

# 000 001 002 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020 021 022 023 024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039 040 041 042 043 044 045 046 047 048 049 050 051 052 053 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

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

114

115

## 2 RELATED WORK

116

117

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

128

129

### 2.1 AI-ENHANCED SCRIPT CREATION

130

131

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

141

142

### 2.2 AI-DRIVEN STAGE DESIGN

143

144

145

146

147

148

149

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

158

159

### 2.3 DIGITAL AVATARS AND VIRTUAL PERFORMERS

160

161

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

162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215

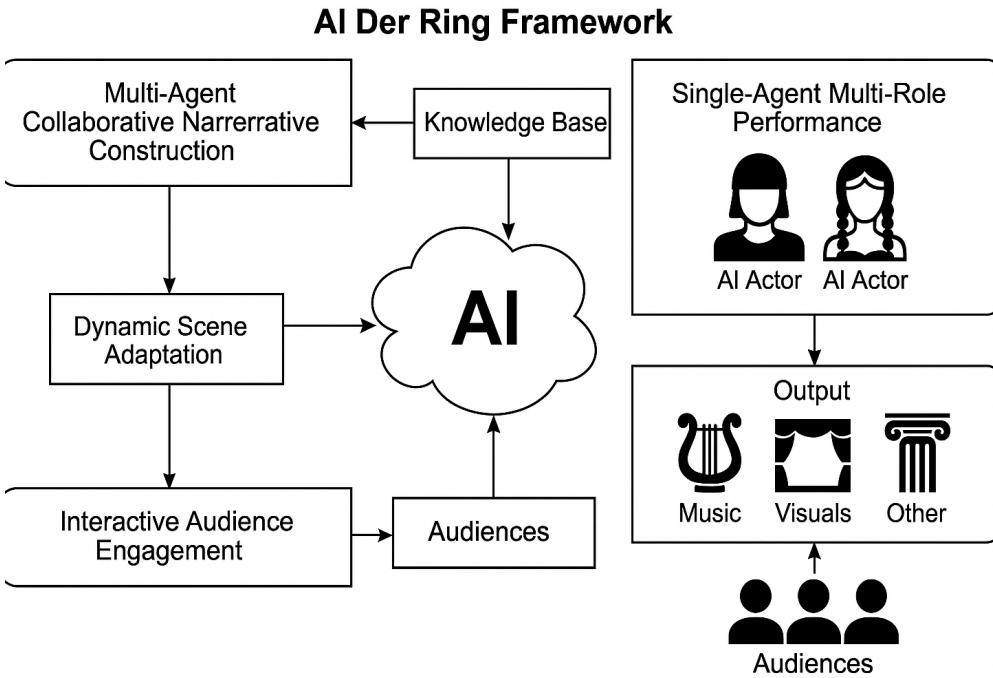


Figure 2: The AI Der Ring framework diagram

#### 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

216 parallels between different cultural narratives, potentially leading to hybrid productions that resonate  
 217 with diverse audiences.  
 218

219 **2.7 CHALLENGES AND ETHICAL CONSIDERATIONS**  
 220

221 The integration of multi-agent system into artistic creation is not without challenges. Technical limi-  
 222 tations, such as the difficulty of achieving truly autonomous creative decision-making and the black-  
 223 box nature of some AI models, present hurdles to overcome. Ethical considerations are equally  
 224 important. The use of AI raises questions about authorship, copyright, and the potential dehuman-  
 225 ization of art. Ensuring that multi-agent system serves as a tool for amplifying human creativity  
 226 rather than replacing it requires careful navigation. Issues of bias in AI training data and the digital  
 227 divide in access to AI technologies further complicate the ethical landscape. Ongoing discourse  
 228 among artists, technologists, ethicists, and policymakers is essential to address these challenges and  
 229 establish guidelines for responsible AI use in the arts.  
 230

231 **3 RESEARCH CONTENT**  
 232

233 **3.1 A. MULTI-AGENT COLLABORATIVE CREATION IN OPERATIC NARRATIVE**

234 The “AI Der Ring” framework proposes a multi-agent system that reimagines Wagner’s Ring cycle  
 235 through collaborative narrative construction. This system comprises several intelligent agents, each  
 236 specializing in different aspects of operatic creation such as music composition, libretto develop-  
 237 ment, stage design, and audience interaction. These agents collaborate through a shared knowledge  
 238 base that contains information about Wagner’s original works, including musical scores, librettos,  
 239 historical context, and philosophical themes. The agents communicate via a well-defined protocol  
 240 that allows them to exchange ideas, provide feedback, and collectively make decisions about the  
 241 narrative direction. For example, the “Music Agent” focuses on generating leitmotifs and musical  
 242 themes that align with the narrative developments suggested by the “Libretto Agent.” The “Stage  
 243 Design Agent” then creates visual concepts that complement both the music and the storyline. This  
 244 collaborative process is guided by a “Conductor Agent,” which ensures coherence and consistency  
 245 across all elements of the production. The system has been tested in several experimental produc-  
 246 tions, where it demonstrated its ability to generate complex and coherent narratives that stay true to  
 247 Wagner’s vision while introducing novel interpretations.  
 248

