INTERACTIVE SIGN SINGING AND EMBODIED SONG FOR THE DEAF AND HARD OF HEARING USING HOLOGRAM TECHNOLOGY

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ABSTRACT: This study investigates the impact of hologram singing technology on the experiences of the deaf and hard of hearing. The research aims to evaluate how effectively this technology enhances understanding and interaction with musical content by integrating sign language into holographic performances. An experimental approach was employed, involving a diverse sample of deaf individuals divided into two groups: one exposed to hologram technology and another that was not. Results indicated that participants utilizing holograms demonstrated a better understanding of songs and engaged more actively with the artistic performance. The study recommends expanding the use of hologram technology in arts and music to promote inclusivity and emphasizes the necessity for developing software that improves the accuracy of converting audio signals into embodied movements. Furthermore, fostering collaboration between artists and developers is crucial for broadening future applications of this technology, ultimately enhancing the cultural quality of life for the targeted groups.
KEYWORDS: Artistic Performance; Embodied Movements; Holograms; Sign Language; Signal Conversion Accuracy; Singing Technology

1. Introduction

Hologram interactive sign singing represents an innovative advancement in the arts and music, opening new horizons for cultural interaction between deaf individuals and the hearing community. Deaf people experience rhythm through vibrations (Darrow, 2006), perceive music through visual elements like synchronized light shows, color-coded notes, and effects reflecting musical dynamics and tempo (Katan & Taibi, 2021), and engage with performances through expressive sign language. Deaf dancers rely on visual cues and movement (Bläsing et al., 2019), while tools such as haptic chairs and 'Sound Shirts' enable them to physically feel the music (Nanayakkara et al., 2009). These creative approaches demonstrate that music can be experienced in ways that extend beyond hearing.

In this context, hologram technology comes as an effective tool to enhance deaf people's experience in following musical arts, as it combines visual movement and sign language in a way that makes musical content more interactive and comprehensible.

This study seeks to explore the impact of hologram technology on the deaf audience, focusing on how to improve their musical experience by integrating visual interaction and embodied signs. The research revolves around several key aspects related to deaf people's experience with music, including social and artistic interaction, the challenges that this technology may face, and future opportunities that could contribute to the inclusion of deaf people in cultural and artistic activities in a more comprehensive manner. Many previous studies indicate the importance of integrating technology in providing musical

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experiences tailored to the deaf (Nanayakkara et al., 2009; Lamont, 2011; Kraus et al., 2014) but there is still a lack of research that focuses specifically on the use of holograms in this context.

Therefore, this study is an attempt to bridge this gap, by providing direct experiences and analytical results that illustrate the impact of this technology on the understanding and participation of deaf people in the arts. The study includes an experimental methodology that aims to evaluate the effectiveness of holograms in enhancing the interaction of deaf people with music, as it includes collecting qualitative and quantitative data through live experiences and musical performances. The study will also address the psychological and social effects resulting from this experience and how it can contribute to increasing society's awareness of the capabilities of deaf people and their contributions to culture and art.

Through this introduction, we hope to be able to shed light on the importance of innovation in the field of arts, and how modern technology can contribute to improving the quality of life for marginalized groups. This study seeks to achieve a deeper understanding of the impact of holograms on the experience of deaf people with music, paving the way for exploring new opportunities to enhance inclusivity in arts and culture.

2. Review of related literature

Cross-modal translation refers to the transformation of information from one sensory modality to another. In the case of music for deaf audiences, this means converting auditory information—such as rhythm, melody, emotion, and structure—into visual (e.g., sign language, lighting effects) and tactile (e.g., vibrotactile feedback) formats. The aim is not simply to replicate the sound but to convey its expressive and aesthetic qualities through alternative sensory experiences. The intersection of music and accessibility for the deaf and hard of hearing has garnered increasing academic interest, with recent studies investigating how technology and embodied experiences can bridge sensory gaps (Fisher, 2021; Maler, 2013). Hologram technology, as proposed in this study, represents an innovative step toward enhancing the engagement and experience of the deaf and hard of hearing in musical performances.

