Enemy Localization Tools for VR Games Accessibility to Blind and Low-Vision Players

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DOI: 10.54337/aau.icdvrat26.41

Abstract

Virtual reality (VR) offers new opportunities for accessible interaction, yet action-oriented gameplay remains largely inaccessible to blind and low-vision (BLV) players, especially in multi-enemy combat requiring rapid situational awareness. This ongoing project investigates audio-based assistive tools for enemy localization in VR shooting games. We designed a VR shooting platform integrating three localization tools: a radial shockwave, a joystick-controlled scan, and a controller-attached detection cone. In this work in progress, we present the system and an experimental protocol combining gameplay sessions on a dedicated mini-game with post-hoc focus groups, aiming to understand how BLV players perceive and use these tools to iteratively refine them.

1. Introduction

Video games are a major cultural and social medium, yet they remain largely inaccessible to blind and low-vision (BLV) players due to their reliance on visual information. Despite this, BLV players have expressed a desire to participate in these games and become part of these communities (Andrade et al. 2019), making use of assistive technologies and developing their own compensatory strategies (Gonc¸alves et al. 2023). Recent advances in game accessibility have improved inclusion, particularly through audio-based features in mainstream titles such as *The Last of Us Part II (TLOU II)* and *Diablo IV*. However, these solutions remain limited and inconsistently implemented, especially in situations requiring rapid decision-making, such as multi-enemy combat.

In a preliminary investigation, we conducted interviews with 12 BLV players to explore their experiences with action-oriented games. The results highlighted persistent difficulties in rapidly understanding surrounding threats, even when accessibility features are available. Participants reported relying heavily on spatial audio cues and expressed appreciation for existing localization tools, while also identifying limitations in their precision, timing, and level of control, particularly when automation constrained their ability to plan and execute strategies.

Virtual reality offers a promising context to address these challenges through embodied interaction, spatial audio, and motion-based input (Mott et al. 2019). Designing accessibility features early in the development of VR systems may enable more inclusive interaction paradigms. However, accessibility features for BLV players in VR remain scarce (Aich et al. 2025). Building on these findings, this work investigates the following research question: how can enemy localization techniques from traditional games and prior research be adapted to support situational awareness in VR combat scenarios for BLV players? To address this question, we design a VR-based study in which participants interact with a shooting mini-game integrating multiple enemy localization techniques. These methods are evaluated through gameplay sessions, followed by a focus group aimed at collecting qualitative feedback and refining the proposed approaches for VR use.

2. Related work

Video game accessibility research has long identified barriers faced by BLV players and proposed early guidelines for inclusive design (Bierre et al. 2005). Studies show that while these players demonstrate strong interest in video games, many accessible experiences rely on simplified mechanics or automated assistance, which can limit player control and reduce the complexity of gameplay, particularly in dynamic situations (Andrade et al. 2019). A substantial body of work has demonstrated that non-visual gameplay is feasible through spatial audio and multimodal feedback, enabling players to perceive game events and navigate environments without vision (e.g., Atkinson et al. (2006)). More recent studies show that BLV players rely on compensatory strategies such as memorization, timing, and audio cues when interacting with mainstream games, while still facing significant accessibility limitations (Gonc¸alves et al. 2023). Prior work on fast-paced interaction further highlights the importance of prioritizing critical information and providing concise auditory feedback in real-time gameplay (Smith & Nayar 2018). However, the effectiveness of these approaches in highly dynamic scenarios such as multi-enemy combat remains insufficiently understood.

Situational awareness refers to the perception of environmental elements, the comprehension of their meaning, and the projection of their future states in dynamic contexts (Endsley 1995). In games, this involves continuously tracking multiple entities and anticipating threats under time constraints. Existing work has focused mainly on spatial awareness in navigation contexts, where tools such as *NavStick* and *Surveyor* provide structured auditory feedback to support exploration and environmental understanding (Nair et al. 2022, 2024). Although effective for navigation, these approaches are typically designed for low time-pressure scenarios and do not directly address the constraints of fast-paced gameplay.

