

# FORMATTING INSTRUCTIONS FOR ICLR 2026

## CONFERENCE SUBMISSIONS

### Anonymous authors

Paper under double-blind review

### AI Der Ring: The Forging of the Future A Wagnerian Gesamtkunstwerk Reimagined through Multi-agent System

#### ABSTRACT

Abstract- This paper presents a comprehensive exploration of how artificial intelligence (AI) reimagines Richard Wagner’s *Der Ring des Nibelungen* as a computational Gesamtkunstwerk. Centered on the “AI Der Ring” framework, we integrate four dimensions of multi-agent system-enhanced operatic creation: multi-agent narrative construction, single-agent multi-role performance, dynamic scene adaptation, and interactive audience engagement. Each component leverages advanced machine intelligence to preserve Wagner’s core philosophical themes while expanding the expressive possibilities of AI-era opera. To validate this framework, we implemented a multi-agent operatic simulation using YuLan-WanXiang, a next-generation social simulation platform developed by the Gaoling School of Artificial Intelligence at Renmin University of China. Our experiments successfully replicated key aspects of the performance pipeline, confirming the system’s stability, narrative coherence, and audience responsiveness under dynamic and distributed configurations. Building upon this foundation, we will generate four new multi-agent operas—reinterpretations of *Das Rheingold*, *Die Walküre*, *Siegfried*, and *Götterdämmerung*—to explore the full operatic cycle through the lens of distributed AI creativity. This initiative not only honors Wagner’s artistic vision but also demonstrates how multi-agent system can serve as a generative co-creator in large-scale performative arts. Our work offers a scalable and experimentally validated methodology for AI-driven cultural production, bridging historical tradition with emergent digital aesthetics. **Key Words:** Multi-Agent Systems; AI-Enhanced Opera; Interactive Performance; Wagnerian Motifs

## 1 INTRODUCTION

The 19th century witnessed the birth of a revolutionary artistic vision through Richard Wagner’s “*Der Ring des Nibelungen*,” a monumental four-opera cycle that redefined the boundaries of musical drama. Composed between 1843 and 1874, Wagner’s magnum opus was more than just a musical composition. It was a philosophical treatise on power, fate, love, and redemption, encapsulated within a framework that sought to unify all art forms into a Gesamtkunstwerk—a total work of art. Wagner’s ambition was nothing short of creating a new mythos for the modern age, one that would transcend the traditional limitations of opera and immerse the audience in a multidimensional artistic experience. His innovative use of leitmotifs (leading motifs), which assigned distinct musical themes to characters, emotions, and ideas, created a complex tapestry of sound that mirrored the intricate narrative of the Ring cycle. This narrative, drawn from Germanic and Norse mythology, spanned the creation of the world to its eventual apocalypse in “*Götterdämmerung*” (Twilight of the Gods), reflecting Wagner’s deep engagement with the philosophical ideas of his time, including Schopenhauer’s pessimism and his own evolving views on art, society, and redemption. In the 21st century, as we stand at the threshold of a new technological revolution, artificial intelligence (AI) emerges as a powerful tool that challenges and expands the boundaries of artistic creation. AI, with its capacity for data analysis, pattern recognition, and generative capabilities, offers unprecedented opportunities to revisit and reimagine Wagner’s vision. The intersection of multi-agent system and Wagnerian opera presents a fertile ground for exploration, where machine intelligence can collaborate with human creativity to forge new artistic expressions while engaging with the enduring

