XR IN DANCE PERFORMANCE: A SURVEY

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ABSTRACT

Extended reality (XR) technologies have increasingly been adopted across various entertainment industries due to their immersive capabilities and engaging content. Dance, as a form of artistic expression, has also begun to integrate XR in both performance and training systems. In particular, the COVID-19 pandemic has significantly accelerated interest in social virtual reality (VR) as a medium for remote engagement with the arts. However, implementing XR in dance is a complex process, requiring expertise in motion capture, character animation, and human-centered interaction design. This paper reviews recent developments in the use of XR for dance performances, with a focus on enhancing the overall quality of virtual theater experiences. It also identifies key challenges in the field and explores potential future directions.

1. INTRODUCTION

Extended reality (XR), an umbrella term encompassing virtual reality (VR), augmented reality (AR), and mixed reality (MR), has seen significant advancements in recent years. VR offers fully immersive digital environments, while AR enhances our perception of the real world by overlaying digital elements onto physical surroundings. MR goes a step further, enabling interaction with virtual objects as if they were part of the real world.

These technologies have increasingly been applied in various artistic domains, such as concerts, museums, and dance performances. Integrating XR into the arts not only makes artistic expression more accessible to broader audiences but also serves as a powerful medium for preserving and communicating cultural heritage.

Dance, as a dynamic and expressive art form, conveys deep emotions and cultural narratives through movement. Researchers have explored the use of XR in applications such as digitization, training, and immersive social theater experiences. However, applying XR to dance presents unique challenges due to the complexity of capturing and rendering nuanced, expressive movements.

The COVID-19 pandemic further accelerated interest in remote and socially distanced experiences. Creating authentic and engaging virtual dance theaters offers new opportunities for presentation and innovation in choreography.

This paper aims to review and synthesize current research on the use of XR in dance performance and virtual theater. It identifies key challenges and outlines potential future directions. To the best of our knowledge, this is the first review paper dedicated specifically to the intersection of XR and dance performance.

2. METHOD

To identify relevant research on dance performance utilizing extended reality (XR) technologies, we conducted a structured search using the following query:

> ("audience" OR "dancer" OR "agent" OR "avatar") AND AB("augmented reality" OR "AR" OR "virtual" OR "virtual reality" OR "VR" OR "mixed reality" OR "MR" OR "extended reality" OR "XR") AND AB("dance performance" OR "choreography" OR "theater")

The first group of terms (*"audience", "dancer", "agent", "avatar"*) targets character representation, including both performers and observers in immersive environments. The second clause ensures inclusion of studies related to XR technologies by querying the abstract (AB) for relevant terms. The final clause narrows the focus to dance and performing arts. The search was limited to the period from 2018 to 2025 to capture recent developments.

After applying this query and screening for relevance, we selected 7 papers for review. These works were categorized into two primary themes: **avatar representation** and **social experience**.

2.1 Avatar Representation

Holojam in Wonderland [1] presents a mixed reality theater where users participate in a narrative and interact with the virtual environment. Although not dance-specific, it represents a critical branch of interactive theater. Users are represented by simplified avatars (head and hands), yet precise motion tracking creates a strong sense of presence.

Kerryn [2] proposed a complete pipeline for a VR dance piece, including choreography, motion capture, and visualization. A single-camera volumetric capture setup was used for portability. Despite producing partially hollow visuals, the stylistic consistency between motion and rendering proved artistically effective.

Temi et al. [3] digitized traditional African dance with performers in costume. They emphasized the importance of attire in preserving cultural identity within digital heritage performances.

Sofiia et al. [4] proposed augmenting audience perception through dynamic shadows. They varied shadow colors and shapes based on musical rhythm and style, creating expressive and immersive visual enhancements.

2.2 Social Experience

Daniel et al. [5] designed a system supporting up to 20 users experiencing an XR dance performance simultaneously. The virtual environment featured reactive elements (e.g., lighting shifts, growing mushrooms). Users could see and interact with both virtual elements and other participants' avatars. The study identified Wi-Fi capacity and reliability as critical challenges with increasing participant numbers.

Youjin et al. [6] introduced virtual audiences to enhance the sense of social presence in immersive performances. A digital twin of the venue was constructed to manage occlusions between virtual and real elements, serving as the environment for training audience movement paths. Reinforcement learning and motion-matching techniques were employed to generate realistic agent trajectories and ensure smooth motion transitions. Additionally, the impact of avatar height on user experience was examined to improve the overall sense of presence and realism.

Ángel Muñoz-González et al. [7] implemented a VR concert modulated by EEG signals. Specifically, the β/α brainwave ratio adjusted the scale of virtual effects, enhancing the audience's sense of unity and emotional connection.

3. FUTURE WORK OPPORTUNITIES

3.1 Dancer Modeling

Current methods for visualizing dancers typically rely on volumetric capture or animation using forward/inverse kinematics. With the advent of parametric models like SMPL-X [8], full-body motion and facial expressions can be realistically represented. Costumes, a vital element of performance, can be animated using physics-based simulations [9], GNN-based approaches [10], and newer neural representations like neural radiance fields (NeRFs) or 3D Gaussian splatting.

Despite advances, these methods often demand significant computational resources. Balancing visual fidelity with real-time performance remains a key challenge. TaoAvatar [11] proposes a hybrid approach combining SMPL-X with 3D Gaussian splatting. By employing distillation strategies and blendshape modeling, the system runs in real-time on mobile devices.

Generative models for text-to-motion [12, 13] and music-to-motion [14, 15] offer promising tools for creative choreography and rapid prototyping.

In parallel, user-centered studies are needed to evaluate which styles of digital dancer representation—photorealistic or stylized (e.g., cartoon-like) avatars—are most effective at minimizing the uncanny valley and fostering emotional engagement.

3.2 Audience Modeling

While audience modeling shares similarities with dancer modeling, the focus shifts to trajectory and motion behavior. Two important aspects include agent-scene interaction and agent-human interaction.

Agent-scene interaction. TokenHIS [16] is a unified model that synthesizes both trajectory and motion through transformer architectures and reinforcement learning. Such models offer potential for simulating responsive virtual audiences. During performances, audiences often move in rhythm with the music; hence, incorporating music-driven motion and interpolation techniques may improve realism and immersion.

Agent-human interaction. Conversational avatars powered by large language models and text-to-speech technologies can provide engaging and personalized interactions among audience members and between audience and performer. Evaluating these experiences through user studies will be crucial to ensure naturalism and social presence.

3.3 Environment Modeling

The stage environment plays a crucial role in dance performance, encompassing spatial layout, character positioning, and lighting design. Emerging tools could enable 3D object generation from text prompts, streamlining the modeling process and allowing for flexible, customized environment reconstruction. Additionally, adaptive lighting systems driven by music or sound features could further enhance the responsiveness of virtual stages. Together, these technologies have the potential to create personalized, emotionally resonant environments that align with the tone and genre of a performance.

4. REFERENCES

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