scale. This increases costs and limits large-scale navigation application development. However, current advances in Visual Positioning Systems (VPS), offers a promising and cost-effective solution for indoor wayfinding. Visual Positioning Systems (VPS) fuse imagery, smartphone sensors, LiDAR, and machine learning and cloud computing technologies to create detailed 3D models of indoor spaces for precise positioning. VPS is rapidly advancing, and combined with Augmented Reality (AR), it has the potential to offer a cost-effective solution for navigational aids that can run on a personal handheld device using only an app. However, VPS systems often rely in communication with external servers and services which may hinder their deployment in communal buildings and services.

The Veiviser Research project explored the feasibility of combining augmented reality (AR) with VPS-based indoor and outdoor wayfinding technologies. This pilot project engaged relevant local stakeholders and end-users to validate the approach, aiming to ensure that developed solutions address real user needs. Its goal was to design, develop, and evaluate a prototype app to support users with diverse accessibility needs in navigating indoor and outdoor environments. The project placed significant emphasis on transparency, scalability, and privacy. It examined the extent to which different software architectures can provide usable navigation at scale while providing users with transparency concerning the types of information disclosed, the management of consent, data collection and storage, the definition of access permissions, and the procedures for data deletion, all situated within the scope of Data Governance.

2 Background

Electronic Travel Aids (ETAs) [12] are assistive technology devices designed to gather information about the surrounding environment and [13, 14] provide localization and navigation assistance in both indoor and outdoor spaces [15]. These devices have proven effective in improving mobility and alerting users about obstacles [16] particularly in unfamiliar or constantly changing environments [17–19]. Building such a device requires combining technical expertise with usable design choices.

ETAs systems may include components such as cameras, ultrasonic collision detectors, smart glasses, sensors, or actuators that are head-, hand- or chest/torso- mounted or placed on user items such as gloves, shoes, or canes or directly implemented on a smartphone or smart watch [20]. Due to their wide availability ETAs running on smartphones and smart watches are used or tried out universally by impaired users. ETAs may display information visually but usually provide also auditory and haptic stimulation to cater for a wider and diverse range of disabilities.

Handheld AR, such as that used on smartphones, is a recent and widely accessible technology, and AR has proven to be an effective and intuitive interface for navigation applications. AR can overlay virtual information such as arrows, tags, or sounds on the real world is used often in navigation applications for people with various types of impairment. This may well be combined with speech, sonification, audio descriptions, and haptic interfaces which enable receiving alerts about detected physical elements and comprehending wayfinding instructions [21]. However, precise navigation with minimal roaming around the optimal path remains a challenge and researchers try out ways to optimize user mobility. For example, conveying the precise angle of body rotation or the relative position of detected obstacles through sonification has been found to enhance navigation accuracy [22]. Spatial audio is particularly relevant for visually-impaired users as it can convey directional information in AR and has been associated with improvements in navigation [21, 23, 24]. ETAs may often complemented by a screen reader and feature adapted screen layouts which prioritize simple visual designs, proper shapes, sizes, and locations, and high color contrast while avoiding irrelevant visual effects and overlapping items to cater for people with various degrees of visual impairment [20, 25]. Speech is a common input method while touch screen gestures, pointing gestures, and gestural interactions are commonly supported. Augmented reality in particular has proven to be a successful interface metaphor for navigation applications. Overlaying virtual information such as arrows, tags, or sounds on the real world is used often in navigation applications for people with various types of impairment. This may well be combined with speech, sonification, audio descriptions, and haptic interfaces which enable receiving alerts about detected physical elements and comprehending wayfinding instructions [21].