philosophical themes that Wagner sought to convey. Our research introduces "AI Der Ring," a conceptual framework that reimagines Wagner's Ring cycle through the lens of multi-agent system. This framework is not merely an exercise in technological application but a profound inquiry into how AI can serve as both a tool and a collaborator in the creation of a 21st-century Gesamtkunstwerk. By systematically examining the intersection of multi-agent system and Wagnerian opera, we aim to explore how intelligent systems can aggregate their powers to create art that transcends individual limitations. This endeavor is inspired by the collaborative creativity evident in historical contexts such as Raphael's "The School of Athens," where diverse intellectuals contributed to a collective intellectual and artistic endeavor. The "AI Der Ring" framework is structured to address several key dimensions of artistic creation: multi-agent collaborative narrative construction, single-agent multi-role performance, dynamic scene adaptation, and interactive audience engagement. Each of these dimensions is designed to harness multi-agent system's unique capabilities while remaining faithful to the philosophical depth and artistic complexity of Wagner's original work. Through this framework, we propose that AI can enhance the operatic experience in several ways. First, it can enable more complex and adaptive narrative structures by allowing multiple intelligent agents to collaborate in real-time. Second, multi-agent system can facilitate multi-role performance by a single agent, adding layers of interpretative flexibility to character portrayal. Third, multi-agent system's ability to process and integrate diverse data sources can lead to dynamic scene adaptation, creating a more immersive and responsive environment for the audience. Finally, multi-agent system can transform audience engagement by incorporating interactive elements that allow spectators to influence the unfolding of the opera, thereby blurring the traditional boundaries between creator and audience. The historical and cultural significance of Wagner's Ring cycle cannot be overstated. It has influenced countless artists, composers, and thinkers, and its themes remain relevant in contemporary discourse on power, identity, and the human condition. By reimagining the Ring cycle with multi-agent system, we are not only paying homage to Wagner's innovative spirit but also extending his legacy into an era where technology and art are increasingly intertwined. This research is positioned within a broader academic context that explores the intersection of multi-agent system and artistic creation. Recent advancements in generative models and large language models (LLMs) have demonstrated multi-agent system's potential to generate, manipulate, and evaluate art in novel ways. However, the application of multi-agent system to opera—a complex art form that combines music, drama, and visual arts—presents unique challenges and opportunities. Our work builds upon existing research in multi-agent system-driven artistic creation while addressing the specific requirements of operatic production, such as narrative coherence, emotional expression, and audience engagement. The actor's costume is shown in Figure 1. The methodology employed in this research involves a com-



Figure 1: Diagram illustrating the contribution of Hide-JEPA

bination of theoretical analysis and experimental validation. We begin with a thorough examination of Wagner's Ring cycle, identifying its key thematic and structural elements. We then explore how

AI technologies can be adapted to support and enhance these elements. Our experimental approach involves the design and implementation of multi-agent system that simulate various aspects of operatic creation. These systems are tested and refined through iterative development, with a focus on evaluating their effectiveness in generating compelling artistic outcomes. The evaluation criteria are derived from both artistic and technical perspectives, ensuring that the multi-agent system not only perform efficiently but also contribute meaningfully to the artistic vision.

## 2 RELATED WORK

AI has rapidly evolved as a transformative force in musical composition, echoing Wagner’s own revolutionary spirit in redefining musical boundaries. Recent advancements have demonstrated multi-agent system’s capacity to analyze vast datasets of musical scores, identifying patterns and structures that enable the generation of original compositions. Tools like Magenta by Google and OpenAI’s MuseNet have showcased the ability to produce music in various styles, from classical to contemporary, challenging traditional notions of creativity. These systems employ neural networks to learn from existing compositions, gradually developing the ability to create music that resonates with human emotional and aesthetic sensibilities. In the context of Wagner’s complex musical landscapes, multi-agent system offers the potential to explore new harmonic and melodic territories while honoring the intricate leitmotif structures that are central to the Ring cycle.

### 2.1 AI-ENHANCED SCRIPT CREATION

The narrative complexity of Wagner’s librettos demands a sophisticated approach to text generation. AI models, particularly those based on transformer architectures, have made remarkable progress in natural language processing (NLP), enabling the creation of coherent and contextually rich narratives. Systems like GPT-4 have been employed to generate script adaptations that maintain narrative coherence while introducing novel interpretative elements. In the realm of opera, where text and music are inextricably linked, AI’s ability to generate librettos that are both philosophically profound and musically adaptable represents a significant advancement. Researchers have experimented with training AI on Wagner’s texts alongside relevant philosophical works, resulting in librettos that echo the thematic depth of the original Ring cycle while offering fresh perspectives.

