Section 2: Research Methods

2.1.1 Method 1: Documentation Review (Valdyslav Lohvynovskyi)

We analysed academic papers concerning game accessibility for individuals with hearing impairments. This enabled a deeper understanding of the issue and revealed existing solutions.

2.1.1.1 Article 1: Accessibility for Gamers with Hearing Impairments (Costello et al., 2019)

Full title: 'How to Make Video Games More Accessible for Gamers with Hearing and Visual Impairments'

Authors: Robert Costello, Murray Lambert, Florian Kern

Journal: International Journal of R&D Innovation Strategy, Vol. 1, No. 1, pp. 16-32.

According to Costello, Lambert, and Kern (2019), about 15% of the global population experiences some degree of hearing loss. It has also been shown that about 20% of gamers have some form of disability. This has been proven and validated by previous research done by Hamilton (2013). Finally, it is said that while subtitles alone are not enough for hearing-impaired gamers, they also have a need for visual information on direction and distance.

Recommendations in this paper regarding subtitles:

This paper is based on the best practices suggested by Hamilton 2015 and Williams 2009 regarding subtitling. Hamilton (2015) proposes increasing the contrast between text and background. It also proposes limiting the number of texts that are to be shown at any given time. William (2009) says every subtitle should not be over three lines. Each line should, wherever possible, not contain more than 32 to 34 characters.

Recommendations regarding visual cues:

Deaf viewers utilise facial expressions where possible. That is, in realistic games, lip-reading enhances immersion. Alternative visual cues within the game environment can potentially improve accessibility (Barlet and Spohn, 2012).

How it works in SoundSight: Subtitles alone should not be relied upon. Our radar and visual indicators address directional issues. Regarding text size and contrast, we follow the recommendations of Hamilton (2015).

2.1.1.2 Article 2: Accessible Audio Toolkit (Naranjo et al., 2021)

Full title: 'Developing a Video Game Accessibility Toolkit for the Deaf and Hearing Impaired'

Authors: Omar Naranjo, Gonzalo Pérez, Manuel López Ibáñez, Federico Peinado

Published in: CEUR Workshop Proceedings, Vol. 3082, 2021

Research Background:

Deaf people make use of facial expressions when possible. That is, lip-reading is an immersion-enhancer in realistic gaming. Other visual alternatives within the gaming environment have the theoretical capacity to enhance accessibility as suggested by Barlet and Spohn (2012).

Subtitle System: It separates dialogue subtitles from event subtitles. Event subtitles include elements like gunshots and explosions. It is very easy to customize. A user can set the position, font size, characters per line, color, and display duration. It follows guidelines outlined by Netflix in 2021.

Compass: The compass shows the direction of sound with relation to your direction. It is very graphically rich. The position on the compass shows you direction, size shows sound strength (stronger sounds are larger), color shows type, and a small up/down arrow shows if it's above or below.

3D Radar: The 3D Radar is an extension of this idea into three-dimensional space. It translates sound into a sphere whose surface changes shape based on the direction from which the sound source is approaching, creating vertices. The height of these vertices relates to the strength of the sound signal, and colors stand for different types of sound. Importantly, it shows sounds from all directions and even from behind.

The set of tools was tried on 25 people under a simulated hearing-impaired scenario with all sounds completely turned down. An A/B experiment took place, with half the group proceeding without the tools and the rest using them. Most participants also agreed that shooting games were among those most requiring these tools. Improving subtitling and sound radar were among the specific demands made by people without tools. The compass obtained very positive judgments, but primarily on sound representation from front and side directions. The 3D radar obtained 75% approval, but it couldn’t allow sounds from directly behind a player (Naranjo et al., 2021).

How SoundSight works: We decided to combine the ideas of the compass and the radar. SoundSight's 360-degree radar is designed to resolve the limitations a standard compass has regarding “behind”, visually encoding the intensity and type of sound, similar to that used in AAT.

2.1.1.3 Industry Examples

Examples given include games. Naranjo et al. mention “Innovation in Accessibility” at Game Awards 2020. It emphasizes games that have been recognized with nominations for Innovation in Accessibility at The Game Awards 2020.

The game ‘The Last of Us Part II’ is normally cited as an example of an accessible game. According to Naranjo et al. (2021), there exist predefined settings that favor players with different disabilities. It is accessible for people with hearing disabilities because it contains arrows pointing towards sources of harm, messages on-screen that alert about detected

enemies, and arrows pointing towards movement if a player is lost. Subtitle size, color, and background can be customized, and speaker and arrows towards directions are shown.

Fortnite Battle Royale becomes an important reference source for hearing-impaired people as well. By “Visualise Sound,” there is an indication depicted as a ring with an icon that represents footsteps, gun effects, and gun builds, as well as chests and cars. Distance continues to be indicated with color changes and degree changes based on a certain distance. Deaf gamers believe that the implemented system within Fortnite should be implemented within all gaming tools.

Other titles for the candidates are Hyperdot (McGregor, 2019), Grounded (Brenneke, 2020), Assassin's Creed Valhalla (Ismail et Baptizat, 2020), and Watch Dogs: Legion (Hocking and Hudson, 2020), and they tackle different avenues on making gaming accessible via multi-sensory interfaces.

2.1.1.4 Literature Review Summary

In a nutshell, there exist some exemplary examples from literature and practice that culminate at one and the same result. An unignorable percentage of gaming enthusiasts suffer from some disabilities. That is why accessible gaming emerges as a heavy-duty task with serious ethical and monetary implications (Hamilton, 2013). Solutions should implement more than mere subtitles. Enthusiasts who are deaf or hard of hearing should get a visible indicator for direction and distance, and it should be done at a reasonable latency within competitive gaming sessions (Costello, Lambert, and Kern, 2019). Solutions with radars and compasses have already proven their efficacy within testing procedures among researchers (Naranjo et al., 2021), and work well for the shooting game genre, in which audible cues regarding direction play a significant role in the game dynamics.