2.1 Indoor-localization Technologies for ETAs

Electronic travel aids can be categorized into three groups based on the localization technology used: vision-based, non-vision-based, and hybrid technologies [18]. Non-

Vision-Based Systems employ various sensors and tags [26] to detect potential obstacles and alert users. As emphasized by [27], these encompass infrared sensors, ultrasonic sensors, laser sensors, beacons, and NFCs. There is a prevalence of non-camera-based systems in industrial settings, commonly used for robot navigation [28]. These systems utilize sensor network tags (RFID, NFC, BLE, and UWB) for rapid item identification in large warehouses. In general, non-camera-based systems require the installation of infrastructure and that users carry dedicated equipment like tags, tag readers, or other receiver/transmitter devices so that they can be localized while navigating their surroundings. There are also proposals suggesting adopting technologies such as Wi-Fi and magnetic-field-based methods but these have limited accuracy.

Vision-Based Systems utilize cameras and computer-vision and image processing technology to provide visual information to individuals with visual impairments [28]. They rely on video cameras as their main source of information, including RGB cameras, RGB-D cameras, thermal cameras, Kinect sensors, etc. [18]. The application of such systems is primarily in vision-based assistive devices executing object detection, navigation to objects, collision avoidance, and providing descriptions of the surrounding environment [28]. The potential of such systems has been significantly enhanced due to advancement in machine learning technologies [29].

Hybrid systems [30], involve devices that contribute to both detection (object, obstacle) and localization. These devices utilize a combination of vision and/or non-vision-based sensors for object detection and may incorporate GPS modules for navigation purposes. An example is the Tyflos system employing two vision cameras, IP camera-based systems, Visual Simultaneous Localization and Mapping (VS-LAM) technology, and the LiDaR Assist Spatial Sensing (LASS) system using LiDaR sensors [6]. Major mobile computing platforms offer such localization capabilities often in connection with the development of Augmented Reality reality applications, for example Apple's ARKIT or Google's ARCore. Such systems are often also called Visual Positioning Systems, even if they fuse data from several sources for localization. In some cases, hybrid indoor navigation systems may combine non-vision based techniques such as tags with vision-based techniques to overcome their respective limitations and leverage unique strengths [31].

2.2 VPS and OSCP as an indoor and outdoor ETA

Visual Positioning Systems (VPS) will most often fall within the hybrid category because the device camera input is the core sensory modality used for localization and camera pose estimation. VPS requires that a 3D representation of the physical environment has been created in advanced. This is achieved typically by capturing/scanning the environment using imagery or in conjunction with other sensor modalities and then processing this data into a form (such as a point cloud) that can be used by a pose-estimation algorithm. A core advantage of this approach is that it can provide very high positioning accuracy (less than a meter of error both indoor and outdoor), without requiring expensive and time-consuming installation of beacons or markers in the environment. Importantly, VPS can be done on generic consumer devices like a smartphone with a camera.

In small-scale ETA use-cases, it may be practical to use a self-contained VPS on a single device that is shared among users. In this setup, all steps from capturing location data, generating the 3D map to pose estimation and adding navigation are handled locally, without sending sensitive data to third parties or requiring georeferencing. However, setup for each user is time- and cost-intensive and small areas can only be supported due to memory limits which make such applications rare.

For larger scale ETA deployments, like within a municipality, VPS is supported by cloud services. These store and distribute georeferenced 3D representations of the related indoor and outdoor environments and navigation possibilities which can be shared, updated and maintained in one solution for the benefit of all users. Georeferencing not only supports reuse of existing map data but also helps the VPS pose estimation algorithm by narrowing the search space within available 3D models.

While VPS can enable precise positioning at scale, the technology comes with important challenges. First a considerable amount of preparation needs to be done which involves scanning target buildings, defining paths and points of interest, and aligning this data with existing building coordinates and documentation. Special care is needed when navigating between floors, stairs, or low-feature environments, where anchor points or objects must often be placed along routes to reduce ambiguity. These requirements must all be managed through the user interface while also accommodating the diverse accessibility needs of different user groups. Current development remains focused primarily on visually impaired users, leaving usability for broader user gorups uncertain.

