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HUMPLAY: Exploring Sound-Based Interaction in Games for Enhanced Accessibility and Inclusivity

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Abstract

HUMPLAY introduces an interactive game designed for deaf and mute individuals, utilizing visuals and vibrations to convey musical elements and interactive play features. This system incorporates non-verbal controls, specifically using humming and sound frequencies, where the pitch controls character action. This approach breaks traditional communication methods to establish a platform that is inclusive, creative, and supports emotional connection. The research details the design, implementation, and evaluation of HUMPLAY, emphasizing its innovative features, technical architecture, and potential impact on accessible gaming. The project is a substantial effort to bring inclusive gaming and technology to the deaf and mute communities.

Keywords: Accessible Gaming, Deaf and Mute Individuals, Non-Verbal Control, Humming, Sound Frequencies, Pitch Detection, Visual Cues, Inclusivity.

I. INTRODUCTION

Digital entertainment, including gaming and music platforms, offers creative spaces, emotional support, and social connection for millions. However, these same experiences present significant barriers for deaf and mute individuals, limiting their full participation. A great majority of popular games are sound-heavy in design, relying on audio cues, dialogue, and music for immersion and to pass along key information. Music-based platforms are also predominantly centered around audio feedback. For non-speaking users, issues arise in multiplayer games and musical projects requiring audio communication. These challenges cause a sense of isolation, widening the gap between inclusive design principles and actual practice.

Deaf and mute individuals face barriers when interacting with tools that are mostly auditory, which blocks complete participation in platforms like music and games and hinders creative expression and emotional engagement. The absence of auditory feedback limits their ability to fully engage with sound-oriented digital spaces.

HUMPLAY addresses this problem by offering a multisensory system that translates music and sound into visual and tactile forms, allowing users to fully participate in sound-oriented digital spaces. It is one of the first accessible games where non-verbal control is possible, using humming and pitch frequencies incorporated as game mechanics. A key milestone was introducing a system using visual feedback that completely substitutes old sound-based instructions. This increases engagement and facilitates active learning for all players.

The core objectives of the HUMPLAY project are:

- ✓ To design and create an accessible gaming platform that allows deaf and mute players to interact via humming and sound frequency detection, mapping vocal vibrations to game actions.
- ✓ To stimulate user's creativity and self-expression in a game environment utilizing visual and tactile feedback.
- ✓ To promote the development of rhythm and timing through visual.
- ✓ To enhance emotional player engagement by translating sound expression into tension and rhythm, reinforcing the game's mood and intensity in alternative forms.
- ✓ To offer an exciting game that improves focus, hand-eye coordination, and sensory perception.

II. LITERATURE SURVEY

I. Sr. no.	II. Paper title and it's Author	III. Details of Publication	IV. Finding	V. Methodology
VI. 1	VII. The Role of Haptics in Training and Games for Hearing-Impaired Individuals Andrea Gulli, Federico fontata	VIII. DEC 2024(MDPI)	IX. Research on haptics for hearing-impaired training has increased in recent years. Most studies (77.14%) evaluate the effectiveness of rehabilitation methods. Vibrotactile devices that convert sound into vibration can successfully transmit aspects of sound through touch.	X. Systematic Review of literature analyzing trends and effectiveness of haptic devices in hearing-impaired training.
XI. 2	XII. How to Design Games for Deaf Children: Evidence-Based Guidelines Alessandra Melonio and Rosella Gennari	XIII. 2024springer	XIV. Electronic games can enhance visual and working memory abilities in deaf children. Effective game design for deaf children should focus on visual clarity, non-verbal communication, and adaptive pacing. The TERENCE project	XV. Literature Review and Synthesis of findings from field studies and the TERENCE project to create evidence-based game design guidelines.

			provides practical examples of smart games tailored for deaf users.	
XVI. 3	XVII. Intelligent gloves: An IT intervention for deaf-mute people Amal Babour*, Hind Bitar	XVIII. 2022 DE Gruter	XIX. IG functioned as expected, enabling two-way communication between deaf-mute and non-deaf-mute users. Participants found it usable and acceptable, showing potential to bridge communication gaps using low-cost assistive technology.	XX. Prototype Development and User Testing with 10 participants to evaluate usability and acceptability of a two-way communication glove system.
XXI. 4	XXII. Games for Education of Deaf Students – A Systematic Literature Review Costa, C., Marcelino, L., Neves	XXIII. 2019 Research gate	XXIV. Game-based learning showed positive effects on cognition and learning for deaf children, including those with cochlear implants.	XXV. Systematic Literature Review (SLR) evaluating 12 studies on the effects of game-based learning for deaf students' cognition and learning.
XXVI. 5	XXVII. Smart Assistant for deaf and mute using Micro Bit Intesar Abd Ul-Salam Asa'ad	XXVIII. May 2025 Research gate	XXIX. The micro:bit watch enabled simple communication and sound alerts for deaf-mute children. Younger children (under 6) benefited most. The device proved low-cost, easy to use, and effective in improving interaction and independence.	XXX. Prototype Development and Experimental Evaluation involving testing a low-cost micro:bit watch device on 10 deaf-mute children.
XXXI. 6	XXXII. "Serious Game as Support for the Development of Computational Thinking for Children with Hearing Impairment" A. L. Marciales, R. H. Villamil, N. C. Villamil	XXXIII. December 2020 MDPI	XXXIV. The "Perdi-Dogs" serious game was highly motivating for children with hearing impairments. The game effectively helped in developing computational thinking skills..	XXXV. Case Study/Quasi-Experimental Design evaluating the impact and motivation of a specific serious game ("Perdi-Dogs") on computational

