Accessible Game Design: Exploring Innovative Technologies for Blind Players

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ABSTRACT

The paper focuses on enhancing digital game accessibility for blind players through Universally Accessible Game Design and assistive technologies like haptic feedback and echolocation. It aims to improve game accessibility and experience for blind players by addressing game development challenges for inclusivity. The paper suggests further research on integrating echolocation, AI for testing and audio descriptions, and developing more advanced haptic feedback systems to make gaming more inclusive and enjoyable for all, including those with disabilities.

CCS CONCEPTS

• **Applied computing** → **Computer games**; • **Human-centered computing** → **Accessibility**; • **Human computer interaction (HCI)**;

KEYWORDS

blind, accessibility, gaming, digital games, navigation, tools, AI

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1 INTRODUCTION

Today's accessible games for blind players are mainly games that are developed directly for them [7]. While these games are enjoyable, mainstream games are a serious challenge for blind players because they consist of complex environments, mechanics and interactions with *Non-Player Character* (NPC) players or even real players in *Player versus player* (PvP) games.

Implementing accessibility features is much needed in digital games to ensure that everyone, including people with disabilities can enjoy gaming. However, game developers in general face various problems in the process of developing games, some of them are:

- Diverse Needs
- Technical Challenges
- Design Compromises
- Standardization

So, the main idea of this paper is to give a broad insight into *Universally Accessible Game Design* (UAGD), which addresses the previously mentioned developing problems. Additionally, this study explores different and innovative accessibility features and tools, including haptic feedback and its ways to improve game experience, which is a major technical challenge.

This raises following relevant research questions (RQ) that contribute to blind players playing visual-centric digital games:

- RQ1: How can UAGD improve the development of games with regard to accessibility? (subsection 5.1)
- RQ2: In what ways can haptic feedback enhancements improve the game experience for blind players? (subsection 5.2)
- RQ3: Which innovative accessibility features and tools can enhance the gaming experience for blind players? (subsection 5.3)

1.1 Motivation

One big step forward making mainstream games more accessible for blind players was the game *The Last of Us Part II* (TLOU2) [15, 14]. According to Leite and Almeida [12] the game company *Naughty Dog* implemented more than 60 accessibility features and is considered as the most accessible game ever produced.

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Additionally, Dale [6] described that the game can be played all the way through with audio cues and navigation aids. It includes preset accessibility options, as shown in Figure 1, for common disabilities such as hearing or vision impairments. It also introduces accessibility menus when the game is first started, making it easier for players with disabilities to adjust settings. To top that, *Naughty Dog* released a remastered version of TLOU2 in 2024 with a reworked *Cinematic Audio Descriptions* feature [16].

In the past, video games were not designed with accessibility in mind, which resulted in bad gaming experience for people with disabilities. Over time, however, game companies began to develop and include accessibility features in their games, significantly improving the gaming experience for disabled players.

Nevertheless, there are still many games that have not been developed in a way that everyone can play them. With a focus on blind players, this paper aims to find a way to support the development cycle of games as well as explore existing accessibly features and ways to improve them.

2 THE PROBLEM

Blind players encounter many different barriers when playing visual-centric digital games, which often rely mainly on graphical interfaces and visual cues. Additionally, games have different perspectives such as top-down, first-person, and third-person views, where all three views give the player unique challenges in navigating within game environments, understanding game objectives and interacting with in-game elements like players or objects.

Popular games, such as *The Legend of Zelda* rely mainly on visuals. For blind players, this is obviously a big problem because they miss a lot of important information on how to complete tasks or what is happening around them.

As Gonçalves et al. [7] states, players express feelings of frustration, telling their viewers the need for more and better accessibility features, so that everyone including blind players can have a great game experience.

Building on that, the authors of Gonçalves et al. [7] have categorized seven themes and identified unresolved barriers (see Figure 2) that still represent a great challenge for both players and developers.

Figure 2 gives a great overview what accessibility features are still missing and in which direction the gaming industry should focus.