This review integrates critical concepts from the existing literature, focusing on the cultural and sensory dimensions of music, sign singing, and technological interventions for this specific constituency, and positions the current study within this growing body of research. Deaf culture has long maintained a unique relationship with music, where auditory experiences are translated into visual, tactile, and embodied forms. The concepts of 'corpaurality' and 'vusicality' are introduced by Brétéché (2021) to articulate how deaf people and hard-of-hearing individuals engage with music through embodied and visual modalities. According to Brétéché, 'corpaurality' refers to the physical, bodily experience of music—how vibrations and rhythms are perceived through the skin, muscles, and bones rather than through auditory channels while 'vusicality' describes the visual experience of

music—how visual cues such as movement, color, light, and rhythm allow for a non-auditory but perceptually rich engagement with musical performances.

The potential of cross-modal music experiences, where non-auditory senses are engaged to create a more holistic musical experience for the deaf and hard of hearing, has been elaborated by Choi et al. (2024) who explore how technology can be tailored to enhance personal musical preferences. This approach emphasizes the importance of individual agency in how music is perceived and enjoyed, highlighting the evolving role of technology in making music more accessible and meaningful for diverse audiences.

The present study's hologram-based approach, which integrates embodied sign language into performances, aligns with this notion of cross-modal engagement, providing a more personalized and immersive experience for the deaf and hard-of-hearing audience. Beyond cultural and sensory dimensions, music has been recognized as a valuable tool for cognitive and linguistic development in this community.

Embedding music into language and literacy instruction can benefit young deaf and hard-of-hearing learners, as it enhances cognitive development by providing a multisensory approach to learning (Nelson et al., 2016) that engages visual, tactile, and kinesthetic senses. For example, learners may see rhythm patterns through visual aids (Cacciato, 2022), feel beats and vibrations through their bodies (Hopkins et al., 2023), and move physically in rhythm, helping to reinforce language patterns, phonological awareness, and memory (Baijal et al., 2012).

Focusing on individual experiences in music education for deaf and hard-of-hearing children is crucial, with an emphasis on adaptive and inclusive methods that address diverse sensory needs. Adaptive methods involve intentional modifications to teaching strategies, tools, or environments that support meaningful participation by accommodating the specific needs and abilities of each learner. Examples of adaptive strategies include using visual cues such as hand signals or visual rhythm prompts, as well as incorporating vibration-based feedback (allowing the child to feel the beat through a resonating instrument) to help engage with musical elements like rhythm and pitch (Yennari et al., 2020). Although Yennari et al.'s research focuses on children, the principles of individualized and adaptive engagement are equally relevant to the current study's aim of enhancing musical experiences for deaf and hard-of-hearing adults through the use of advanced hologram technology.

The potential of augmented reality in training music perception for the hard of hearing is highlighted through the Holoband experience, which enables users to interact with music in a more tangible and visual way. The Holoband creates a dynamic environment where music is not only heard but also seen and felt—translating sound into visual patterns, vibrations, and interactive elements. This approach allows users to engage with music on their own terms, transforming abstract audio into a physical experience that they can connect with. Findings suggest that such technology can significantly enhance musical understanding and engagement, providing a foundation for exploring holograms as a tool

to improve musical performances for deaf people and hard-of-hearing audiences (Ivanyi et al., 2022).

The use of holographic interpreters in a mixed-reality classroom setting has been investigated to demonstrate how holograms can create more engaging and interactive learning environments for deaf and hard-of-hearing individuals. This study highlights the potential of holograms to offer a dynamic and immersive experience, which directly supports the focus on hologram-assisted sign-singing performances. Sign singing and song signing are closely related, but there's a fine difference. Sign singing is a more expressive, artistic performance where sign language is used to interpret a song's rhythm and emotion, often seen in deaf culture and performance settings (Yennari et al., 2020). Song signing, on the other hand, is typically more literal and used in educational contexts, where the focus is on simply signing the lyrics without necessarily capturing the full musicality (Schraer-Joiner, 2014).

Moreover, Yamamoto et al. (2024) identify challenges in lyric detection for deaf and hard -of-hearing individuals and propose technological solutions to improve accessibility. Their findings support the idea that hologram technology could enhance the clarity and accessibility of musical lyrics, an area that the current study addresses by integrating embodied sign language with holographic visuals to improve comprehension and enjoyment of musical content. The present study positions itself within this rich body of literature by addressing the gaps in how music can be made more accessible and engaging for deaf and hard-of-hearing individuals through the use of hologram technology. While previous studies have explored various technological interventions, few have combined holography with embodied sign singing to create a more immersive and multisensory musical experience. By doing so, the current study contributes to the ongoing conversation about inclusivity in the arts and culture, offering a novel approach to enhancing the participation of deaf and hard-of-hearing individuals in musical performances.