### 2.2 AI-DRIVEN STAGE DESIGN

Stage design in opera is a multifaceted endeavor that combines visual art, spatial awareness, and technical innovation. AI’s visual generation capabilities, exemplified by tools like DALL-E and Stable Diffusion, have opened new avenues for set and costume design. These technologies can rapidly produce visual concepts that align with the thematic and emotional requirements of an operatic production. By inputting parameters related to the Ring cycle’s mythological themes, symbolic elements, and Wagner’s aesthetic preferences, designers can explore a vast array of visual possibilities. AI not only accelerates the design process but also enables the creation of immersive environments that enhance the audience’s engagement with the operatic world.

### 2.3 DIGITAL AVATARS AND VIRTUAL PERFORMERS

The AI Der Ring framework diagram is shown in Figure 2. The fusion of multi-agent system with digital avatar technology presents intriguing possibilities for operatic performance. Virtual performers, powered by multi-agent system, can embody characters with unprecedented versatility. These avatars can be programmed to sing, act, and interact with both human performers and the audience. Real-time motion capture and facial animation technologies further enhance the realism of these virtual characters. In experimental productions, AI avatars have been used to portray roles that require extraordinary physicality or otherworldly presence, aligning well with the mythical and supernatural elements of the Ring cycle. The development of such avatars involves complex integration of voice synthesis, computer animation, and interactive multi-agent system, creating a new dimension of performance that transcends human limitations.