Importantly, VPS depends on using cameras which can be problematic in public spaces. Furthermore, cloud-based VPS solutions typically require sending imagery, GPS, or sensor data from the device to remote servers likely across-borders, raising privacy risks such as surveillance, third-party access, and profiling. While image anonymization and on-device processing can reduce exposure, transmitting data off-device inevitably introduces vulnerabilities. Organizations providing ETA services therefore bear significant responsibility for ensuring user privacy. Ideally, they should use services where 3D map data storage is owned and controlled by the organization itself to guarantee data sovereignty.

A final concern is vendor lock-in. Different cloud VPS providers often use proprietary APIs or SDKs that are not interoperable, making it costly and disruptive to switch providers. To mitigate this risk and foster competition, solutions should adopt open standards such as GeoPose (standardized by the Open Geospatial Consortium) and protocols developed by the Open AR Cloud Association, including the OSCP GeoPose Protocol for VPS endpoints [32]. Open standards not only reduce switching costs but also support a more sustainable ecosystem of interoperable, open-source components.

2.3 Summary and contribution

The literature review testifies to the amount of work already directed towards developing electronic travel aids to assist impaired users with outdoor and indoor navigation. Originally, outside the focus of attention due to technical limitations, indoor navigation is receiving increased interest due to the availability of indoor-navigation technology, especially Visual Positioning. In the context of this project, the combination of VPS with handheld AR is especially interesting as it has the potential to provide a low-cost, high-precision ETA solution for adoption by the public sector. Widespread adoption, however, depends on providing convincing answers to the following research questions:

- Does combining VPS and AR offer a usable electronic travel aid solution for individuals with disabilities or visual impairments?
- How to ensure privacy, transparency and scalability in data handling for governance when using VPS?

3 Methodology

To make a first step towards answering these research questions, the project we report about here developed and tested a prototype navigation app for impaired users in Halden municipality while considering privacy, transparency, and scalability. A user-centered design approach was adopted to ensure both technical quality and that the app meets the real-world challenges and expectations of its users. Key steps included: (1) conducting initial user research to identify navigation goals and challenges, (2) developing and testing concepts through meetings with user representatives, (3) producing visual designs and prototypes to simulate scenarios, evaluate usability, and identify issues, (4) adapting two state-of-the-art applications based on earlier research insights, and (5) evaluating the prototype in real-world scenarios using observation, questionnaires, and interviews.

To ensure that the prototype addresses real user needs, relevant stakeholders and end-users from the Halden Kommune and Norges Handikapforbund was actively involved. Three user groups were established to assist in the various stages of the project. The **Expert Group c**omprised of one municipal staff (universal design advisor), two, end-users with disabilities (one visually impaired and one motion impaired), and two representatives from Norges Handikapforbund. This group was used in the first phase of the project in which we informed ourselves about the design domain, defined realistic scenarios, contributed firsthand insights, and articulated user needs. The **Technology Group** included researchers in human-centered technology, AR/VR, interaction design, and software development. This team was responsible for the app's technical development, interaction models, and evaluation. The **Evaluation Group** was a group of users with different types of impairment that was selected to participate in the evaluation of the prototype. It included a total of six users, two female and one male, with various degrees of visual and motion impairment. The age range was between 50 and 75 years.

4 User research, scenario development, design attempts, and challenges

The goal of the user research phase was to understand better the views of the different stakeholders, get input on the features that need to be provided by the application, and get input on designing a representative evaluation scenario of user interaction with the navigation app. To achieve this, we performed a workshop with the expert group. The workshop was recorded and notes were taken. A complete analysis of context and themes is outside the scope of the paper. We will mention here that based on the comments we received, we were able to conclude that an app which provided auditory and visual indoor-navigation feedback would provide a good starting point for our tests and cover a wide range of impairments. The stakeholders also raised concerns about the privacy of their interactions and complications due to the use of the cameras in a public place. One important observation from the motion impaired user was related to possible difficulties in holding the phone camera while moving with a wheelchair. The expert group also helped us define the representative scenario of navigating to a wedding meeting at a town hall as follows: A guest with mobility or visual impairments needed to travel from outside the building entrance to a meeting room on the second floor, including using the elevator. They identified the paths that users with different types of impairment would have to travel and alerted us to possible difficulties.