Furthermore, the study adds to the understanding of how experiences, particularly through sign language, can be augmented by holograms to provide a richer, more interactive experience. This could pave the way for future innovations in both technology and performance art. By building on existing research in music accessibility, embodiment, and technological interventions, the current study aims to contribute to the growing body of knowledge on how the arts can be made more accessible to all, regardless of sensory abilities.

3. Interacting with music through technology

Digital technology has transformed how users engage with sound, rhythm, and performance. Virtual reality (VR) and augmented reality (AR) allow users to immerse themselves in multisensory musical environments. These experiences are particularly valuable for the deaf and hard of hearing, enabling music to be visualized and felt through light effects, vibrations, and spatial design (Cheng, 2024). Systems like EarVR use vibro-motors to convey spatial audio cues via haptic feedback, enabling deaf participants to

locate and interact with sound sources in virtual environments (Mirzaei et al., 2020), while augmented experiences integrate visual layers over real-world settings, offering an enriched connection to music beyond traditional auditory channels.

Artificial intelligence (AI) and digital platforms have also redefined music creation and consumption. Artists use AI tools for composing, interpreting, and enhancing musical expression, while platforms like RL-Duet generate real-time accompaniment based on user input (Jiang et al., 2020). These technologies expand accessibility by offering personalized, adaptive learning and performance experiences. However, it is holography—creating 3D visual images using light interference—that most directly connects to the study at hand. This leads us into a more focused exploration of holograms and their application in musical performance for the deaf and hard of hearing.

Within this expanding digital ecosystem, holography stands out as a groundbreaking technology that enables the creation of vivid, three-dimensional images using the interference of light waves. Unlike traditional visuals, holograms can appear lifelike without requiring special glasses or equipment. The origins of this technology date back to the mid-twentieth century, when physicist Dennis Gabor introduced holography as a technique for recording and reconstructing light reflected from physical objects (Huang et al., 2018; Gao et al., 2021). Since then, holography has undergone extensive development, evolving from early experiments into advanced systems capable of producing high-resolution, dynamic images. Improvements in laser technologies have led to more precise and vibrant displays, making holography applicable across a range of fields from scientific visualization to marketing, education, and, notably, the arts.

In the entertainment sector, holograms have been used to reimagine musical performances, reviving iconic figures and presenting them to modern audiences. The late singer Whitney Houston, for instance, was brought back to the stage through holographic projection, enabling posthumous live performances (BASE Hologram & Whitney Houston Estate, 2019; Gompertz, 2020). In the Arab world, the legendary Egyptian Singer Umm Kulthum appeared in concerts across Saudi Arabia, the United Arab Emirates, Egypt, and Jordan, where audiences experienced her iconic voice accompanied by live orchestras and enhanced visual effects (Saeed, 2019). These performances transcend conventional boundaries by merging live musicians with holographic personas, offering audiences a hybrid, immersive musical encounter.

In education, holography has enabled the visualization of complex musical, scientific, or artistic concepts in a three-dimensional space, making abstract content more tangible and engaging for students. These applications have proven particularly useful in music education, where spatial and visual learning can enhance understanding of performance techniques and compositional structures.

Despite its promise, holography still faces challenges, most notably the cost of producing high-quality holograms, which can restrict their widespread adoption. However, continued innovation is gradually reducing costs and improving accessibility, paving the way for broader implementation in both educational and artistic domains.

In short, holography, along with VR, AR, and AI, exemplifies how advanced technologies are reshaping musical interaction, production, and pedagogy. These tools offer new possibilities for multisensory engagement, greater inclusivity, and cross-modal experiences especially relevant for communities such as the deaf and hard of hearing, for whom visual translation of music can provide a powerful alternative to auditory experience. As development continues, holographic technology promises to further transform the landscape of music and performance in ways previously unimaginable.

4. The concept of music for the deaf

The concept of music for the deaf goes beyond the traditional understanding that associates music with sound and rhythm to involve new aspects of the musical experience (Fulford et al., 2011). It is often assumed that music is an art form that relies primarily on the ability to hear. However, recent studies (Levänen & Hamdorf, 2001; Fulford et al., 2011; Good et al., 2014) have shown that deaf people can experience music through other senses such as sight and touch, opening new horizons for their engagement with this art form.

