Evaluation Results Analysis: Vision assistance simulator

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ABSTRACT
This study engaged four participants to evaluate a sensory assistance simulator designed for environment such as subways and grocery stores. Participants varied in age and professional background, providing a small but diverse demographic sample. The primary research questions focused on the intuitiveness of the interface, the utility of the blur video toggle, the effectiveness of auditory cues, and the overall user satisfaction with the sonification scheme. Key findings indicated a high level of intuitiveness and usefulness across most features, with specific notes on the clarity of directional audio cues and the importance of TTS in the user experience.

CCS Concepts
• **Human-centered computing→Human computer interaction (HCI) and Interactive systems and tools**

• **Information systems→Multimedia and multimodal retrieval**

Keywords
Auditory display; sonification; simulation; interactive systems; auditory cues; virtual environments; text-to-speech (TTS)

1. INTRODUCTION
The project's goal was to develop an immersive simulator that could aid individuals with visual impairments by providing auditory cues to navigate various scenarios, specifically subways and grocery shopping environments. Existing tools in the domain primarily focus on tactile and auditory feedback; however, our simulator sought to integrate these cues more seamlessly and translates spatial layouts into intuitive soundscapes. By employing advanced sensor technology, it offers real-time auditory feedback on obstacles, and provides detailed cues about objects within reach. This system is an enabler for the visually impaired to navigate, interact, and engage confidently in varied spaces, facilitating independences and enriching their quality of life.

2. METHODS
Our evaluation plan involved a structured protocol where participants engaged with the simulator through predetermined scenarios. Each participant navigated two different environments using the simulator and provided feedback via a questionnaire. To accommodate for remote testing, the simulation was provided via e-mail with brief instructions. Participants included a diverse group of friends and family members that are sighted individuals who typically rely on visual cues for navigation, simulating the experience of a newly visually impaired person. This approach ensures the system's standards accommodate users without prior development of heightened auditory senses. The protocol focused on quantifying the effectiveness of the auditory simulation in conveying spatial and navigational information to sighted individuals, intending to simulate a visually impaired user's experience.

2.1 Protocol
1. Introduction and Consent: Provided an overview of the evaluation process and explained the purpose of the study, what will be expected of them, and how their data will be used.
2. Pre-Evaluation Training: Introduced the sonification system to the participants, explaining how to interpret different sounds and what each sound represents within the context of navigation and object identification.
3. Task Execution: participants performed tasks that simulate real-world scenarios: Navigation through a virtual environment mainly using audio cues & Identifying objects on sonification. Corresponding video of the given scenario is shown with blurred effects.
4. Video Assisted Evaluation: After completing audio-main tasks, show participants a clear video of the same scenarios they just navigated or interacted with. After viewing, ask them to perform same tasks to evaluate their performance with visual context.
5. Post-study Assessments: Conduct a structured interview or focus group session to gather qualitative feedback on the user experience. Administer a survey to quantitatively measure user satisfaction, perceived utility, and cognitive load.

2.2 Shortcomings
The main shortcoming of our methods is the difference between the inteded user group for the simulator and the participants available for the study. The simulator is designed for visually impaired individuals, yet our participant pool consisted of sighted individuals. This could lead to a disparity in the perceived effectiveness of the sonification strategies. Additionally, due to the remote nature of the study, there was no standardized audio output device used by all participants, which could affect their perception of the audio cues. Finally, the small sample size limits the generalizability of our results, and larger-scale studies would be required for more robust conclusions.

3. RESULTS
3.1 Overview
The results from our evaluation reflect a generally positive response to the simulator across various features. A total of four participants, all sighted individuals, were surveyed after interacting with the simulator to provide feedback on its usability and effectiveness. The feedback covered a range of features including the intuitiveness of the interface, the effectiveness of the

blur video toggle, volume control sliders, and the clarity and helpfulness of audio cues, etc.