Research has explored navigation and spatial awareness in VR for BLV, as well as more interactive experiences such as sports-oriented applications and systems supporting environmental awareness (Furtado et al. 2025, Ribeiro et al. 2024). However, these applications are generally limited to structured or low-pressure scenarios. Accessibility in dynamic VR gameplay, particularly situations involving multiple moving entities, time pressure, and rapid decision-making, remains largely underexplored. This highlights the need to investigate how existing techniques can be adapted to support situational awareness in VR combat scenarios.

3. VR Platform and assistive tools

Building on preliminary interviews investigating BLV players' experiences in action-oriented games, we aim to address the difficulty of rapidly understanding the spatial distribution of multiple enemies during combat. While existing accessibility features in traditional games provide partial support, they often fail to support fast-paced decision-making. To address this, we developed a set of assistive tools aimed at supporting enemy localization in VR combat scenarios. These tools are inspired by both accessibility features found in commercial games and techniques proposed in prior research, and are adapted to leverage VR-specific interaction capabilities. To evaluate these techniques, we developed a VR shooting mini-game designed to reproduce controlled yet dynamic multi-enemy combat situations, allowing us to collect both usage observations and qualitative feedback from players.

3.1. VR Combat Assistive Tools

We implemented three complementary assistive tools designed to support enemy localization through different interaction strategies, ranging from global scanning to directional and embodied exploration.

Radial Shockwave (M1): The radial shockwave, inspired by scan-based mechanics found in *TLOU II*, is activated by pressing a button and generates an expanding sphere centered on the player up to a fixed range. When colliding with enemies, spatialized audio cues are emitted from their positions, providing a global overview of nearby threats.

Joystick-Controlled Zone (M2): The joystick-controlled method, inspired by the *NavStick* (Nair et al. 2021), allows players to actively probe their surroundings by holding a directional input. It defines a cone-shaped detection zone oriented according to the absolute direction of the joystick, independently of head or controller orientation. This approach enables rapid and targeted scanning of specific directions without requiring physical movement.

Controller-Attached Zone (M3): The controller-attached method provides a continuously active cone-shaped detection zone aligned with the orientation of the VR controller, similar to a flashlight beam. By directly coupling detection with hand movement, this technique supports embodied exploration of the environment and may enhance spatial understanding through physical interaction.

3.2. VR Shooting Mini-Game

We developed a simplified VR shooting mini-game in which the player must survive by eliminating multiple enemies approaching from all directions. Idle robots spawn around the player at predefined positions. The player can then use the localization tools to assess the surrounding enemies. Upon the first shot, enemies become active and move toward the player while continuously emitting spatialized footstep sounds as they advance. Upon reaching the player, enemies inflict damages. The player has a limited number of lives, and must eliminate all enemies before losing all health points. To reduce motor and aiming constraints, the weapon uses an adjustable SphereCast-based shooting system, increasing projectile size to mitigate the difficulty of precise aiming in VR. Levels vary in terms of number of enemies, movement speed, and spatial configuration. Specific configurations are designed to challenge localization abilities, including enemies at similar distances but different orientations and enemies at similar orientations but different distances.