After concluding the workshop, the design and engineering members focused on how we could design an application which would help users go through the scenario we have defined. This involved discussing on the type of accuracy required by the VPS but also the need for feedback to be provided to the users by the application. To address users with both visual and motion impairments, we decided that the application should provide both visual and auditory feedback about the optimal path and the location of the user within it. Furthermore, we focused on the additional feedback that could be necessary on critical and important waypoints which were included in the path in particular when transitioning from an outdoors to an indoors environment, using stairs, or using the elevator.

Concerning visual feedback, we decided on drawing a line on top of the camera feed to show the optimal direction. For people with visual impairment, we decided to use speech commands. However, we also considered beacon sounds together with spatial audio as design possibilities. We felt that by combining audio and visual feedback, we could cater for a significant number of disabilities as both motion-impaired, visually impaired, and hearing-impaired users would be in the position to use the application. We also thought that motion-impaired users could attach the phone to the wheelchair or use a strap to mount it on their bodies.

5 Prototyping: Technology Considerations and Research Platform

Following the workshop, we considered possible options for the development of the prototype to be tested in the evaluation. In this context, we evaluated two technologies: VPS and Apple's ARKit framework.

The initial choice of VPS provider was Augmented City, a small startup based in Italy, that offers a VPS endpoint that is compliant with the Open Spatial Computing Platforms, GeoPose Protocol, developed by the Open AR Cloud Association. The idea was to develop a user interface supporting the use case build on this open platform. During the project, due to the war between Russia and Ukraine and the discovery that Augmented City had server endpoints in Russian territory, we decided to swap this out with an alternative VPS from a US vendor that used a proprietary protocol but still offered assurances of reasonable levels of privacy protection. The prototype still worked as intended on a technical and functional level.

In contrast, ARKit offers a privacy-focused alternative that stores navigation routes locally on the device. When investigating ARKIT, we initially developed an application providing the ability to record and navigate paths based on an existing solution used by IFE using Unity on ARKIT using which users could record a route using the phone camera and retracing their path through a combination of tactile feedback, audio cues, and spoken instructions. However, we soon realized that it offered a very similar functionality to the also ARKIT-based open-source CLEW app [33], which supports users with disabilities by facilitating independent and accurate indoor navigation. We decided to use CLEW in subsequent development as it specifically targets impaired users, was more mature, has been tested already, and would therefore make subsequent implementation easier. By means of working on ARKIT, CLEW does not transmit images, location, or sensor data to external servers, dramatically reducing the exposure of sensitive information and minimizing risks such as profiling, data leaks, and unauthorized tracking. Being open-source, it also is easily extended which could be useful in future projects. Furthermore, CLEW offers a significant number of customization possibilities including custom audio messages. To ensure the user could understand the messages provided by the application, CLEW was modified to support Norwegian by replacing the Text-to-Speech (TTS) system with one capable of rendering the Norwegian language.

Participant	**SUS**
Multiple sclerosis (wheelchair):	92.5
Blind participant (former guide dog user):	82.5
Severe visual impairment (10–40% vision):	77.5
Cerebral palsy:	80

Mobility pedagogue/representative:	72.5
Severe visual impairment (10% vision):	70
Average:	***79.16***

Fig. 1. (left) Early prototype design showing core functional components and user interface layout using Augmented City, (right) the System Usability Scores for each user.

6 Evaluation

To prepare for the evaluation, the development team recorded the entire route into ARKit using CLEW, ensuring the application could generate navigation instructions based on the user's location. The route was mapped from the taxi drop-off point, through the entrance and elevator, to the final meeting point. At key decision points, visual waypoints and recorded voice instructions were added to clarify actions where signage or tactile cues might be insufficient. All instructions were provided in Norwegian.