3 MY IDEA

The gaming industry came a long way from no accessibility features and assistant tools at all to implementing more than 60 accessibility features in one game [15]. According to research papers [7, 9, 8, 3] some of the most important accessibility features for blind players in visual-centric games include:

- Audio Cues and Descriptions
- *Text-to-Speech* (TTS) and Voiceover
- Navigation Aids and Wayfinding Tools
- Comprehensive Audio Design
- Customizable Controls and Inputs
- Tactile Feedback and Controller Design

Some of these have already been implemented to a certain extent in some games, but as Figure 2 notes, there are still problems. Especially when it comes to the environment, pathfinding, perspective and interacting with the world, blind players face major challenges, which according to Gonçalves et al. [7] could mean they stop playing these games because they simply can not find the right way to play.

To address the environment and pathfinding problems, one new technology was introduced in 2018 by Andrade et al. [2] to use echolocation to explore a virtual environment, which could drastically improve navigation in it. As for perspective (camera) and interacting with the world, hardware solutions like haptic feedback or *Artificial Intelligence* (AI) tools could be a solution when developed and integrated further. Whereas the haptic feedback [4] of, for example *PlayStation 5* (PS5) controllers [1, 5], could indicate the environment they are walking on by adjusting the vibrations.

The goal is to find an answer to the research question above by researching the field of UAGD, how to use haptic feedback to improve accessibility features and to find new ways to enhance existing accessibility features and tool in combination with AI. Therefore, game developers should use the UAGD as a guide and ensure that all important accessibility features listed above are included in their games.

4 RELATED WORK

As digital games continue to evolve making them more complex to play, accessibility becomes increasingly more important. This section provides a deeper insight into related work that has contributed to the understanding of the importance of accessibility in visual-centric digital games.

4.1 Themes of accessibility

The paper Gonçalves et al. [7] explores the strategies blind players use to play visual-centric mainstream games. It analyzes over 70 hours of YouTube content from blind players to identify the strategies and methods they use to navigate and interact within games environments.