249 **3.2 B. SINGLE-AGENT MULTI-ROLE PLAYING IN OPERATIC CHARACTERS**

250 Another key aspect of the “AI Der Ring” framework is its ability to simulate single-agent multi-role  
 251 playing. This feature allows a single AI agent to take on multiple roles within the operatic narrative,  
 252 switching between them seamlessly based on the demands of the performance. The agent can adapt  
 253 its behavior, dialogue, and even vocal characteristics to match the requirements of each role. This  
 254 is achieved through a sophisticated system of role templates and adaptive algorithms that enable the  
 255 agent to modify its outputs in real-time. For instance, an agent can portray the character of Siegfried  
 256 in one scene, showcasing his heroic qualities and bravery, and then transform into Mime in the next  
 257 scene, exhibiting entirely different personality traits and vocal patterns. This versatility not only  
 258 enhances the depth of the operatic performance but also provides a unique opportunity to explore  
 259 the relationships and contrasts between different characters within the Ring cycle. Experimental  
 260 implementations of this feature have shown promising results, with audience feedback indicating  
 261 a high level of engagement and interest in the dynamic performances of these multi-role AI multi-  
 262 agents. Schematic diagrams of multi-agents actor modeling are shown in Figures 3 and 4.  
 263

264 **3.3 C. MULTI-SCENE ADAPTATION AND DYNAMIC PERFORMANCE**

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

270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293

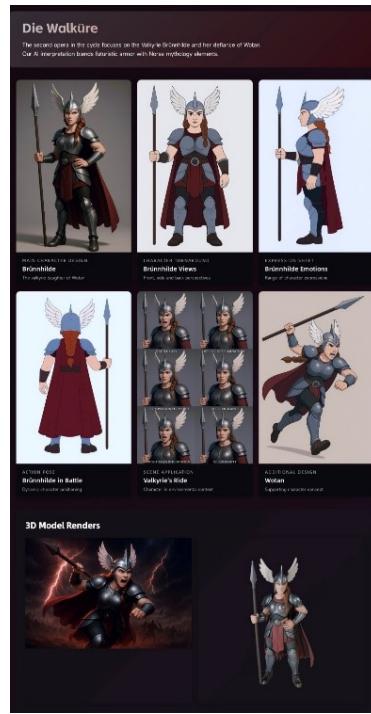


Figure 3: Schematic Diagram of Multi-Agent Actor Modeling

294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321



Figure 4: Schematic Diagram of Multi-Agent Actor Modeling

322  
323

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

### 330 3.4 D. INTERACTIVE AUDIENCE ENGAGEMENT

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

### 341 3.5 E. INTEGRATION OF HISTORICAL AND CULTURAL CONTEXT

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

### 353 3.6 F. EVALUATION OF AI’S IMPACT ON OPERATIC CREATION

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

364 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

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

378

379

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

390

391

- 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.

402

403

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.

407

408

### 3.7 G. CHALLENGES AND FUTURE DIRECTIONS

409

410

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.

413

414

## 4 DISCUSSION

415

416

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.

421

422

### 4.1 TRANSFORMATIVE IMPACT OF AI ON OPERATIC FORM

423

424

425

426

427

428

429

430

431

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.

432 4.2 HUMAN-AI CREATIVE SYNERGY AND ITS LIMITATIONS  
433

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

442  
443 4.3 PHILOSOPHICAL AND ETHICAL REFLECTION  
444

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

455  
456 5 CONCLUSION AND PROSPECT  
457

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

485

486 REFERENCES  
487

488 [1] Zhang, L., Lu, W., Zhao, Y., Li, J., Zhai, L. (2024). Yuan: Research on the Concept of Digital  
489 World Analogue Scientific Infrastructure and Science Popularization Communication Based  
490 on Suzhou Gardens Pattern. *arXiv preprint arXiv:2410.10248*. <https://export.arxiv.org/abs/2410.10248>

492 [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/>

496 [3] Zhang, L., Zhao, Y., Zhai, L. (2024). The Athenian Academy: A Seven-Layer Architecture  
497 Model for Multi-Agent Systems. *arXiv preprint arXiv:2402.00961*. <https://arxiv.org/abs/2402.00961>

500 [4] Li, J., Zhang, L., Hong, Q., Yu, Y., Zhai, L. (2022). Space spider: a hyper large scientific  
501 infrastructure based on digital twin for the space internet. In *AI2IOT '22: Proceedings of the 1st*  
502 *Workshop on Digital Twin & Edge AI for Industrial IoT* (pp. 31–36). <https://doi.org/10.1145/3566099.3569007>

504 [5] Li, J., Guo, X., Zhao, Y., Zhang, L., Zhai, L. (2025). Poster: SpiderSim: Multi-Agent  
505 Driven Theoretical Cybersecurity Simulation for Industrial Digitalization. *arXiv preprint*  
506 *arXiv:2502.13778*. <https://doi.org/10.48550/arXiv.2502.13778>

508 [6] Zhang, L., Lu, W., Yuan, W., Zhai, L. (2025). Integrating IRT and Knowledge Graphs for  
509 the Selection of Cybersecurity Talent. In *Proceedings of the 2025 IEEE 29th International*  
510 *Conference on Computer Supported Cooperative Work in Design (CSCWD 2025)*. IEEE.

511 [7] Wu, X., Qiu, Q., Li, J., Zhao, Y. (2023). Intell-dragonfly: A Cybersecurity Attack Surface Gen-  
512 eration Engine Based On Artificial Intelligence-generated Content Technology. *arXiv preprint*  
513 *arXiv:2311.00240*. <https://arxiv.org/abs/2311.00240>

514 [8] Ali, A. H., et al. (2024). Unveiling machine learning strategies and considerations in intrusion  
515 detection systems: a comprehensive survey. *Frontiers in Computer Science*, 6. <https://www.frontiersin.org/articles/10.3389/fcomp.2024.1387354/full>

518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539