				thinking skills in seven children.
XXXVI.	XXXVII. Dartanan: Prototype evaluations of a serious game to engage children in the calibration of their hearing aid functionalities“Madeline Halleswell, Davide Salanitri	XXXVIII. July 2021Research Gate	XXXIX. The game prototype successfully engaged children in the process of calibrating their hearing aids.	XL. Mixed-Methods Prototype Evaluation involving three stages of testing (formative and summative) and an online survey on a sample of 106 children.
XLI. 8	XLII. "A Novel Machine Learning Based Two-Way Communication System for Deaf and MuteS.A. Khan, S. A. Ghaffar	XLIII. December 2022 MDPI	XLIV. The developed system, which uses machine learning for two-way communication, achieved a hand gesture detection accuracy of over 90% for most users.	XLV. Mixed-Methods Prototype Evaluation involving three stages of testing (formative and summative) and an online survey on a sample of 106 children.
XLVI. 9	XLVII. How Can Accessibility for Deaf and Hearing-Impaired Players be Improved in Video GamesAris P. Vrakas	XLVIII. July 2019IGI Global	XLIX. The paper highlights the importance of visual cues and closed captions for game accessibility. It provides a review of best practices in the gaming industry to improve the user experience for deaf and hard-of-hearing players.	L. Review Paper analyzing and synthesizing existing literature and industry practices to recommend improvements for video game accessibility.

III. METHODOLOGY

To ensure that the HUMPLAY system was not just a clever idea but a genuinely reliable and helpful tool, we developed a thorough, four-step evaluation process. We started with Unit Testing, which was like putting the pieces under a microscope, we isolated the core technology specifically the audio filtering and the pitch detection algorithms to confirm they could flawlessly recognize a user's hum and translate it into the right command, even with background noise present.

Next, Integration Testing verified that all the pieces worked together seamlessly, ensuring that the detected pitch instantly flowed through the Game Logic and triggered the corresponding visual or haptic cues with

minimal latency. Our goal here was a quick, natural response time, like hitting a drum and hearing the beat right away.

The third phase, Performance Testing, put hard numbers to our success, aiming for a Pitch Recognition Rate above 90 percent and a response time of less than 100 milliseconds, a measure crucial for keeping the game feeling fluid and responsive.

Finally, the most important step was User Acceptance Testing (UAT), where we invited the very people the game was designed for deaf and mute participants to play and tell us honestly about their experience. Through detailed observations and surveys, we assessed the game's intuitive nature, overall comfort, and genuine usefulness, ensuring the technology felt less like a machine and more like a supportive partner in play.

IV. ACCESSIBLE AUDIO TOOLKIT

The Accessible Audio Toolkit represents the core technological innovation of HUMPLAY, consisting of highly integrated modules for real-time sound-to-control translation and sensory output.

4.1 System Architecture and Design

The overall system is designed as a low-latency, synchronized pipeline connecting input to immediate sensory output.

Module	Functionality	Key Technology/Process	Output
Input & Audio Processing	Captures, filters, and analyzes user humming.	Fast Fourier Transform (FFT)	Real-time Frequency (Hz)
Game Logic	Translates pitch frequency into in-game commands.	Game Engine (e.g., Unity/Unreal), Logic Scripting	Gameplay Events (e.g., Jump, Move, Attack)
Visual Feedback	Renders pitch, timing, and game state visually.	High-contrast UI, Color change, Dynamic motion	On-screen Visual Cues
Haptic Feedback	Converts game events and sound rhythm into vibration.	Haptic Engine API, Predetermined vibration patterns	Tactile Sensations

4.2 Implementation Details of Core Modules

A. Input and Audio Processing Module

The Audio Capture component utilizes Pixi libraries, for robust real-time signal recording. The raw sound

waveform is passed to a preprocessing stage, which involves digital filtering to reduce ambient noise and normalization to stabilize amplitude, ensuring reliable input quality.