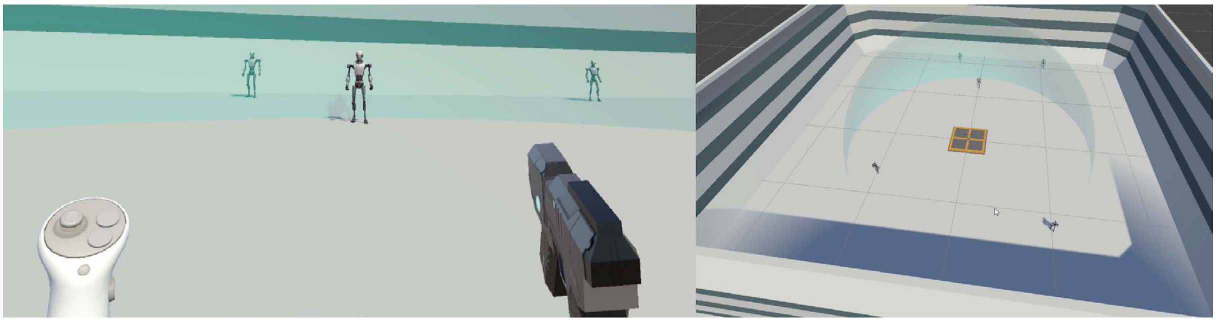

Figure 1: Left: First-person view of the player with a controller and weapon, and multiple enemies positioned around the player. Right: Top-down view illustrating the spatial configuration of enemies and the sphere of a localization tool (radial shockwave).

4. Ongoing experiments

4.1. Hypotheses

(H1.a) M1 is expected to require multiple successive activations to progressively build a mental representation of enemy distribution, before the first shot. **(H1.b)** M2 & M3 are expected to be used more frequently during combat, as they provide a direct localized and rapidly accessible information that supports real-time decision-making.

(H2) M3, which relies on active body movement, is expected to improve players' understanding of relative enemy positions, but may also be perceived as more physically demanding over time.

4.2. Experimental Procedure

Each session lasts approximately an hour. The three localization methods (M1, M2, and M3) constitute the experimental conditions. Participants only test one method per block. For each block, a short training phase allows participants to explore the technique with idle enemies placed around them, ensuring proper understanding of the interaction. This is followed by a combat phase in which participants must eliminate all enemies before losing all health points. The difficulty increases progressively through variations in the number and speed of enemies. Throughout the experiment, quantitative data are collected, including the number of levels successfully completed or failed, player movement trajectories, tool activations, robot eliminations, and level completion times. After each condition, an oral questionnaire is conducted to capture immediate impressions regarding usability and perceived effectiveness. Short breaks are provided between conditions. We aim to recruit at least eight blind and low-vision participants.

4.3. Focus Group

A semi-structured focus group is conducted remotely within one week of the individual sessions to facilitate scheduling and collect delayed feedback after participants have had time to reflect on their experience. Each focus group consists of up to four participants. The discussion provides an opportunity for participants to revisit and collectively exchange on their experiences with the different interaction techniques. The session is structured around several themes (1) perceived effectiveness and preferences across methods, (2) contextual factors influencing usability (e.g., number of enemies, speed), (3) physical and cognitive load,(4) strategies developed to compensate for limitations, (5) perceived contribution of VR compared to traditional games. The discussion also explores how these techniques could be adapted to different gameplay situations.

This participatory approach aims to involve users directly in the design process and to iteratively refine assistive tools based on their feedback.

5. Conclusion

The aim of this ongoing study is to collect feedback from BLV players on prototype assistive solutions within a VR shooting mini-game. Through post-experiment discussions, we seek to iteratively refine these tools in order to design solutions that are usable and effective in VR combat situations. Additionally, this work aims to explore the potential relevance and appeal of virtual reality games for BLV players. Beyond this study, several research directions emerge. First, future work will involve integrating and consolidating complementary assistive techniques, both those proposed in this paper and existing approaches from prior work (Nair et al. 2021, 2024, Apavou et al. 2024), into unified systems. A key challenge will be to understand how these techniques can effectively complement each other while avoiding redundancy and preventing auditory overload within already dense game soundscapes, potentially by distributing information across modalities such as haptics. Second, extending localization tools with obstacle and environment awareness could support a more complete understanding of scene layout, enabling players to develop more advanced strategies. Finally, these approaches may generalize beyond gaming contexts to VR applications where situational awareness is critical, such as social and collaborative virtual environments.

Acknowledgments

This work was partially supported by the French PIA grant ANR-21-ESRE-0030 CONTINUUM, and by the PEPR ICCARE program receiving government funding managed by the French National Research Agency under France 2030, reference ANR-23-PEIC-0001.

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