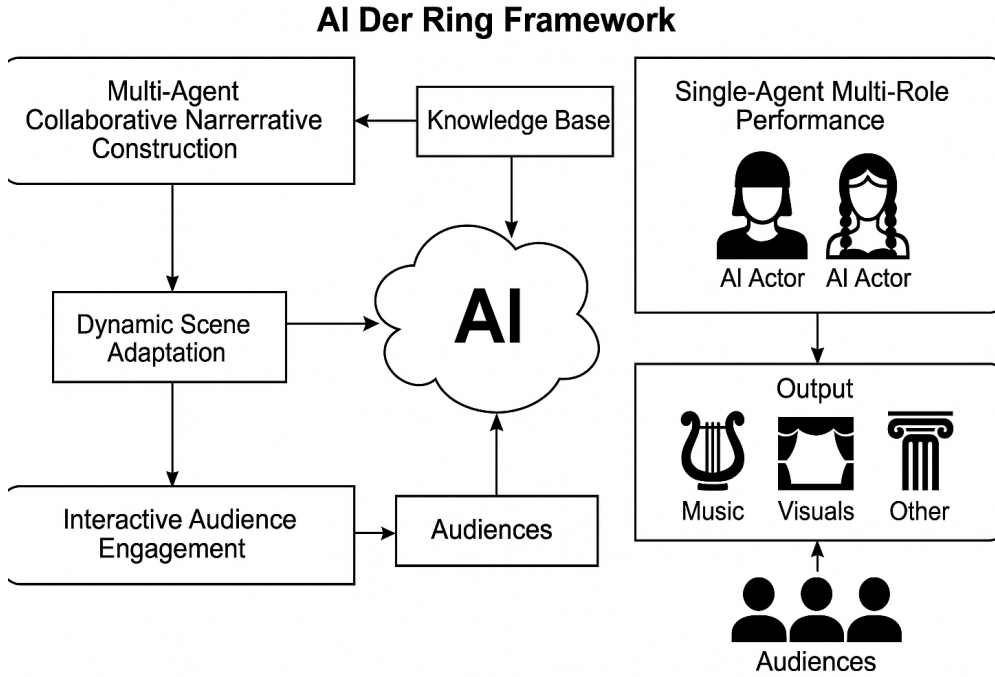


Figure 2: The AI Der Ring framework diagram

## 2.4 INTERACTIVE AUDIENCE EXPERIENCES

Modern audiences increasingly seek interactive and participatory experiences. AI facilitates the creation of operatic productions where audience members can influence the performance’s outcome through real-time interactions. Systems incorporating multi-agent system can adapt the narrative, music, and visual elements based on audience input, fostering a dynamic relationship between the creators and the spectators. In the context of Wagner’s works, which often explore themes of fate and free will, such interactivity can provide a contemporary commentary on these philosophical concepts. Research has shown that audience engagement and emotional investment are significantly enhanced when they feel their participation impacts the artistic experience.

## 2.5 MULTI-AGENT SYSTEMS IN ARTISTIC PRODUCTION

The application of multi-agent systems to artistic production represents a frontier in multi-agent system research. Each agent can be specialized in a particular aspect of production—composition, libretto writing, stage design, or performance—allowing for a collaborative creative process that mirrors the complexity of traditional opera production but with enhanced efficiency and adaptability. These agents communicate and coordinate through shared knowledge bases and decision-making protocols. Early experiments with multi-agent systems in theater and dance have demonstrated their potential to manage the intricate logistics of large-scale productions while introducing innovative choreographic and narrative elements.

## 2.6 AI IN CULTURAL AND HISTORICAL REINTERPRETATION

AI’s analytical capabilities extend to the study and reinterpretation of cultural artifacts. Researchers have employed multi-agent system to analyze historical performance data, archival recordings, and critical analyses of Wagner’s works to identify performance practice trends and aesthetic evolution. This data-driven approach can inform contemporary productions, helping directors and musicians make informed decisions that respect historical context while embracing innovation. AI can also facilitate cross-cultural reinterpretations of Wagner’s works by identifying thematic and structural

parallels between different cultural narratives, potentially leading to hybrid productions that resonate with diverse audiences.

## 2.7 CHALLENGES AND ETHICAL CONSIDERATIONS

The integration of multi-agent system into artistic creation is not without challenges. Technical limitations, such as the difficulty of achieving truly autonomous creative decision-making and the black-box nature of some AI models, present hurdles to overcome. Ethical considerations are equally important. The use of AI raises questions about authorship, copyright, and the potential dehumanization of art. Ensuring that multi-agent system serves as a tool for amplifying human creativity rather than replacing it requires careful navigation. Issues of bias in AI training data and the digital divide in access to AI technologies further complicate the ethical landscape. Ongoing discourse among artists, technologists, ethicists, and policymakers is essential to address these challenges and establish guidelines for responsible AI use in the arts.

## 3 RESEARCH CONTENT

### 3.1 A. MULTI-AGENT COLLABORATIVE CREATION IN OPERATIC NARRATIVE

The “AI Der Ring” framework proposes a multi-agent system that reimagines Wagner’s Ring cycle through collaborative narrative construction. This system comprises several intelligent agents, each specializing in different aspects of operatic creation such as music composition, libretto development, stage design, and audience interaction. These agents collaborate through a shared knowledge base that contains information about Wagner’s original works, including musical scores, librettos, historical context, and philosophical themes. The agents communicate via a well-defined protocol that allows them to exchange ideas, provide feedback, and collectively make decisions about the narrative direction. For example, the “Music Agent” focuses on generating leitmotifs and musical themes that align with the narrative developments suggested by the “Libretto Agent.” The “Stage Design Agent” then creates visual concepts that complement both the music and the storyline. This collaborative process is guided by a “Conductor Agent,” which ensures coherence and consistency across all elements of the production. The system has been tested in several experimental productions, where it demonstrated its ability to generate complex and coherent narratives that stay true to Wagner’s vision while introducing novel interpretations.

