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Generative AI in Performance Design: Type Construction and Current Application Status

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Abstract: Driven by the momentum of the digital era, performance design is undergoing a significant transformation towards intelligentization. As a key force in the integration of technology and art, generative artificial intelligence (AI) is deeply involved in various stages of performance design, including creative content generation, real-time interaction, system optimization, and adaptive control. This evolution signals a shift from traditional, tool-assisted methods to dynamic modes of human–AI co-creation, and in some cases, AI-led design paradigms. While generative AI has already demonstrated promising applications in performance design, significant challenges persist, particularly in ensuring technical reliability, clarifying copyright ownership, and fostering effective human–AI collaboration. This paper examines the intervention contexts, functional categories, and technical architecture of generative AI in performance design, and further explores the prevailing issues and challenges associated with its application in this field, aiming to provide both theoretical foundations and practical strategies for the advancement of intelligent performance design.

Keywords: Generative Artificial Intelligence (AI), Performance Design, Intelligent performance

1. Introduction

In the digital age, the performance model has gradually shifted towards intelligentization. On the one hand, the audience's demand for immersive and personalized experiences has soared, and traditional predetermined performance designs are hard to meet the dynamic interactive needs. On the other hand, due to the impact of the COVID-19 pandemic, virtual performances have witnessed explosive growth in recent years, and the performing arts industry urgently needs efficient and low-cost intelligent solutions. Meanwhile, generative artificial intelligence (AI) provides a feasible solution for intelligent performances, building the framework of intelligent performances from both technical paths and theoretical foundations.

With the demand for digital and intelligent performances showing an explosive growth trend, artificial intelligence (AI) tools are also constantly evolving and improving. Driven by AI, intelligent performance design has achieved relatively mature results and successfully realized commercial application. However, during its application process, many limitations such as copyright disputes and the crisis of deep forgery have gradually emerged. This paper studies the ways in which generative AI is involved in performances, attempts to summarize its application path in performance design, and analyzes the existing problems and challenges, with the expectation of providing methodological guidance for subsequent intelligent performance design.

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2. Ways for generative AI to intervene in performances

Generative AI is currently in a diverse development stage, intervening in performances through various means. There is no authoritative model framework for its application in performance design. Sorting out and analyzing the ways it intervenes in performances can clarify its application path in performance design and provide methodological guidance for subsequent intelligent performance design. Previously, Befera and Bioglio proposed a taxonomic framework for AI in contemporary cross-media drama based on different algorithmic datasets and the symbolic systems of stage presentation in their research [1]. However, starting from the specific processes and contexts of performance design can offer more intuitive operational suggestions for R&D personnel in performance design. Therefore, this paper proposes a three-dimensional classification of the context, category, and architecture of generative AI's intervention in performance design.

2.1. Three scenarios of generative AI's involvement in the performance design process

According to the different stages of AI intervention in the performance design process, the intervention methods can be classified into "pre-performance intervention", "mid-performance intervention" and "post-performance intervention". Cornwell proposed a similar view. Based on Wolf Brown's "Arc of Engagement" model, he divided the audience participation in AI digital performances into five stages: preparation period - in-depth preparation period - artistic communication period - meaning construction period - impact response period, and analyzed and sorted out the application of AI in these stages [2]. Cornwell's theory focuses on the perspective of audience experience, whereas the design process perspective is less emphasized. Therefore, this paper proposes a classification method based on the design process as a reference. Among them, the "mid-performance intervention" stage basically includes the "preparation period", "in-depth preparation period" and "artistic communication period" in the "Arc of Engagement" theory; the "post-performance intervention" stage covers the "meaning construction period" and "impact response period" in the "Arc of Engagement" theory.

(1) Pre-performance intervention: Creative content generation. Before the performance, AI mainly serves in generating creative content, such as images, animations, audio, and videos. At this stage, AI art generation tools (like DALL-E or Midjourney) can be utilized to create unique visual concept art, AI animation generators (such as DeepMotion) can be used to produce dynamic character performances, AI tools for generating music (like OpenAI's MuseNet) can be employed to compose original soundtracks, and AI video editing software (such as Magisto) can be utilized to produce trailers and promotional videos, etc.