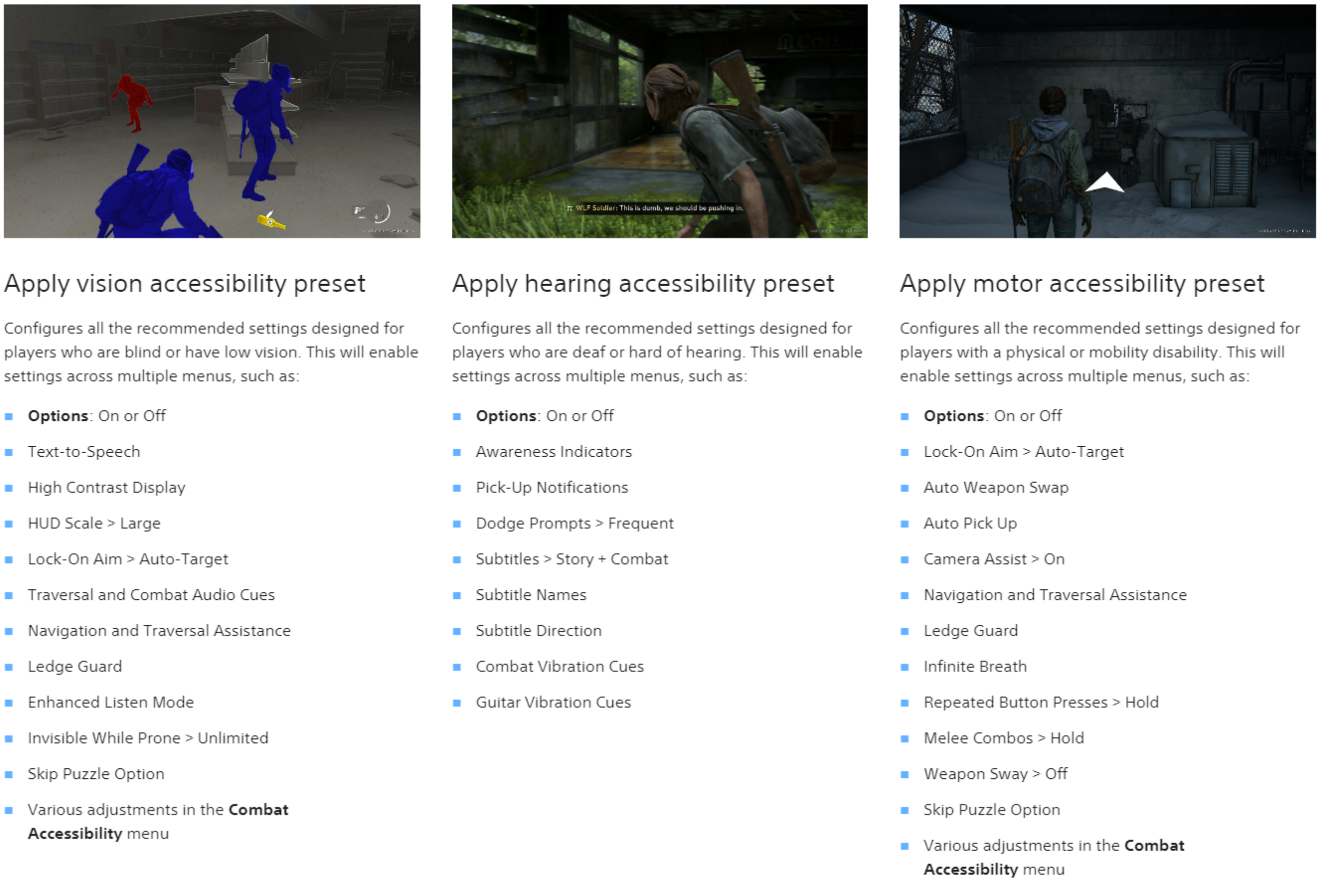

Figure 1: Accessibility presets in TLOU2 (Source: PlayStation [14])

The study highlights that blind players often rely on audio cues to understand and navigate within game environments. They use repetitive actions like bumping into a wall to create a mental map of the environment. Players also try to create landmarks by interacting with the game world, for example, by leaving enemies behind to know in which area they are at the moment. This approach helps to navigate within game environments but also scare of new blind players due to frustration if the player become disorientated.

The result of their findings are seven themes focusing on describing strategies blind players created and adopted: (See Figure 2)

- Understanding the surroundings
- Wayfnding in virtual environments
- Dealing with perspective
- Interacting with the world
- Preparation, demand and cognitive load
- Automation and difficulty
- Playing with others

Additionally, Figure 2 shows us the existing barriers mainstream games have.

The paper also acknowledges the efforts of some game developers to make new and existing games more accessible to blind players. This approach by developers is essential for reducing the accessibility gap in the upcoming years of game development.

4.2 Inaccessibility in Games

In 2008 Grammenos [8] developed a game called *Game Over!*, which is the first universally inaccessible game, created as an educational tool to teach game developers about accessibility guidelines. This approach aimed to raise awareness and motivate game developers to make their games accessible for everyone.

The developed game *Game Over!* has 21 levels implemented, each one violating a specific game accessibility

T1. Understanding the surroundings. Leveraging spatial audio, discerning sound effects (e.g., footsteps, voice lines) and soundscape changes (e.g., audio treatment). Feeling through bumping and interacting with objects.	*Surroundings (Untackled barriers):* Elements not interacting with the player are often silent; Time-sensitive challenges hinder feeling around; Occlusions.
T2. Wayfinding in virtual environments. Navigating based on landmarks (sound or collision) and authoring new ones; Re-orienting by reaching a familiar spot (respawning, save states); Semi-automatic navigation.	*Wayfinding (Untackled barriers):* Objective indications are visual-only (markers, text); Own movement is not perceived; Irrelevant sounds attracting players.
T3. Dealing with perspective. Remapping camera control, recentering through key-binds, and adjusting sensitivity; Leveraging aim assistance; Perceiving height changes based on landing sounds.	*Perspective (Untackled barriers):* Misunderstanding camera yaw (aiming too high or too low); Height changes are ignored and platforming is inaccessible.
T4. Interacting with the world. Experimenting with controls; Button mash to check for interactions; Avoiding fine-grained interactions (resorting to area effects); Curating abilities and features (accessibility paths).	*Interacting (Untackled barriers):* Prompts are inaccessible or do not provide context; Precise aligning and aiming; Complex interactions (e.g., stealth, taking cover).
T5. Preparation, demand & cognitive load. Memorizing controls; Maintaining a mental map; Consulting walkthroughs and guides; Unintuitive and overwhelming sounds; Keeping up with the game state (e.g., health).	
T6. Automation & difficulty. Settings automating or reducing the challenge; Playing a game differently but able to participate.	
T7. Playing with others. Sighted co-players and spectators describing the surroundings, menus, and controls; Co-piloting by distributing controls; Collaborating and gaining autonomy; Latency and cumbersome assistance.	