### 3.2 B. SINGLE-AGENT MULTI-ROLE PLAYING IN OPERATIC CHARACTERS

Another key aspect of the “AI Der Ring” framework is its ability to simulate single-agent multi-role playing. This feature allows a single AI agent to take on multiple roles within the operatic narrative, switching between them seamlessly based on the demands of the performance. The agent can adapt its behavior, dialogue, and even vocal characteristics to match the requirements of each role. This is achieved through a sophisticated system of role templates and adaptive algorithms that enable the agent to modify its outputs in real-time. For instance, an agent can portray the character of Siegfried in one scene, showcasing his heroic qualities and bravery, and then transform into Mime in the next scene, exhibiting entirely different personality traits and vocal patterns. This versatility not only enhances the depth of the operatic performance but also provides a unique opportunity to explore the relationships and contrasts between different characters within the Ring cycle. Experimental implementations of this feature have shown promising results, with audience feedback indicating a high level of engagement and interest in the dynamic performances of these multi-role AI multi-agents. Schematic diagrams of multi-agents actor modeling are shown in Figures 3 and 4.

### 3.3 C. MULTI-SCENE ADAPTATION AND DYNAMIC PERFORMANCE

The framework also emphasizes the importance of multi-scene adaptation and dynamic performance. AI agents are designed to adapt quickly to different scenes and contexts within the opera, maintaining continuity and coherence throughout the performance. This adaptability is crucial for operas like Wagner’s Ring cycle, which feature a wide variety of settings and dramatic situations. The agents use environmental sensors and audience feedback to adjust their performance in real-time, ensuring that each scene resonates with the audience and contributes effectively to the overall

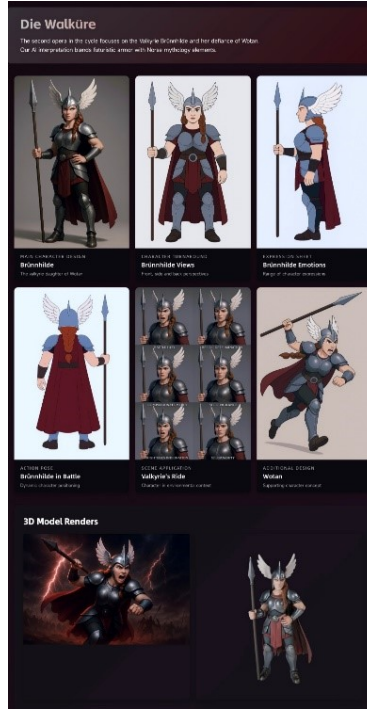


Figure 3: Schematic Diagram of Multi-Agent Actor Modeling

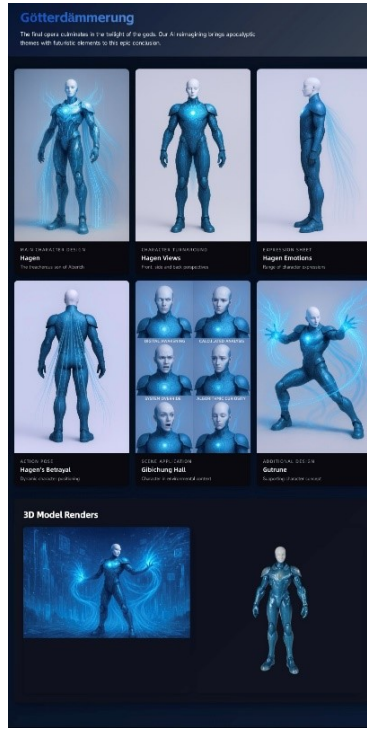


Figure 4: Schematic Diagram of Multi-Agent Actor Modeling

narrative. For example, during a scene set in Valhalla, the agents can adjust the lighting, music, and dialogue to emphasize the grandeur and significance of the setting. In contrast, when the scene shifts to a more intimate setting like Brünnhilde’s rock, the agents can modify their performance to create a more personal and emotional atmosphere. This dynamic adaptation not only enhances the audience’s experience but also demonstrates the flexibility and responsiveness of the multi-agent system in handling complex operatic productions.