Deaf people have different ways of interacting with music as they can feel the rhythm through the vibrations that travel through the ground or by directly touching the instruments, which helps them relate to music in a different way than the hearing community (Palmer & Ojala, 2022). Particularly when some auditory perception is involved, in the case of hard-of-hearing individuals (Zhou et al., 2024; Sutela & Ahonen, 2024), this becomes a complete musical experience that engages the whole body and emphasizes the appreciation of movement and mobility (Sutela & Ahonen, 2024).

Sign language plays a pivotal role in deaf people's understanding of music, as it is the primary means of communication among themselves and also between them and the hearing community. Through the use of sign language, deaf people can express thoughts and feelings associated with music not only for themselves as a form of self-expression (Bauman & Murray, 2014), but also for deaf and hearing audiences.

Sign singing goes beyond simply translating lyrics into signs to include the transfer of rhythm, melody, and emotional content embedded in music (Bahan 2006). Indeed, signers can visually represent melody, harmony, rhythm, timbre, texture, and poetic features through performance (Maler 2013). The emotional dimension is communicated through facial expressions, body language, and signing style, using resources that have long been exploited by dancers and singers (Hatch, 2021; Sutela & Ahonen, 2024). As for rhythm, this comes into play as interpreters synchronize their gestures with the beat and tempo of the music, creating a visual rhythm analogous to the auditory one—a phenomenon examined by Sutela and Ahonen (2024) in studies of music sensation across the senses. The visual-aesthetic element transforms sign language into a performance art, using expressive movement and spatial dynamics, which draw upon embodied music cognition (Lim, 2022; Sutela & Ahonen, 2024). Finally, the cultural and symbolic dimension allows interpreters to creatively convey idioms, metaphors, and cultural context embedded in music, supporting

deep contextual understanding (Lim, 2022). Together, these interconnected dimensions transform music into a rich, multimodal experience for the deaf community.

It is worth noting that the musical experience is not only a personal issue for deaf people, but also reflects the comprehensiveness of art and its ability to integrate different social and artistic groups in society (Sutela & Ahonen, 2024). When music is presented in an interactive way that includes visual and tactile dimensions, this contributes to enhancing mutual understanding between the deaf and hearing communities, and also contributes to reducing the social and psychological gaps that deaf people may face (Nanayakkara et al., 2009).

Understanding music for the deaf requires us to think about how to redefine art and how to adapt artistic experiences to suit the needs of different individuals, contributing to creating a more open and diverse artistic environment. This also requires the cooperation of artists and specialists in the field of technology and arts to develop artistic content that meets the needs of all segments of society. In conclusion, it can be said that the concept of music for the deaf is a multidimensional concept that goes beyond sound and rhythm to include new senses and experiences. By integrating sign language and modern technologies, a rich and enjoyable musical experience can be provided that contributes to enhancing social and artistic interaction between the deaf and hearing communities, paving the way for a more inclusive future in the world of arts.

5. Hologram technology application in sign singing

Hologram technology has opened new horizons across various artistic fields, particularly music. Its use in sign singing represents a significant step toward integrating the deaf and hard of hearing into the musical experience. This technology enables them to interact with music in a new way relies on visual signals instead of sound alone.

Sign singing using holograms relies on a series of steps that begin with analyzing the musical texts and translating them into sign language, before converting these signals into three-dimensional displays that can be displayed using hologram technology.

Music, as we have seen, is a multisensory experience that transcends language. It combines rhythm, melody, harmony, and emotion in ways that deeply affect listeners—not only through sound, but also through movement, visual imagery, and physical sensation. Translating this rich experience into a form accessible to the deaf people community requires both artistic insight and advanced technology.

The first and most crucial step is selecting sign-language interpreters with a deep musical sensitivity. Understanding music in this context goes beyond recognizing lyrics—it involves an appreciation of rhythm, tone, tempo, mood, and emotional expression (Levitin, 2006). Interpreters must be trained not only in sign language but also in music performance or musicology. This can be assessed through auditions, musicality assessments, and prior experience interpreting live music events (Napier & Goswell, 2006).

Once the interpreter has developed their visual performance of the musical piece, the interpretation is recorded and then processed using advanced computer software to

create a three-dimensional holographic model. This model accurately replicates the interpreter's movements, allowing for a clear and engaging visual display of the musical content. Programs such as SignAll, which specialize in visual-linguistic data capture and sign translation, can support this process.