Figure 2: Seven themes and respective unresolved barriers (Source: Gonçalves et al. [7])

guideline to frustrate but also educate by directly showing the developer what impact their design decisions have. Some of the guidelines are:

- Require complex key combinations
- Rapidly changing control schemes
- Presenting information in inaccessible formats

Collected feedback from developers and players through surveys and public discussions indicate that the game raises awareness and educates about accessibility as intended. It was also suggested to include direct access to additional information about each violated guideline, such as how specific accessibility can improve the game experience for disabled players.

The feedback also highlighted to add more levels to cover a wider range of accessibility guidelines, which would add the potential to adapt the concept and further improve it as well as to highlight the importance of game design in digital games.

4.3 Navigate a virtual environment using echolocation

In 2018 Andrade et al. [2] investigates the use of echolocation to help blind players to navigate within a game environment. This approach aimed to investigate whether it is possible to create a *virtual environment* (VE) where players can simulate echolocation to navigate and understand complex scenes within that VE.

Therefore, they developed a VE with Unity 5.6 and the SteamAudio plug-in. This VE basically represents a three level house called *Echo-House*, where users can navigate using sounds such as mouth-clicks, claps and footsteps, which generate echoes to receive information about the environment. Each level had a goal players needed to reach to get to the next level of the house (See Figure 3).

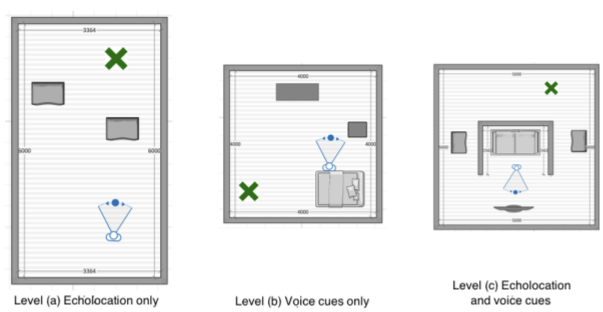

Figure 3: Layout of the three levels (Source: Andrade et al. [2])

The evaluation consists of a 45-minute playing session followed by an interview. They found out that the echolocation provided the player with an improved sense of space within the VE. However, challenges in orientation and mobility were still present, which indicates the need of further support.

The paper highlighted the limitation of the study such as the small sample size and the need for further research to validate their findings. Nevertheless, this work provides an important insight into the possibilities of using echolocation to help blind players.

5 THE DETAILS

In this section, we delve into enhancing accessibility in digital games for blind players. Firstly, we aim to explore previously mentioned developing problems in section 1, from diverse needs and technical challenges followed by design compromises and standardization efforts. Secondly, we explore various types of feedback, which are essential in enhancing of accessibility in digital games and focus on haptic feedback as well as further possibilities to use that to improve the experience in digital games for blind players. Lastly, we propose enhancements of already existing accessibility features and tools.

5.1 Universally Accessible Game Design

In recent years, the awareness of accessible game design has been growing tremendously. According to the *World Health Organization* [13], one out of ten persons has disabilities, which often results in limitations in hearing, memory, vision or motor functions.