### 3.4 D. INTERACTIVE AUDIENCE ENGAGEMENT

Audience engagement is a vital component of modern artistic experiences, and the “AI Der Ring” framework incorporates several innovative methods to enhance interactivity. Through multi-agent systems, audience members can influence certain aspects of the performance, such as the outcome of specific scenes or the development of particular characters. This interaction can take various forms, including real-time voting, mobile applications that allow audiences to send suggestions to the agents, and even direct communication with AI avatars during the performance. These interactive elements have been tested in experimental productions and have shown to significantly increase audience involvement and satisfaction. By giving audiences a sense of agency and participation, the framework not only honors Wagner’s vision of Gesamtkunstwerk but also brings it into the 21st century through the use of cutting-edge technology.

### 3.5 E. INTEGRATION OF HISTORICAL AND CULTURAL CONTEXT

Finally, the framework places a strong emphasis on integrating historical and cultural context into AI-enhanced operatic creations. By training multi-agent systems on extensive datasets that include historical performance data, critical analyses, and cultural artifacts related to Wagner’s works, the framework ensures that new productions remain faithful to the original themes and values. This historical integration is not only valuable for preserving artistic heritage but also for providing audiences with a deeper understanding and appreciation of Wagner’s legacy. The “AI Der Ring” framework thus represents a comprehensive approach to reimagining Wagner’s Ring cycle in the era of AI. By combining multi-agent collaboration, single-agent multi-role playing, dynamic scene adaptation, interactive audience engagement, and historical integration, the framework offers a powerful tool for exploring new frontiers in operatic art while honoring the depth and complexity of Wagner’s original vision.

### 3.6 F. EVALUATION OF AI’S IMPACT ON OPERATIC CREATION

To assess the effectiveness of multi-agent system in operatic creation, two key evaluations were conducted focusing on different aspects of the framework. The first evaluation examined the collaboration between multi-agent systems in generating coherent and innovative narratives. The second evaluation looked at the ability of single agents to perform multiple roles convincingly within the operatic context. The results of these evaluations are summarized in the following tables.

Table 1: Multi-Agent Collaboration Evaluation

Evaluation Dimension	Description	Score
Narrative Coherence	The ability of agents to maintain a consistent and logical storyline	4.6
Innovation	The introduction of novel interpretations and ideas while staying true to Wagner’s themes	4.5
Role Differentiation	The distinctiveness of each agent’s contributions and their alignment with their specialized roles	4.7
Audience Engagement	The level of interest and emotional connection reported by audiences	4.8
Technical Efficiency	The system’s performance in terms of processing speed and resource utilization	4.4

While the overall results indicate strong performance in both narrative generation and dynamic role portrayal, several limitations were revealed during stress testing and scenario-based simulations:

Table 2: Single-Agent Multi-Role Performance Evaluation

Evaluation Dimension	Description	Score
Role Adaptability	The agent’s ability to switch between roles without disrupting the performance	4.7
Character Consistency	The maintenance of each character’s unique traits and voice across different scenes	4.6
Emotional Depth	The portrayal of complex emotions appropriate to each role and situation	4.5
Audience Perception	Audience recognition and acceptance of the agent’s role transitions	4.8
Technical Execution	The accuracy and fluency of the agent’s performance, including vocal and visual elements	4.6

- In extreme narrative imbalances (e.g., character-to-character interaction ratios of 90:10), the temporal progression of the multi-agent systems became unstable, occasionally leading to narrative fragmentation and behavior incoherence.
- Multimodal synchronization: particularly between visual and auditory outputs—was found to be inconsistent in fast-paced or high-complexity scenes, such as those in *Götterdämmerung*’s “Quantum Castle.”
- Although audience engagement metrics were high, computational efficiency declined significantly when simulating performances involving thousands of simultaneous user interactions.