The central mechanism is Pitch Detection, implemented using the Fast Fourier Transform (FFT) algorithm over small, overlapping audio windows. FFT efficiently decomposes the sound into its constituent frequencies. The system then identifies the dominant frequency (pitch) of the user's hum. This frequency is continuously compared against predefined frequency bands, where each band is explicitly mapped to a specific in-game action (e.g., a low pitch triggers "low jump," a high pitch triggers "high jump").

B. Visual and Haptic Feedback Modules

The Visual Feedback Module provides complete sensory redundancy for all auditory information. Game elements are high-contrast and dynamically responsive. For instance, the pitch level is instantly shown by the color and height of an on-screen visualizer. Timing cues and rhythm are conveyed through pulse effects and synchronized motion guides, which direct the player without using any sound.

The Haptic Feedback Module translates core game events (like impacts, power-ups, and game rhythm) into specific vibration patterns. This is achieved by linking the game logic output to a haptic engine API. The vibration patterns are carefully designed to be distinct and easily recognizable, allowing users to "feel" complex musical or combat sequences.

C. Materials and Requirements

The system requires specific software resources for optimal performance:

Software: Game Engine (e.g., Unity, Unreal),

Programming Languages: JavaScript, HTML,CSS, pixi libraries.

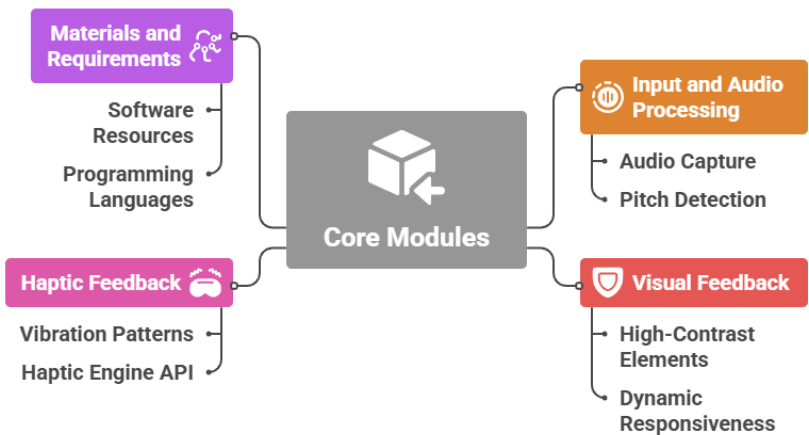


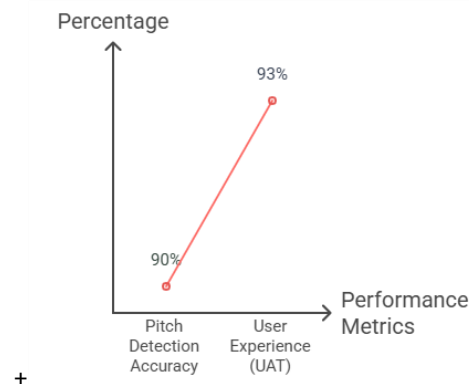
Fig. Core Modules of HUMPLAY

IV. RESULT

The HUMPLAY prototype successfully demonstrated its primary functionality by converting humming and sound frequencies into interactive game actions

- **Pitch Detection Accuracy:** Performance testing showed a high degree of accuracy in pitch detection, maintaining an average recognition rate above 90 percent under controlled conditions.
- **System Responsiveness:** The haptic and visual feedback systems responded smoothly, ensuring minimal latency and consistent user engagement..
- **User Experience (UAT):** User testing with deaf and mute participants indicated positive experiences in rhythm recognition, focus, and enjoyment. Feedback highlighted the systems in tuitive interface and accessibility benefits.

Overall, the outcomes strongly align with the project objectives, validating HUMPLAY as a promising tool for inclusive and creative digital interaction.



VI. CONCLUSION AND FUTURE WORK

6.1 Summary of Key Achievements

The HUMPLAY project successfully demonstrated how auditory elements can be transformed into visual and tactile experiences, allowing deaf and mute individuals to interpret sound through alternate sensory channels. By integrating real-time pitch detection, responsive vibration feedback, and color-based visual cues, the project achieved its objectives of enabling creative expression, improving coordination, and fostering emotional engagement in a non-verbal environment.

6.2 Contribution to Accessible Gaming

HUMPLAY's core contribution is in redefining the boundaries of digital accessibility by introducing a multisensory framework that bridges visual, auditory, and tactile domains. It focuses on inclusivity from the design level, giving equal importance to perception and interaction. For deaf and mute players, HUMPLAY transforms sound into experience, transcending traditional communication limits and promoting empathy among all users.

6.3 Future Work Future developments will focus on enhancing the system108108108108:

- Incorporating adaptive AI for difficulty adjustment.
- Expanding haptic ranges for deeper sensory experiences.
- Integrating multi-user interaction features and additional game modes.
- Integrating machine learning for adaptive feedback and broader platform integration for multiplayer

accessibility. The long-term vision is to integrate inclusive designs like HUMPLAY into main stream.

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Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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