3.2 Quantitative Feedback

Table 1. Intuitiveness of Interface

Average	Highest	Lowest
2.75	3	2

Intuitiveness of Interface was recorded on the scale of 1 to 3, 1 being not intuitive to 3 being very intuitive. The question asked was, "How intuitive did you find the interface of the simulator?" The interface was found to be very intuitive by all participants, with an average rating of 2.75 out of 3. The highest response was 3, and the lowest response was recorded 2.

Table 2. Blur Vide Toggle Helpfulness

Average	Highest	Lowest
2.75	3	2

The helpfulness of blur video toggle was recorded on the scale of 1 to 3, 1 being not helpful to 3, being very helpful. The question asked was, "Did you find the blur video toggle useful for experiencing visual impairment in the given environments?" The blur video toggle was found to be very helpful by most participants, with an average rating of 2.75 out of 3. The highest response was 3, and the lowest response was recorded 2.

Table 3. Volume Control Sliders Usefulness

Average	Highest	Lowest
2,75	3	2

The usefulness of volume control sliders was recorded on the scale of 1 to 3, 1 being not useful to 3, being very useful. The question asked was, "How would you rate the usefulness of the volume control sliders during the simulation?" The volume control sliders were found to be very useful by most participants, with an average rating of 2.75 out of 3. The highest response was 3, and the lowest response was recorded 2.

Table 4. Preset Volumes Usefulness

Average	Highest	Lowest
4.75	5	4

The usefulness of provided preset volumes was recorded on the scale of 1 to 5, 1 being not useful at all to 3, being very useful. The question asked was, "How would you rate the usefulness of the preset volumes?" The preset volumes were found to be very useful by most participants, with an average rating of 4.75 out of 5. The highest response was 5, and the lowest response was recorded 4.

Table 5. Auditory Cues Clearness

Average	Highest	Lowest
4.25	5	3

Clearness of auditory cues in general was assessed on the scale of 1 to 5, 1 being not clear at all to 5 being very clear. The question asked was, "How clear were the auditory cues in the simulator?" The auditory cues were found to be very clear by participants, with an average rating of 4.25 out of 5. The highest response was 5, and the lowest response was recorded 3.

Table 6. Directional Audio Cues Helpfulness

Average	Highest	Lowest
4.75	5	4

Helpfulness of directional auditory cues was assessed on the scale of 1 to 5, 1 being not helpful at all to 5 being very helpful. The question asked was, "How helpful were the directional audio cues in understanding the environment?" The directional audio cues were found to be very helpful by all participants, with an average rating of 4.75 out of 5. The highest response was 5, and the lowest response was recorded 4.

Table 7. Proximity Audio Cues Helpfulness

Average	Highest	Lowest
4.75	5	4

Helpfulness of proximity audio cues was evaluated on the scale of 1 to 5, 1 being not helpful at all to 5 being very helpful. The question asked was, "How helpful were the proximity audio cues in understanding the environment?" The proximity audio cues were found to be very helpful by all participants, with an average rating of 4.75 out of 5. The highest response was 5, and the lowest response was recorded 4.

Table 8. Text-To-Speech Usefulness

Average	Highest	Lowest
2.75	3	2

Usefulness of TTS was evaluated on the scale of 1 to 3, 1 being not useful to 3 being very useful. The question asked was, "How would you rate the usefulness of the narration of TTS (Text to Speech)?" The TTS was found to be very useful by all participants, with an average rating of 2.75 out of 3. The highest response was 3, and the lowest response was recorded 2.

Table 9. Train Arrival Alerts Accuracy

Response type	Yes	No
Number of Responses	4	0

Accuracy of train arrival alerts accuracy was evaluated in a dichotomy manner. The question asked was, "Were the train arrival alerts timely and accurate?" The result was found to be very accurate, with all 4 responses of "Yes".

Table 10. Item Locator Alerts Effectiveness

Response type	Yes	No
Number of Responses	4	0

Effectiveness of item locator alerts was assessed in a dichotomy manner. The question asked was, "Were the item locator alerts helpful in navigating the store?" The result was found to be very effective, with all 4 responses of "Yes".