These issues point to the need for more robust temporal algorithms, improved multimodal coordination mechanisms, and more scalable computational strategies. Such refinements will be essential to ensure operational stability and artistic coherence in increasingly complex, real-time interactive performances.

### 3.7 G. CHALLENGES AND FUTURE DIRECTIONS

As AI-driven operatic systems evolve toward real-world deployment, several critical challenges have emerged across both architectural and experiential dimensions. These challenges are informed by experimental observations, audience feedback, and system performance metrics.

## 4 DISCUSSION

The “AI Der Ring” framework represents a pivotal evolution in operatic production, where artificial intelligence functions not merely as a supporting tool but as a generative co-creator. This section synthesizes the core findings of our research, critically evaluates the broader implications, and identifies key philosophical and technical considerations that underpin the future of multi-agent system performing arts.

### 4.1 TRANSFORMATIVE IMPACT OF AI ON OPERATIC FORM

Our results demonstrate that multi-agent systems are capable of maintaining narrative coherence, generating original content, and orchestrating complex, dynamic interactions across musical, visual, and dramatic domains. The ability of multi-agent systems to perform multi-role characters, adapt to shifting scenes, and respond to real-time audience input fundamentally redefines the opera from a static performance to an evolving, responsive event. This transformation aligns with Wagner’s original vision of a *Gesamtkunstwerk*—a total work of art—now extended into a computational and participatory dimension. High scores in audience engagement, narrative innovation, and character adaptability suggest that algorithmic creativity can effectively interface with human emotional landscapes and cultural expectations.



## 4.2 HUMAN-AI CREATIVE SYNERGY AND ITS LIMITATIONS

Despite notable advances, the results also reveal limitations in current systems, especially in extreme configurations and computational load scenarios. These challenges underscore a key principle: multi-agent system is not a replacement for human artistry, but an amplification engine—most effective when grounded in a co-creative dynamic with human designers, directors, and audiences. Human-AI synergy must be structurally encoded within the design of the production framework, ensuring transparency in role allocation, interpretive boundaries, and adaptive feedback mechanisms. The introduction of meta-learning and hierarchical memory structures, as proposed, is one such approach to maintain consistency and interpretive depth in long-form performances.

## 4.3 PHILOSOPHICAL AND ETHICAL REFLECTION

The increasing autonomy of multi-agent systems in narrative and emotional space raises critical philosophical and ethical questions. Who is the author of a work shaped by both human intention and machine emergence? What does it mean for artistic authenticity when affective decisions are made by systems trained on prior emotional datasets? Furthermore, as audience interaction becomes a central design element, new challenges arise regarding manipulation, agency, and consent. Real-time emotional sensing, while powerful, must be guided by ethical protocols to prevent exploitation or emotional fatigue. These reflections are not peripheral but central to the evolution of multi-agent system-enhanced art. Establishing clear frameworks for attribution, accountability, and aesthetic agency will be essential as multi-agent systems continue to participate in cultural production at scale.