5.1.1 Addressing Diverse Needs. Digital games are getting more demanding in terms of limitations and this is where UAGD comes into play. Through the implementation of UAGD, players with diverse needs can benefit from features such as support for alternative input devices, including switches, eye-tracking systems, and mouth-operated controllers, which as a result can drastically enhance the game experience. By implementing these features, UAGD ensures that games are accessible to players with various disabilities, ensuring that games are enjoyable for a wider audience.

5.1.2 Technical Challenges. Implementing UAGD presents several technical challenges including compatibility with different hardware and the scalability of accessibility features. By using a user-centered approach, as presented by Grammenos et al. [10], developers can integrate accessibility into the game development cycle and ensure that technical challenges are considered from the beginning of the project. The basic steps are (See Figure 4):

- Abstract task-based game design
- Polymorphic specialization with design alternatives
- Appropriateness analysis for the design alternatives
- Compatibility analysis among design alternatives
- Prototyping
- Usability and accessibility evaluation

An elaboration of these steps is provided in Grammenos et al. [10].

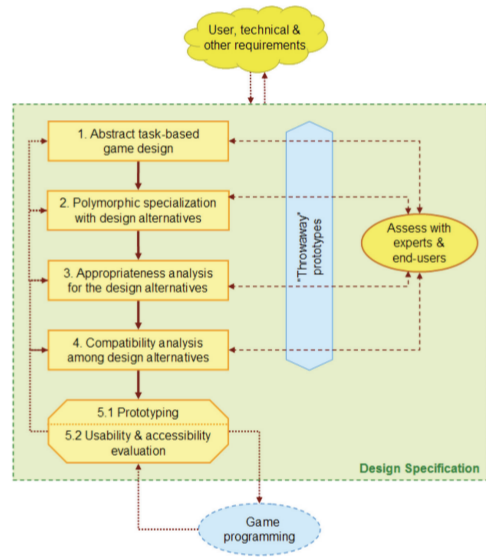

Figure 4: Applying UAGD (Source: Grammenos et al. [10])

5.1.3 Design Compromises. UAGD encourages developers to rethink design approaches, so that all players can enjoy the game they are developing. This includes reimagining game mechanics, levels, and interfaces to ensure everyone gets the best game experience without destroying the game's core idea. The key here is to create games that are challenging and fun for all players, regardless of their abilities.

5.1.4 Standardization Efforts. An important aspect of UAGD is to push towards standardizing accessibility features in all games. To achieve that, common guidelines and best practices are needed, so that the gaming industry can create a more standardized approach to accessibility, making it easier for developers to implement these. One key aspect of this is sharing these approaches and ideas with the software community as well as making the implementations open source.

In summary, UAGD is not just about making games playable for players with disabilities. It should redefine how a game is developed and designed, so that the needs of all players are satisfied.

5.2 Assistive haptic feedback

Assistive haptic feedback gets increasingly more important, especially in the gaming industry [11]. In this section we delve into innovative approaches to enhance the gaming experience for blind player through tactile technologies. First, we will give an overview of sensory perception which consists of visual (sight), haptic (tactile), and aural (hearing) as shown in Figure 5. Then we will explore different possibilities to enhance game experience with haptic feedback.

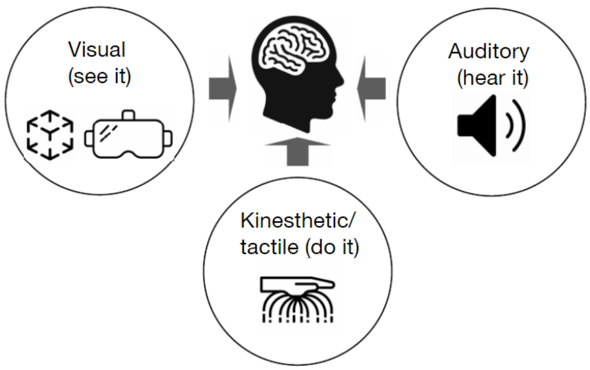

Figure 5: Sensory perception (Source: Sanfilippo et al. [18])

5.2.1 Sensory Perception in Gaming for Blind Players. Visual perception, which the player mainly get though sight, is often the primary interaction in most games. However, for blind players, haptic and aural senses are the key.