Before starting the main task, participants received a short training session on an Apple iPhone 14 Pro Max. They could choose between ear-pods with hear-through functionality or the phone's built-in speaker, enabling them to experience CLEW's multimodal guidance according to their preferences.

Each participant then executed the navigation task, beginning at the designated taxi drop-off. They oriented themselves using signage displayed in the app and followed tactile guidelines toward the entrance. Upon reaching the door, a waypoint delivered the instruction: "Use the door opener on the wall to the right, positioned below elbow height." Continuing inside, they approached the elevator, where another waypoint advised: "Use the through elevator; the call button is on the right side." Once inside, the message "Use the buttons on the left side and take the elevator to the 2nd floor" was played. The scenario concluded when participants reached the meeting point on the second floor, where the system confirmed: "You have arrived at your destination."

During this process, CLEW provided turn-by-turn guidance through audio and vibration feedback, warning of obstacles such as tripping hazards and highlighting important waypoints like the entrance and elevator. The app also monitored deviations and offered corrective feedback, though guidance was limited to the pre-recorded path.

Upon completion of the route, participants provided usability ratings using the System Usability Scale (SUS) [34] and participated in an interview. SUS is a validated 10-item questionnaire containing a number of questions that receive a rating from 0 to 100 by each user which are aggregated to a single usability score. SUS results provide a benchmark for interpreting the overall ease of use and satisfaction with an application, enabling comparisons to industry standards and helping to identify areas for improvement. Participants were also asked about their technological skill level as we thought this may be important for understanding the results.

Figure 1 to the right shows the SUS score we obtained by each user. The average was 79 which is well above the average score of 68 observed across multiple studies. The high average SUS score indicates that the application has high usability and high potential for user adoption. However, SUS scores range from 70 to 93. The range can be explained by participants' perceived technology level. Participants who rated their technological skill level as high tended to view the prototype more positively during testing. However, the small sample size limits the generalizability of these results, suggesting that further testing with a larger group is needed to confirm this finding.

SUS does not diagnose specific aspects of a solution and is designed to assess overall usability in systems and applications. For this reason, we complemented SUS with interviews to capture qualitative feedback on the participants' reasoning and issue identification. A full thematic and contextual analysis of these discussions, however, is beyond the scope of this paper.

7 Discussion

Concerning our first research question, which investigated whether combining a VPS with AR can provide a usable solution for both outdoor and indoor navigation for users with different types of disability, the initial results we have obtained from the evaluation of the application we developed based on the open-source Clew app are quite positive. All participants managed to complete the user scenario, and the SUS score they provided are promising. Transitioning from an outdoor to an indoor environment and challenging environments such the elevator were possible to handle with careful planning. Our observation, however, highlighted cases in which unsighted users roamed along the optimal path before finding their way as often observed in similar studies [35]. Furthermore, our test was performed in a controlled environment and on a quiet day, so the impact of unforeseen factors such as obstacles or people was not taken into account.

There were a number of important observations concerning the use of telephone for capturing images in a public setting both in relation to usability and in relation to privacy. For example, holding the telephone is not an option for users with mobility problems and special care needs to be taken with respect to that. Furthermore, visually impaired users who use a cane also expressed concern about this option. The very accuracy of holding the phone in the right position is also a concern as it can lead to images that cannot be localized sufficiently. Finally, users considered that holding the phone to places in which strangers are located can be a problem. Usability related problems may, however, be mitigated with new technologies such as smart glasses which can provide a more stable and socially acceptable platform to work on.

The CLEW app and the ARKit proved to be a promising combination. An advantage is that localization is done locally on the iPhone which solves a good number of privacy related problems. Furthermore, being an open-source app Clew provides a good starting point for research and development. However, using ARKit naturally restricts the user-base to iOS users. Even if a version for ARCore, the Android-compatible technology, is possible to develop, larger scale deployment is subject to a number of compromises.