Table 11. Audio Cues Satisfaction Level

Average	Highest	Lowest
4.5	5	4

Satisfaction level of audio cues overall was evaluated on the scale of 1 to 5, 1 being not satisfied at all to 5 being very satisfied. The question asked was, "How satisfied are you with audio cues, overall?" The audio cues were found to be very satisfactory in general by most participants, with an average rating of 4.5 out of 5. The highest response was 5, and the lowest response was recorded 4.

3.3 Qualitative Feedback

Qualitative feedback from participants highlighted the simulator's strength and areas for improvement. The intuitive nature of the interfae and the efficacy of directional audio cues were widely appreciated, with participants noting that these aspects provided a heightenendsense of space and orientation. The blur video toggle was celebrated for its ability to focus attention on auditory senses, enhancing the simulation of a visually impaired experience.

Despite these positives, certain aspects were pinpointed as needing refinement. Participants expressed that the volume of the Text-to-Speech (TTS) notifications was sometimes too low, particularly when juxtaposed with other sounds within the simulation. This occasionally resultd in missed information, suggesting a need for better balancing of audio levels.

The simulator's effectiveness in navigating environments varied across scenarios. In the subway scenarios, the TTS announcements regarding train arrivals were considered crucial and were commended for their clarity and timeliness. Conversely, in the shopping scenario, the item locator alerts were found to sometimes confusing. Participants suggested that clearer distinction and timing of these alerts could improve the experience. Additionally, the high pass filter used to indicate 'Back' locations received mixed reviews. Some participants felt the effect could be more pronounced, while others found it disorienting initially.

Participants offered constructive feedback for enhancing the simulator. Suggesting included refining the high pass filter settings, and possibly incorporating visual cues to aid new users. Such insights indicate needs for future developments, aiming to cater to a broader spectrum of users and their individual needs.

4. DISCUSSION

The evaluation of the sensory assistance simulator yielded rich qualitative and quantitative data that align with the research questions posed. The feedback received indicated a high level of user satisfaction with most features of the simulator. The intuitive interface was well-received by all participants, and the directional audio cues were commended for enhancing spatial awareness. The blur video toggle feature, designed to simulate visual impairment, was reported to be particularly effective, focusing user's attention on auditory inputs and enriching the experience.

However, some issues were highlighted necessary attention for future development of the simulator. The volume of TTS alerts was a notable concern among participants, with some reporting that the alerts were not adequately audible over environmental sounds. This suggests that while the TTS feature is valued for its utility, its current implementation requires enhancements to ensure that alerts are delivered with sufficient volume to capture the user's attention.

The effectiveness of audio cues for navigation varied across scenarios. While the subway scenario's alerts were timely and clear, the shopping scenario presented challenges with overlapping item locator alerts. This confusion points towards a need for better differentiation and possibly spatial distribution of auditory cues to prevent cognitive overload and to allow users to distinguish between alerts more effectively.

The high pass filter's efficacy was another issue. Some participants indicated a need for stronger effects, and others experienced initial disorientation. This feedback highlights the importance of customizable settings in auditory systems to cater individual user preferences and sensitivity levels.

Overall, the study indicates the simulator's potential as a valuable tool for sighted individuals simulating the experience of visual impairment. However, the insights gained also emphasize the necessity for adaptive audio mechanisms to cater varying user needs and environments.

5. CONCLUSION

The study offers promising evidence that the sensory assistance simulator could be a significant aid for visually impaired individuals. The high ratings for intuitiveness and the functionality of audio cues support the simulator's design goals. However, the feedback also outlines critical areas for improvement, such as TTS volume adjustment and the management of overlapping auditory cues.

Given the limited sample size and the fact that the participants were not the primary user group (visually impaired individuals), the results are preliminary. Yet, they provided directional insights that can inform the next stages of development. Future work will focus on refining the audio feedback system, incorporating adjustable settings for the high pass filter, and possibly adding visual aids to assist new users.

If the project were to continue, a larger-scale study with visually impaired participants seems essential to validate the simulator's effectiveness in real-world settings. Such a study would offer a more detailed understanding of the simulator's impact and ensure more representative understanding of the simulator's impact.