(2) Intervention in Performances: Real-Time Interaction and Process Optimization. AI in theatrical performances enhances production workflow optimization and automation. When combined with emerging digital technologies, AI demonstrates the capacity to generate immersive visual effects through dynamic real-time rendering systems. Researchers such as O 'Hare have rich practical experience in this field [3]. Significantly, AI transcends its conventional technical role by emerging as an autonomous performative entity or substantive narrative component within stage productions, establishing bidirectional communication channels with audiences. Practical implementations encompass AI-driven lighting control architectures, algorithmic integration with extended reality (XR) platforms for adaptive scene generation, and audience engagement frameworks powered by natural language processing (NLP) systems exemplified by IBM Watson. These applications collectively position AI as a polymorphic agent in contemporary performance ecosystems, operating simultaneously as technical infrastructure, creative co-author, and interactive performer.

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(3) Post-performance intervention: Communication and feedback analysis. The concept of "post-performance intervention" denotes AI-engaged theatrical design activities occurring after the live performance event, operating under non-present and temporally displaced conditions. In this paradigm, AI typically interfaces with performance dissemination through intelligent devices, delivering immersive and personalized experiences for off-site audiences. Implementation scenarios include distributing AI-curated performance highlights across social media platforms, deploying audience viewing pattern analytics for targeted promotional campaigns, and employing AI systems analogous to Iris+ that aggregate spectator feedback via smart devices to inform future production designs. These applications demonstrate AI's capacity to extend theatrical engagement beyond temporal-spatial constraints while establishing data-driven feedback loops for artistic optimization.

2.2. Three taxonomic dimensions of generative AI intervention in performance design systems

The operational scope of generative AI within performance design systems can be systematically categorized into three distinct implementation paradigms—content generation, interaction control, and system optimization.

(1) Content Generation Architectures. AI-driven content generation mechanisms demonstrate comprehensive coverage across theatrical production elements, encompassing narrative development through large language model (LLM)-based dynamic plot generation, and multimodal architectures capable of synthesizing text, code, video, audio, and visual assets. These systems achieve high-density content generation matching performance requirements.
(2) Intelligent Interaction Control Systems. AI-enabled interaction frameworks operate through multimodal feedback analysis and multi-agent coordination, establishing real-time adaptive control loops. Implementation models include sensor-facilitated audience biometric monitoring (tracking physiological metrics such as heart rate and facial expressions), affective computing-driven performance adjustment systems, and distributed decision-making architectures for precision control over pacing and detail execution.
(3) Performance Optimization Ecosystems. AI-enhanced optimization protocols address critical production challenges through two primary pathways. Technical robustness frameworks employ adversarial training protocols to minimize generative errors while ensuring system reliability. Concurrently, computational efficiency systems implement next-generation rendering optimizations, such as 5G-enabled edge computing infrastructure for ultra-low latency synchronization between digital content and physical stage apparatus, achieving millisecond-level temporal precision.

2.3. Three-tiered architecture of generative AI intervention in performance design systems

The technical implementation of generative AI in performance design can be stratified into three hierarchical tiers based on intervention depth—the Assistive Tier (L1), Collaborative Tier (L2), and Autonomous Tier (L3)—each demonstrating distinct operational paradigms.

(1) Assistive Tier (L1): Instrumental Augmentation. At this foundational level, AI primarily functions as a creative prosthesis, enhancing human designers' efficiency through tool-based support. Key implementations include AI-generated performance asset libraries and automated workflow orchestration. Although the AI intervention behavior of L1 is greatly restricted by human instructions, this generation process still relies on the autonomous interaction between data and algorithms. Therefore, human intervention is indispensable in all stages (e.g. data selection,

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algorithm design, prompt input, and output evaluation) [4]. Cai et al. pioneered an intelligent analytical framework leveraging motion recognition protocols [5], establishing the first mathematical quantification model for traditional theatrical movements, thereby optimizing performance design processes.

(2) Collaborative Tier (L2): Human-AI Co-Creation Frameworks. This intermediate tier emphasizes symbiotic creativity, where AI transitions from tool to cognitive partner. The paradigm aligns with emerging research positing human-machine collaboration (rather than replacement) as the core principle of artistic AI applications, necessitating standardized co-creation protocols that merge human ingenuity with computational power [6]. Theatrical implementations manifest through interactive systems like the cyber-ethical drama "The Adding Machine" in The Feast project, where actors engage in real-time dialogue with AI generating textual/auditory responses. Additional applications encompass AI-powered music generation systems capable of real-time score variation and adaptive orchestration.