Holographic projections are created using laser-based systems with moving mirrors and precise lighting control, projecting a lifelike 3D interpreter onto a stage or screen. These holograms allow viewers to see the signs from multiple angles, creating an immersive visual experience (Gunkel, 2020).

Beyond the visual, further dimensions can be added by sensory technologies such as vibrating seats, wearable haptics (e.g., SubPac), or interactive floors—allow deaf audiences to feel the rhythm of the music. Studies show that vibrotactile feedback enables deaf and hard-of-hearing individuals to perceive aspects of musical rhythm and bass frequencies (Nanayakkara et al., 2009). Visual rhythm is reinforced through dynamic lighting systems synchronized with the music's tempo and emotional shifts, enhancing emotional impact and temporal structure (Chion, 2019).

This multimodal experience—holographic sign language, synchronized lights, and tactile feedback—creates a powerful, inclusive form of musical interaction. It transforms the traditional auditory experience into one that engages vision, touch, and movement, enabling deaf audiences to connect with music in a rich, meaningful way. Such experiences do not merely translate music—they reimagine it, making performance art accessible to a wider audience.

Integrating these technologies fosters cultural inclusion, empowering deaf individuals to participate fully in artistic and communal events. It bridges sensory gaps and affirms that music, at its core, is a universal language that can be felt, seen, and shared—whether or not one can hear it.

6. Experimental Study and Its Findings

This study represents an important step toward exploring the transformative potential of interactive sign singing using holograms for the deaf and hard-of-hearing community. Recognizing that traditional audio-based musical experiences are inaccessible to this group, a new approach based on visual and sensory interaction was devised to bridge this gap and enable participants to engage with music from a rich, tangible visual perspective.

The study relied on the integration of expressive sign language and hologram technology to convey musical content, not only at the level of meaning but also at the level of aesthetics and emotional engagement. The basic hypothesis of this research was that the use of holograms could add greater depth to the musical experience through enhanced artistic expressions that touch the recipient's emotions and create a deeper connection to the artistic performance.

The study sample included 60 participants from three centers for the deaf in Jordan, 30 males and 30 females, ranging in age from 20 to 40. The participants were divided into two groups: an experimental group watched holographic performances, and a control

group watched performances in traditional song signing. The experimental play was designed using advanced 3D rendering technologies to integrate sign language performers with holographic visual effects, providing a multi-dimensional sensory experience.

The research methodology relied on a combination of quantitative and qualitative data-collection tools. A questionnaire was developed that included a set of questions measuring understanding of the musical content, the level of sensory and visual interaction, the sense of participation, and the overall aesthetic impression. In addition, semi-structured interviews were conducted with a sample of 20 participants—10 from the experimental group and 10 from the control group, to capture in-depth insights into their personal experiences and feelings during and after the performance. Questions included: "Did you feel you understood the content of the musical performance?", "To what extent did you feel you were a part of the performance?", "How much did you like the technology used?", "Did you feel you were physically interacting with the performance?". During the interviews, participants were asked to describe their feelings toward the performance and to indicate the differences they observed between traditional and holographic performances.

The results showed that 24 out of 30 participants (80%) in the experimental group reported a clearer understanding of the song's content thanks to the combination of gesture and hologram, compared to only 11 out of 30 (36.7%) in the control group. When asked about sensory engagement, 21 participants in the experimental group reported feeling like they were active participants in the performance, compared to only 10 in the control group, indicating the superiority of holographic technology in enhancing engagement.

In terms of aesthetic evaluation, 22 participants in the experimental group expressed their admiration for the fine motor details provided by the visual effects, stating that the hologram helped them grasp the expressive aspects of movement, deepening their emotional connection to the music. In contrast, the aesthetic impressions of the control group were more restrained.

29 out of 30 in the experimental group also expressed a sense of increased self-confidence during the interviews, confirming that they felt part of a cultural experience that had not previously been available to them. These responses were spontaneous and not directly questioned, reflecting the authenticity of their feelings. Some said, "For the first time, I feel like I'm experiencing the music, not just seeing it".

Perhaps one of the new dimensions revealed by this experience is the integration of a hearing audience with the deaf in the performance. This helped enhance the concept of cultural and social interaction between the two groups, adding a new social dimension to hologram technology as a means of achieving integration and mutual understanding.