2.2.1 Method 2: Similar Systems Research (Saba Sturua)

Objective: Evaluate existing accessibility solutions and their effectiveness.

Systems to Analyze
Built-in Game Features

- Fortnite (visual sound effects)
- The Last of Us Part II (comprehensive options)
- Minecraft (visual subtitles)

2. Third-party Solutions
    - Audio radar applications
    - Haptic feedback devices
    - Visual notification systems

Evaluation Criteria:

- Feature completeness
- Latency and performance
- Customization options
- User satisfaction ratings

2.2.3 Requirements

2.2.3.1 Functional Requirements:

1. System shall display a 360-degree sound radar
2. System shall show edge indicators for off-screen sounds
3. System shall classify sounds by type
4. System shall use color codes for threat levels
5. System shall show distance through icon size
6. System shall provide haptic feedback patterns
7. System shall allow custom color and size settings
8. System shall save and load user profiles
9. System shall support voice-to-text for team chat

2.2.3.2 Non-functional Requirements:

1. Latency shall be under 50ms
2. CPU usage shall be under 5%
3. Setup shall take under 5 minutes
4. System shall work on PC, console, mobile
5. Visual indicators shall not block gameplay

2.2.3.3 UX Requirements:

1. Interface learnable in one gaming session
2. Icons distinguishable in peripheral vision
3. Colors shall work for colorblind users
4. High contrast between indicators and game
5. Pre-configured profiles available for popular games

3 Design Concepts and Scenarios (Maleck Oubeid)

Core Design Principles
Real-time Processing: <50ms latency requirement
Customizability: Adaptable to individual needs and preferences
Non-intrusive: Maintains gameplay flow and competitive integrity

Concept 1: Multi-Modal Feedback System

Visual Components

360° Sound Radar (Central HUD showing sound sources)

- Color coding (red: threats, yellow: caution, green: allies)
- Size indicating proximity/volume
- Movement trails showing direction

Edge Indicators: Directional arrows for off-screen sounds

- Pulse frequency for urgency
- Shape differentiation for sound types

Environmental Integration:

- Footstep ripples on ground
- Muzzle flash directional indicators
- Explosion shockwave visualization

Haptic Feedback:

- 20+ unique vibration patterns
- Directional feedback (left/right controllers)
- Intensity scaling with proximity
- Custom pattern creator

Concept 2: AI-Powered Sound Recognition

Machine Learning Features

- Game-specific sound signature learning
- Automatic priority adjustment based on player behavior
- Predictive alerts for sound sequences
- Community-shared learning data

Adaptive Intelligence

- Learns which sounds players respond to most
- Filters non-essential audio
- Adjusts notification timing for optimal response
- Handles game updates automatically

Concept 3: Community Ecosystem

Profile Marketplace:

- User-created configurations
- Rating and review system
- Search by game, genre, playstyle
- One-click installation

Social Features:

- Live coaching mode with visual overlays
- Accessibility tutorials
- Tournament-approved settings
- Streamer integration tools

Use Case Scenarios:

Scenario 1: Competitive FPS (Sarah, 22, Deaf Since Birth)
Situation: Defending bomb site against multiple enemies

SoundSight Response

- Radar shows 3 approaching enemies with directional indicators
- Footstep ripples increase in size as enemies approach
- Controller vibrates in "heartbeat" pattern for multiple threats
- Defuse sound creates specific visual pulse pattern
- Flashbang warnings appear as yellow screen edge flashes

Outcome: Successfully defends using visual/haptic information to pre-aim and time peeks

Scenario 2: Story Game (Marcus, 45, Recently Deaf)
Situation: Exploring atmospheric horror environment

SoundSight Response

- Ambient sound descriptions: "[Distant infected clicking]"
- Music tension shown through border color gradients
- Enemy echolocation displayed as sonar pulses

- Environmental cues: "[Window creaking]" with directional arrow
- Dialogue includes emotional tone indicators

Outcome: Full atmospheric experience without missing audio-driven elements

Scenario 3: Battle Royale (Alex, 16, Hard of Hearing)
Situation: Final circle with hearing teammates

SoundSight Response:

- Building sounds shown through structural indicators
- Chest locations pulse when nearby
- Vehicle approach creates expanding minimap circles
- Voice chat converted to preset callouts
- Weapon rarity sounds have unique signatures

Outcome: Equal contribution to squad success

Technical Specifications [ARCHITECTURE DIAGRAM HERE]

Performance Requirements:

- Processing latency: <30ms average, 50ms maximum
- CPU usage: <5% on modern processors
- RAM: <200MB footprint
- GPU acceleration for visual effects

Platform Support:

- PC: Windows 10/11, MacOS, SteamOS
- Console: PS5, Xbox Series X/S (companion app)
- Mobile: iOS 14+, Android 10+
- VR: Limited support for Meta Quest 2/3, PSVR2

Prototype Development Plan:

Phase 1: Core Functionality (Weeks 1-4)

- Basic sound detection and classification
- Simple radar visualization
- Latency optimization

Phase 2: Advanced Features (Weeks 5-8)

- AI learning implementation
- Haptic feedback integration
- Customization interface

Phase 3: Community Features (Weeks 9-12)

- Profile sharing system

- Social features
- Developer API

Ethical Considerations

Inclusive Design Process:

- Deaf gamers involved at every stage
- Diverse perspectives represented
- Avoid hearing-centric assumptions

Data Privacy:

- Anonymized learning data
- Opt-in sharing only
- Transparent data usage

Fair Competition:

- Tournament-legal configurations
- No unfair advantages
- Transparency in competitive settings