This relates to the need to develop and provide a database of geo-referenced spatial information to users dynamically and on-demand. The very geo-referencing process also involves sending detailed sensory data from the device to a server for both mapping and relocalization. This provides a privacy and security risk even when private information is stripped from the data though client-side processing and anonymization and from the server-side 3d map that has been generated or during pose estimation. Any detailed 3D representation of an environment, even if processed to remove certain type of private or sensitive features, can still contain significant amounts of sensitive information about the mapped location.

Furthermore, our experience is that such databases need to be controlled by the service-provider as they may contain information that is sensitive. A discussion needs to be done about the extent to which spatial information about buildings and other infrastructure should be considered sensitive, given that it can be used for purposes completely different to the ones it was collected for. Our experiment with using an open platform such as Augmented City only emphasized problems related to distributed systems and cloud-based services when we discovered that the localization service we were using was based on a server located in Russia. The sensitive geopolitical situation following the war between Russia and Ukraine only aggravated the problems that may be encountered when using cloud-based services. At the time of writing the OARC has confirmed that Augmented City has now moved their service to servers in western Europe, however, that did not happen in time for us to benefit from that in the project. Nevertheless, it appears that AR and spatial computing industries still have not reached a lever of maturity where commercial vendors provide interoperable, non-lock, in-turn key solutions for customers like municipalities, special interest NGOs.

From technical, privacy, and security perspectives, the ideal infrastructure in this context would be a fully open decentralized system, governed and controlled by local authorities that can interface to different client-side technologies. Such a possibility would be provided by an Open Spatial Computing Platform (OSCP) which would allow organizations to tailor applications to their needs. Since the project began, the Open AR Cloud (OARC), supported by NGI-Search funding, successfully completed the Oscar4us project (late 2024 to mid-2025) which developed an open-source Visual Positioning System (VPS) compliant with the OSCP GeoPose Protocol, enabling anyone to operate the service on their own local servers while maintaining full control over private and sensitive data. This is a promising development which can potentially address the challenges in deploying AR infrastructure at scale.

8 Limitations

Despite the promising results, there are a number of limitations in this study. Some of which originate in the fact that this was a pilot project with limited resources while others to the readiness level of the technologies we used in the project. The first limitation is that the comparison of the VPS solutions is qualitative and does not involve objective measures of VPS system performance. To the best of our knowledge such tools and benchmarks are not widely available and were certainly not possible to develop within the limited scope of the project. A second limitation relates to the use of the Clew open-source application. This is a well-known application in the assistive technology domain which has been evaluated in a number of occasions and fitted well with the project scope. Furthermore, it provided the customization possibilities necessary for it being used from our user group. Even if our original plan was to extend Clew and experiment further with interaction designs, this did not prove feasible in the project time frame. Another important limitation is that the number of participants used in the study was also limited. Even if it is not uncommon for studies involving people with disabilities to have a small number of participants, this, nevertheless, limits the generalizability of the findings. However, given the pilot nature of this project, we believe that these results could provide motivation for future investigations in the topic. Finally, in this paper we chose to focus on the technical challenges and solutions we have investigated and the quantitative usability study and did not go in depth with the qualitative data analysis. Instead, we chose to provide some small insight from the qualitative data we obtained. We acknowledge that this is a limitation, however, we felt that it would not have been possible to perform a complete and appropriate presentation of the qualitative data we collected given the focus of this article and the available space.

9 Conclusion

We presented a research project that aimed to evaluate the extent to which the combination of VPS localization with Augmented Reality interface technology can provide a usable solution for both indoor and outdoor navigation for people with different types of impairment. We have also considered problems related to the deployment of such systems by public authorities especially privacy, scalability, and transparency. Results of an evaluation with a pilot prototype were quite promising. However, a number of issues need to be resolved to achieve optimal navigation. Importantly, we found that using VPS systems can pose a significant number of privacy, scalability, and transparency issues. These are not easy to handle within closed systems. Open systems have a strong potential to assist in providing navigation solutions without compromising data sovereignty.

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