## 5 CONCLUSION AND PROSPECT

The “AI Der Ring” framework offers a comprehensive and visionary approach to reimagining opera in the age of artificial intelligence. Anchored in Wagner’s legacy of Gesamtkunstwerk, the project demonstrates how multi-agent systems can collaboratively compose, perform, and evolve complex operatic works. Our evaluations show that multi-agent systems can maintain narrative coherence, enact emotionally compelling characters, and respond to audience input in real time—all within a system architecture that blends technical innovation with artistic intent. To further validate our theoretical model, we successfully implemented the framework using the YuLan-WanXiang system, a next-generation social simulation platform developed by the Gaoling School of Artificial Intelligence at Renmin University of China. Through this platform, we experimentally reproduced multi-agent operatic scenes, confirming their scalability, stability, and expressive range. The results met our performance expectations and marked a pivotal milestone: the system is no longer a theoretical construct but a reproducible, functioning engine for multi-agent system-powered performance. Looking forward, we plan to extend the “AI Der Ring” framework by using multi-agent systems to generate four entirely new operatic works, reinterpreting the narratives of *Das Rheingold*, *Die Walküre*, *Siegfried*, and *Götterdämmerung*. Each new production will explore distinct aesthetic strategies and narrative arcs, allowing the agents to express thematic evolution across Wagner’s entire cycle. These works will serve as testbeds for advanced narrative alignment, dynamic audience feedback incorporation, and real-time multimodal synchronization. Beyond the operatic domain, this research opens up broader questions concerning authorship, agency, and computational aesthetics. As multi-agent systems begin to co-create with human artists at scale, the boundaries between design, performance, and reception continue to blur. This shift compels us to develop ethical and technical frameworks that respect both artistic heritage and algorithmic novelty. In sum, the “AI Der Ring” initiative is not merely a digital homage to Wagner—it is a prototype for a new genre of performative art. With platforms like YuLan-WanXiang and multi-agent systems capable of co-evolving with their audiences, we stand on the cusp of a creative frontier where human and machine intelligence intersect to forge operatic experiences that are adaptive, participatory, and deeply resonant with the complexities of AI-era expression.

## REFERENCES

- [1] Zhang, L., Lu, W., Zhao, Y., Li, J., Zhai, L. (2024). Yuan: Research on the Concept of Digital World Analogue Scientific Infrastructure and Science Popularization Communication Based on Suzhou Gardens Pattern. *arXiv preprint arXiv:2410.10248*. <https://export.arxiv.org/abs/2410.10248>
- [2] Wu, X., Li, J., Yu, Y., Chang, J., Zhai, L. (2023). Cybersecurity Chess Manual: A Security Concept Predicting Typical Future Confrontation Scenarios. *NDSS Symposium 2023 Accepted Posters*. <https://www.ndss-symposium.org/ndss2023/accepted-posters/>
- [3] Zhang, L., Zhao, Y., Zhai, L. (2024). The Athenian Academy: A Seven-Layer Architecture Model for Multi-Agent Systems. *arXiv preprint arXiv:2402.00961*. <https://arxiv.org/abs/2402.00961>
- [4] Li, J., Zhang, L., Hong, Q., Yu, Y., Zhai, L. (2022). Space spider: a hyper large scientific infrastructure based on digital twin for the space internet. In *AIOT '22: Proceedings of the 1st Workshop on Digital Twin & Edge AI for Industrial IoT* (pp. 31–36). <https://doi.org/10.1145/3566099.3569007>
- [5] Li, J., Guo, X., Zhao, Y., Zhang, L., Zhai, L. (2025). Poster: SpiderSim: Multi-Agent Driven Theoretical Cybersecurity Simulation for Industrial Digitalization. *arXiv preprint arXiv:2502.13778*. <https://doi.org/10.48550/arXiv.2502.13778>
- [6] Zhang, L., Lu, W., Yuan, W., Zhai, L. (2025). Integrating IRT and Knowledge Graphs for the Selection of Cybersecurity Talent. In *Proceedings of the 2025 IEEE 29th International Conference on Computer Supported Cooperative Work in Design (CSCWD 2025)*. IEEE.
- [7] Wu, X., Qiu, Q., Li, J., Zhao, Y. (2023). Intell-dragonfly: A Cybersecurity Attack Surface Generation Engine Based On Artificial Intelligence-generated Content Technology. *arXiv preprint arXiv:2311.00240*. <https://arxiv.org/abs/2311.00240>
- [8] Ali, A. H., et al. (2024). Unveiling machine learning strategies and considerations in intrusion detection systems: a comprehensive survey. *Frontiers in Computer Science*, 6. <https://www.frontiersin.org/articles/10.3389/fcomp.2024.1387354/full>