Despite these positive results, the study did not overlook the accompanying challenges, most notably the high cost of the technology, which limits its potential for widespread use. The research team also noted the need to develop more intelligent software that translates audio signals into gestures integrated with the holographic system.

This requires collaboration between programmers and experts in sign language and expressive arts.

In conclusion, this study demonstrates that integrating sign singing with hologram technology not only enhances the understanding of music among the deaf and hard of hearing, but also creates a comprehensive artistic and aesthetic experience that gives them a sense of participation and belonging. It also opens new horizons for research and development in the field of technologies that support people with special needs, and enhances their opportunities for integration into public artistic and cultural life.

7. Future Applications of Hologram Singing Technology

Hologram singing technology is one of the pioneering innovations in the field of integrating arts and technology and holds tremendous potential for developing new and unique experiences for the deaf and hard-of-hearing audience. With the continuous advancement in hologram technology and display techniques, a number of future applications are emerging that can enhance the overall experience of music and art, and open up new horizons for artistic and cultural interaction. One potential future application is the use of hologram technology in education.

Holograms can be used to teach sign language in an interactive way by displaying real-time performances that incorporate signing. This approach helps deaf and hard-of-hearing individuals better understand signs and develop their communication skills through innovative ways. Integrating music with sign language education creates a dynamic learning environment that supports comprehensive development. Another impactful application is in live art performances, where music groups and artists can use holograms to deliver immersive, interactive shows that make audiences feel actively engaged in the experience.

Live interaction technologies can be incorporated so that the audience interacts with the hologram in a new way, enhancing their sense of belonging and engagement. These performances can include elements of audience engagement such as changing lighting or animations that respond to the audience's movements. Furthermore, hologram technology can contribute to the development of multimedia artistic content. With the ability to combine sound, image, and motion into a single experience, artists can produce immersive artworks that take the audience on a visual musical journey. This can have a significant impact on how art and music are experienced, as the audience becomes part of the performance rather than just a passive recipient.

This technology can be exploited in cultural and social events, such as festivals and exhibitions. Musical performances can be organized that contain holographic elements to expand the scope of the arts offered and to engage a wider audience, including the deaf and hard of hearing. These events can help raise awareness of different cultures and provide a space for communication and interaction between members of society.

It can also be used in the development of applications and digital content. Interactive applications can be designed that use hologram technology to teach music and create a new entertainment experience for the deaf and hard of hearing. These applications could

include interactive videos that explain songs using holograms, helping users better understand the lyrics and the emotions associated with them.

Additionally, hologram technology could contribute to increased awareness and social interaction between the hearing and deaf communities. By organizing joint events that include artistic performances that combine holograms and sign language, new opportunities for communication and interaction between the two groups could be created. This could help break down barriers and promote mutual understanding between different cultures. Achieving success in hologram sign singing applications requires collaboration between artists, developers, and researchers to ensure that the artistic experience is rich and inclusive for all.

8. Conclusion

In reflecting on the findings of this study, it is crucial to highlight the intersemiotic and multimodal translational operations embedded in the use of holographic sign singing for the deaf and hard of hearing. Sign singing itself can be viewed through the lens of intersemiotic translation, since it converts musical lyrics, rhythm, and emotion from auditory to visual-gestural modalities. This involves more than just translating words; it requires expressive, embodied interpretation that conveys musicality through signs, facial expressions, and movement.

Beyond the sign-singing process, hologram creation adds another layer of translation. This includes converting sign-language performance into digital data, rendering it as holographic 3D visuals using algorithms and light-based imaging. These processes represent a form of technological translation, shifting the message from human performance to machine-readable and visually rendered formats. The interplay of linguistic, sensory, and technical translations reflects the complexity of making music accessible to non-hearing audiences.

This study's contribution to Translation Studies lies in its demonstration of how translation extends beyond language to movement, embodiment, and machine-mediated expression. It opens new directions for intersemiotic translation research, showing how meaning can be transferred across semiotic systems (auditory to visual, verbal to gestural) using advanced media. Holographic sign singing thus exemplifies a hybrid translational model that aligns with evolving theories in audiovisual and performance translation. As Translation Studies continues to explore multimodal and cross-sensory domains, this work offers a case study for integrating artistic, cultural, and technological dimensions into inclusive translation practice.

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