Haptic feedback is the sense of touch providing a physical response by vibration to the player [5, 11, 4], which represent various actions in a game like drawing a bowstring or shooting a weapon. For example, a haptic glove could simulate the sensation of raindrops falling on a player's hand or the resistance encountered when pushing against an in-game object.

Aural feedback, in the other hand, provides sound to transfer information. For example, the sound of footsteps can indicate that an ally or enemy is approaching, while footstep sounds changes indicate a transition from one area to another, such as moving from a city street into a quiet building.

5.2.2 Enhancing Gaming Experience through Assistive Haptic Feedback. Assistive haptic feedback helps blind players feel and interact with game worlds through touch. This form of feedback offers a new dimension of immersion and accessibility. For example, vibration can be designed in a way that they give information to the player by providing them with different vibration patterns on various surfaces such as uneven roads or a sandy beach. By doing that, players receive a sense of location and movement within the game environment.

Beyond that, advanced haptic technologies like shape-changing interfaces or dynamic touch surfaces [17] can simulate more complex interactions. These could include the sensation of touching sand or feel the resistance when drawing a bowstring by using a haptic glove mentioned previously. This feedback technology could also help in navigating within a game environment, where pulses could indicate the direction a player has to go. This not only makes games more accessible to blind players, but also increase the dimension of immersion for all players.

Considering the impact of standardizing this technology as a guideline within UAGD, making it a straightforward implementation for developers would help the game industry tremendously in terms of accessibility.

5.3 Ways to improve existing accessibility features and tools

In this section we explore strategies to improve accessibility for blind players. We are focusing us here on two promising advanced technology ideas:

- AI-Enhanced Testing and Audio Descriptions
- Combining AI with echolocation techniques

5.3.1 AI-Enhanced Testing and Audio Descriptions. By implementing AI into the cycle of game development, we could significantly improve the accessibility for blind players by integrating it into the testing phase of the game. After collecting enough data about accessibility, the AI could automate the testing phase, identifying accessibility issues or UAGD guideline violations that are not immediately visible to the developer. This would ensure that games are designed the right way from the start.

Additionally, by letting the AI collect data during game play tests, it could generate real-time audio descriptions of game environments and player actions which could improve the gaming experience for blind players. The generated descriptions can then be customized to the needs of individual players.

To implement this method, additional research and testing are required. This approach would greatly help developers in designing future games.

5.3.2 Combining AI with Echolocation for Navigation. Combining AI with echolocation technology could assist blind players in navigating within game environments. The AI could interpret the echolocation signals, which could be combined with haptic or aural feedback, helping players understand their environment. For example, a glove or body armor as haptic feedback devices could receive the signals, process them to create a detailed map of the surroundings which provides the player with a much better understanding what is happening.

For this technology to be fully realized, further research like Andrade et al. [2] is required. This approach is promising for not only enhancing the experience for blind but all players.

6 CONCLUSIONS AND FURTHER WORK

This paper addressed the challenge of enhancing accessibility features in digital games for blind players. Our proposed solution is centered around *Universally Accessible Game Design* (UAGD) and innovative assistive technologies like haptic feedback and echolocation. This solution aims to improve the needs of blind players in current games.

6.1 Conclusion

Our findings offer answers to the proposed research questions, highlighting how UAGD (RQ1) can improve game development for better accessibility, how advancements in haptic feedback (RQ2) can significantly enhance the gaming experience for everyone and ways to improve existing accessibility features and tools (RQ3) by using AI.

6.2 Further Work

There are still open challenges, such as the full integration of echolocation techniques, and further research is needed on the use of AI in test phases and the creation of audio descriptions. Future studies should focus on the echolocation technology for gaming, exploring AI in creating dynamic audio descriptions and identifying missing accessibility features, and developing more haptic feedback systems.

Our study opens the door to new opportunities to make digital games and their development a better experience and to ensure that advancements in gaming technology can be enjoyed by everyone, including those with disabilities.

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