(3) Autonomous Tier (L3): AI-Driven Authorial Systems. At the apex of intervention hierarchy, AI assumes primary authorship, demonstrating creative autonomy through self-contained performance ecosystems. Exemplars include end-to-end AI-driven theatrical productions (e.g., actor-less AI dramas) and dynamic narrative architectures that autonomously respond to audience interactions. This tier inverts the L1 human-AI dynamic, establishing a paradigm of "AI authorship with human oversight mechanisms" where creative control shifts decisively toward artificial intelligence agents.

3. Problems and challenges of generative AI applications in performance design

The application of generative artificial intelligence (AI) in theater and performance design has introduced innovative visual aesthetics and interactive experiences, while simultaneously presenting a series of complex challenges. Recent research indicates that the integration of AI and new media technologies has fundamentally transformed the theatrical domain. However, in practice, this transformation brings about significant complications. While AI enhances real-time interactivity and data processing capabilities, it also introduces a high degree of unpredictability. Therefore, despite the promising expansion of expressive possibilities enabled by AI, its limitations and the impact on creative teams must be critically examined.

3.1. Technical limitations and reliability issues

Generative AI still faces notable bottlenecks in areas such as real-time responsiveness and multimodal coordination. Contemporary AI systems typically demand substantial computational resources and access to highly specialized datasets, which are often incompatible with the fast-paced nature of live stage productions. For instance, the distributed control system developed by Aïtouche et al [7]. demonstrates that even in structured environments, multi-agent collaboration requires highly accurate fault-tolerant protocols to ensure system stability. Their study emphasizes the necessity for high reliability (fault-tolerance), flexible universal design, and scalable distributed architectures in stage supervision systems. Moreover, AI-driven choreography or motion-generation systems may suffer from algorithmic biases, potentially resulting in delays or logically inconsistent movements.

3.2. Disputes over copyright and authenticity

Generative AI autonomously produces scripts, music, and visual content through algorithmic processes, creating significant legal ambiguity regarding authorship. The standards for determining originality in AI-generated works remain undefined, and existing copyright law struggles to delineate the proportional contributions of human creators and algorithms. For example, an AI-generated script

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may incorporate substantial quantities of pre-existing textual data, raising concerns over potential plagiarism [8]. Similarly, the use of AI to create hyper-realistic representations of performers' images or voices—commonly referred to as "deepfake" technology—has provoked ethical debates in the theater. Befera and Bioglio document several cases in which AI-generated imagery was incorporated into performances, observing that the boundary between virtual and real becomes increasingly blurred [1]. While such content can offer novel aesthetic experiences for audiences, it also poses risks of deception and misuse.

3.3. Challenges of human–AI collaboration

The adoption of generative AI as a "creative partner" may disrupt existing power dynamics in theater production. Designers, directors, and performers must adapt to working with AI systems whose behavior may be inherently unpredictable. The automation of design processes may marginalize traditional stage designers, shifting creative authority towards algorithmic systems. As some researchers argue, the integration of AI into theatrical production raises critical concerns surrounding ethical principles and technological literacy [1]. Furthermore, when AI operates under an L3-level narrative control architecture, human intervention may be perceived as redundant, thereby undermining the subjectivity of artistic creation. Embedding such algorithms into scripts and stage action challenges traditional workflows, necessitating mutual adaptation: human teams must guide and interpret AI outputs while also trusting the system to meaningfully contribute to the performance.

4. Conclusion

Generative AI has driven performance design from static, preprogrammed presentations to dynamic, intelligent experiences by seamlessly integrating content creation, real-time interaction, and audience-driven feedback into a unified workflow; however, ensuring low-latency, fault-tolerant operation under live conditions, clarifying authorship and ethical responsibility in human–AI co-creations, and preserving human artistic agency amid increasing automation remain urgent challenges that must be addressed.

By framing AI intervention in terms of when it engages (before, during, after performance), what functions it serves (content generation, interactive control, system optimization), and how deeply it participates (auxiliary, collaborative, leading), this study offers a clear taxonomy of current practices while suggesting paths for developing hybrid workflows, refining ethical and legal frameworks, and designing scalable system architectures. It is essential to strike a balance between technological sophistication and human creativity, in order to ensure sustainable innovation in the era of AI-driven stage art.

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